TEHRAN SPECIAL SESSION, 1977

SESSION SPECIALE DE TEHERAN, 1977

INTERNATIONAL COMMISSION ON IRRIGATION & DRAINAGE

PROCEEDINGS

LIKELY IRRIGATED AGRICULTURE OF 2000 A.D.

The Commission is deeply indebted to Mr. K.K. Framji, Secretary-General, International Commission on Irrigation and Drainage for having conceived the idea of holding the Special Session on the above theme in 1974 which the International Executive Council happily approved at its meeting in Moscow in 1975

TEHRAN SPECIAL SESSION, 1977
SESSION SPECIALE DE TEHERAN, 1977

Time : FIRST SESSION : MAY 16, 1977 at 14.00 hour
SECOND SESSION : MAY 17, 1977 at 09.00 hour

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TEHRAN SPECIAL SESSION
1977

THEME : **Probable contribution from irrigation, drainage and flood control to meet the requirements of agricultural production towards the year 2000—Role and activities of ICID and its National Committees**

(with acknowledgement to Dr. H.M. Horning, FAO)

INTRODUCTION

This explanatory note is essentially a transformation of paragraphs 1, 2 and 3 of the Scope* into a questionnaire. However, it should be borne in mind that basically a country report is wanted, presenting the opinion and estimates of the experts in the National Committees: thus, narrative replies to the questions will be needed and only a limited amount of basic statistical data. For one country not all questions might apply; on the other hand, the questions could not be extended far enough to cover all possible problems and constraints. In consequence, the questions can provide guidance only and should by no means be seen as a limiting frame in case National Committees feel it necessary to expand their reports beyond such questions in order to present properly the particular problems their countries are or will be facing with regard to future developments. In case of doubt, the broader outline given in paragraphs 1 to 3 of the Scope should be given preference over the more narrow and detailed formulation of the questionnaire.

The questions follow the outline of *paragraphs* 1 to 3 of the Scope.

1. LONG-TERM PLANNING OF WATER DEVELOPMENT AND WATER USE FOR THE EXPANSION OF AGRICULTURAL PRODUCTION

1.1 ASSESSMENT OF DEMAND FOR HORIZONTAL AND VERTICAL EXPANSION OF IRRIGATION AND DRAINAGE

1.1.1 Present land use and present role of irrigation and drainage [Section 1.1 (a) of the Scope]

This section should give a base line for *paragraph* (1.1) and as such describe the present situation of irrigation, drainage and flood control and its value and importance for agriculture. This could be done by answering the following questions:

1.1.1–1. *Areas*

(use hectares, give figures for 1975 or indicate year for which figures are valid).

1.1.1–1.1 Total cultivated area (without rangeland for extensive grazing).

* Scope follows 'Introduction' (see page xiii).

1.1.1–1.2 Total rangeland used for extensive grazing.

1.1.1–1.3 Total area provided with irrigation facilities.

1.1.1–1.4 Total area provided with drainage facilities.

1.1.1–1.5 Of –1.3 and –1.4 area which is provided with both.

1.1.1–1.6 Indicate if any sizable area of –1.3 to –1.5 is permanent pasture.

1.1.1–1.7 Area which would not be suitable for cultivation without existing flood protection measures.

1.1.1–2. *Irrigation Regions*

1.1.1–2.1 Are irrigation and drainage (*a*) spread more or less uniformly all over the country, or (*b*) concentrated in certain regions or ecological zones? If (*b*) applies, the country report should refer in the following to such irrigation/drainage regions wherever applicable and possible. For the convenience of using available statistical data such ecological zone could if feasible be identified by political units (provinces, countries within a federation, etc.).

1.1.1–2.2 Describe the irrigation/drainage regions in your country giving the main characteristics of each region and the reasons why irrigation/drainage are important in each particular region.

1.1.1–2.3 Describe the relative importance of each region versus the total country giving the figures asked under –1.1 through –1.7 above for each region is possible, or giving the ratio of the cultivated areas region/country.

1.1.1–3. *Crop Yields*

1.1.1–3.1 For the main crops of the country or each irrigation region the areas and crop yields should be shown for both irrigated and non-irrigated production. Crop yields in t/ha (metric tons per hectare) should be given as averages for 1975 and, if possible, as means over a five-year period. Yield figures should refer to one single crop; areas should refer to the total harvested area planted with one crop in one year.

1.1.1–3.2 Indicate the cropping intensity for both non-irrigated and irrigated agriculture for the main crops, again for the country as a whole or for each irrigation region if –2.1(*b*) applies. This can be done by giving the area (or its percentage) on which more than one crop per year is grown with the normally used crop sequence.

1.1.1–3.3 The replies to the foregoing points should already show the value of irrigation for higher value crops, higher yields and more than one crop/year. Should this not be the case, more explanation will be needed about the reason why irrigation is used; in particular, give the constraints to extended double cropping.

1.1.1–4. *Complementary Information*

1.1.1–4.1 What are the irrigation methods used in the country (irrigation regions), giving percentages of areas under the different systems such as surface, sprinkler and drip irrigation? What are the water resources mainly used: diversion from rivers, storage of river water, ground water, giving percentages? What is degree of reliability of water supply: all year sufficient supply, sporadic shortage, regular shortage limiting the area under irrigation giving percentages? Give rough cost figures for typical schemes of different cost level such as ground water, diversion, storage schemes. Is there an appreciable part of special usage of irrigation such as for frost protection, sewage use, fertilizer application? What is the degree of sophistication of irrigation starting with simple, sporadic flood spreading, spate irrigation, gravity, sprinkler, etc., and ending with semi-automated or automated systems? Give a judgement of the skill of the farmers to properly use irrigation.

1.1.1–4.2 What is the importance of drainage:

(*a*) for maintaining the productivity of irrigated land, giving the area, reason for installing drainage and type of drainage (sub-surface field drains, open ditches, etc.)?

(*b*) for reclaiming wet lands?

1.1.1–4.3 Areas for which other reclamation measures have been introduced such as polders, dykes and other flood protection measures.

1.1.1–4.4 Areas for which erosion control measures and/or water conservation measures have been introduced and areas affected by erosion and other degradation due to previous or present land use, giving the degree of degradation and the reasons why degradation occurred, such as abandoned land because of low productivity, salinization, etc.

1.1.1–5. *Summary Assessment*

Summarize in a narrative form from your assessment of the present role and importance of irrigation, drainage and flood control in your country, referring particularly to the following:

1.1.1–5.1 Percentage of the value of agricultural production coming from:

(*a*) irrigated areas;

(*b*) other reclaimed areas;

(*c*) flood protected areas.

1.1.1–5.2 Percentage of rural population living in such areas; specify according to (*a*), (*b*) and (*c*) above.

1.1.1–5.3 Value of irrigation, drainage and flood protection to be found or supported by other factors such as export earnings, balanced regional development, balanced economic development, etc. (if possible, and indicative figures.)

1.1.2. Trends towards changes in land use section 1.1 (b) of the Scope

In the Scope, reference has been made to the need to base forecasts of demand for water development on national and/or regional agricultural development policies and plans, and the difficulty has been mentioned which arises from the fact that such development plans cover periods shorter than required for water planning or even do not exist at all. If we are to foresee the demand for irrigation and drainage development up to the year 2000 we shall, therefore, mainly depend on the assessment of trends. When we speak of trends in this connection, we refer to tendencies which have already been noticed, as well as charges which can reasonably be foreseen but are not yet acute. It should be borne in mind that for the purpose of this report, equal importance is given to extrapolation of known tendencies and reasonable expert-guesses on expected inclinations.

The reports by the National Committees on this section will be given in a narrative form and should cover the subjects listed under 1.1 (*b*) of the Scope. There will be a large variety of alternatives which can be applied with different weight by different countries; therefore, the following questions can only be indicative as a help in preparing this section, wherein the reason why a particular answer is chosen might be more conclusive for the purpose of the report than the answer itself (supply figures and/or ratios wherever possible):

1.1.2–0 *The anticipated Population Explosion likely to effect the Present Trends*

—the scope should be based on the anticipated population growth upto 2000 A.D. by projections of demographic statistics of 1975, separately for rural and urban sectors;

—rural population employed in rainfed agriculture and its future trend;

—agricultural population employed in irrigated agriculture and its future trend;

—rural and urban populations employed in agriculturally-oriented industries.

1.1.2–1. *Demand and Policy for Expansion of Agriculture Production*

1.1.2–1.1 Indicate the expected increase/decrease in demand for local production of the following, and give the reasons for this:

(*a*) staple food crops;

(*b*) high value crops for local consumption;

(*c*) export crops;

(*d*) agricultural raw material for industries for local use and export;

(*e*) other.

Example:

(*a*) the present deficit in self-sufficiency in wheat is 10 per cent; with the continuation of population growth of the present 2 per cent per annum and an estimated additional requirement of growth of wheat production of 1 per cent per annum due to improving standard of living of the population, it can be foreseen that the resulting wheat deficit much before the year 2000 will be intolerable and it is estimated that at least 70 per cent of the additional requirements of tons will have to come from increased national production.

(*b*) expansion of production of export crops (e.g. fruits) to increase rural employment and earnings of foreign currencies: it is estimated that the present level of production of export crops will have to be doubled within the next ten years; estimates going beyond this time limit are not possible because of the uncertainty of the development of the market for such crops.

In answering the above question, the following examples of possible reasons for expansion of production might be helpful (one or several reasons might apply at the same time):

—improved supplies of agricultural products;

—increase in living standards;

—population growth;

—improved nutritional balance;

—increased farm income;

—rural employment;

—stabilization of population movement;

—balanced economic development;

—development of retarded regions;

—export earnings;

—reducing imports.

1.1.2–1.2 How are these demands reflected in the government's long-term policies ? For example, policies of the present five-year plan might be quoted which have a bearing on the long-term planning, such as increased rural employment or promotion of export of agricultural products.

1.1.2–1.3 What are the resources allocated in the present five-year plan towards achieving the above long-term policy objectives and what is the expected increase/decrease of such resources for the following plan-periods?

1.1.2–2. *Trends in changes of Land Use*

Tendencies to change land use can be another indicator of the expected development of demands for agricultural production, particularly in countries with a free market economy.

1.1.2–2.1 What trends have been observed towards (*a*) intensification of production on existing cultivated lands, (*b*) expansion of cultivation to new lands? Give the reply also for each irrigation region separately, if applicable, and refer to typical indicators such as for (*a*) fertilizer use, mechanization, changes of crops or cropping systems, infrastructure and land consolidation, and for (*b*) area of new land per annum, cost per hectare, type of farming, measures for reclamation (e.g. conversion of grassland into ploughland), crops, people settled, etc. Identify the reasons for (*a*) and (*b*).

1.1.2–2.2 Also indicate the tendencies to abandon cultivated land or to change from intensive to extensive production, should this be the case for certain areas or types of farming in your country. Give areas affected and reasons for such tendencies. The reasons might be found in (*a*) the socio-economic field, but also (*b*) physical constraints (e.g. salinization).

1.1.2–2.3 How is the government influencing the trends reported under –2.1 and –2.2 ?

1.1.2–3. *Summary Assessment*

Give an assessment of the expected demand for agricultural production towards the year 2000, summarizing the above points of trends and government policy and adding, according to your own judgement, other aspects which might be of importance, such as changes which might have their causes in other sectors of the economy (e.g. increasing industries limiting resources and/or manpower for agriculture), changing markets, development of infrastructure, pressure of social changes, etc. Summarize in particular the two main trends: (*a*) towards intensification of production, and (*b*) towards expansion of areas under cultivation.

1.1.3 Demand for water development and use [Section 1.1 (*c*) of the Scope]*

The above information should now be converted into demand forecast for water development and use in agriculture. As we want to investigate the supply side of the forecast, i.e., the resources available to meet the demand, separately in chapter 1.2, it is required only to indicate the main thrusts here. This can be done by answering the following questions:

1.1.3–1. *Horizontal Expansion of Irrigation/Drainage*

1.1.3–1.1 What contribution can be expected from a horizontal expansion of irrigation and drainage towards the solutions of the problems which have been identified in paras –1 and –2 above? Estimate the areas which will have to be brought under irrigation/provided with drainage facilities, separately for irrigation regions and each of the items (*a*) to (*e*) of para 1.1.2–1.1 above.

1.1.3–1.2 What are the present trends to expand irrigation/drainage and initiatives taken by farmers/farmers' associations and local water authorities? e.g., new areas for which irrigation facilities have been requested, crops to be grown, people to be involved, etc.

1.1.3–1.3 How is the government supporting these trends, e.g. as reflected in the present five-year plan? Government willingness to grant water rights, to support water development projects, to provide infrastructure for new irrigation and drainage projects. Criteria for such support and methods used to predict the requirements.

1.1.3–2. *Vertical Expansion of Irrigation/Drainage*

This refers to intensification of production in already irrigated/drained lands requiring improved facilities for water supply, distribution and use, rehabilitation of old schemes, etc. Questions–1.1.3–1.1, 1.1.3–1.2, and 1.1.3–1.3 above should be answered in an analogous way.

Note : The subject covered by para 1.1 of the Scope has been dealt with in quite some detail in order to propose a pattern in which the reports by the National Committees could be presented. The remaining paragraphs should be dealt with in the same pattern and similar to para 1.1. This outline is, therefore, limited in the following to the presentation of a few key-words for each sub-paragraph of the Scope.

1.1.3–3. *Other Reclamation Measures*

Questions 1.1.3–1.1 to 1.1.3–1.3 should also be answered in an analogous way for other reclamation measures such as flood protection, swamp reclamation, etc.

1.1.3–4. *Summary Assessment*

Give an assessment of the expected demand to expand and improve water supply for agriculture, irrigation, drainage and other reclamation measures, as this relates to the demand for growth of agriculture; and give the reasons for increasing/decreasing demands for water use in agriculture if this is applicable.

1.2 ASSESSMENT OF THE POTENTIAL FOR HORIZONTAL AND VERTICAL EXPANSION*

1.2.1 The known potential to expand irrigation [item 1.2 (*a*) of the scope]

This is essentially a list of projects which have been accepted for implementation and/or are likely to be accepted. In case of expansion of irrigation by the farmers themselves individually on their own land, only rough guesses might be possible as to the potential of additional land coming under irrigation.

For the reply to this question, please refer to the questions asked under 1.1.1, but be more explicit with regard to the type of planned irrigation systems, water resources to be developed, and the information needed to judge the technical difficulties of new projects in your country, and the agricultural, social (settlement, people involved, organization, etc.) and economic impact, following the outline as given under para 1.1.2–1.1.

1.2.2 The potential to increase the intensity of water use in agriculture [item 1.2 (*b*) of the Scope]

This essentially refers to the possibilities to increase the productivity of irrigated land by improved technology and/or improved water management. In answering the same set of questions as under 1.2.1 above, particular attention should be paid to the technical side (e.g. improved land preparation, sprinkler irrigation, drainage for salinity control, etc.), to the costs of such measures, training required acceptance by the farmers, and expected effects which should be quantified and qualified, if possible, with regard to their contribution to the growth of agricultural production, employment, etc.

1.2.3 The capacity to develop the potential [item 1.2 (*c*) of the Scope]

This item aims at realistically estimating the time factor involved in developing water for agriculture as an essential contribution to agricultural growth; the development potential might be favourable but the future progress might be limited by (*i*) lack of financial means and/or (*ii*) lack of technical capacity to implement projects. It will be necessary to refer to the past and give some examples of the time required to implement projects

* (For questions 1.2.1, 1.2.2, and 1.2.3 the information requested in the introductory para of 1.2 of the Scope should be given, if applicable, according to irrigation regions).

from the inception to the opertional phase, identifying the constraints which have been experienced. This should then be extrapolated towards the time which might be required to develop the potential given in 1.2.1 and 1.2.2 above. The desirable measures to improve the situation (e.g. increased capacity for data collection, planning, financing, construction, manufacturing of equipment) should be identified giving also an idea of their costs. The report should follow the same pattern as for items 1.2.1 and 1.2.2.

1.2.4 Plans for final assessment [item 1.2 (*d*) of the Scope]

Here, the report should give a description to the existing planning machinery for water resources development in the country, the interlinks between the different water sectors (power, municipal supplies, agriculture and others) and the link to the overall economic plan. The report should demonstrate how the long-term water planning is effected and refer to the desirable improvements. Finally, the report should give an overall assessment of the expected development of irrigation, drainage and flood control in the country, expected water shortages and measures to overcome these, including their costs.

2. CONTRIBUTIONS EXPECTED FROM ADVANCED TECHNOLOGIES AND IMPROVED WATER MANAGEMENT

This Chapter refers to the introduction of improved technologies and their improved use for water management in agriculture. It is meant to establish trends and future requirements and should realistically assess the needs for introducing advanced techniques and management practices, costs involved, justifications, expected results (whether positive or partly negative). Particular emphasis should be given to item (*c*) of the Scope which is of high interest to ICID. It should be noted that the report on (*c*) will have to find its justification in items (*a*) and (*b*).

3. EXPECTED CONSTRAINTS AND PROBLEMS

In deviation from the Scope, it is now suggested that the reports by the National Committees summarize in this chapter all constraints they are able to foresee regardless of whether they have been already mentioned or not. Thus chapter 3 should be a summary assessment of the problems and constraints which will influence the development and use of irrigation, drainage and flood control in the countries during the next 25-year period.

Physical constraints might be shortage of water, lack of suitable land, salinity, floods, i.e., they might be of a permanent nature or might be overcome by high investments.

Social constraints might be ethnical (transmigration of population), educational (the time required for training farmers should not be underestimated) and others.

Economic constraints might refer to high development cost, low marketing chances, lack of infrastructure, etc.

Legal constraints imposed by land, water and environmental laws.

SCOPE*

The world community has been shocked by a series of severe food shortages mainly affecting areas of particular susceptibility to the hazards of droughts and floods. This has to be seen together with the need to increase food production at an unprecedented rate to meet the demand of an ever-increasing world population. Eventually, such food crises might occur at increasingly shorter intervals. The United Nations World Food Conference in Rome in November 1974 recognized that the long-term solution of the world food problem will require the accelerated development and improved efficiency of use of the natural resources which are basic to agricultural production: land and water. In particular a rapid increase of irrigation will be required and it has been estimated that the irrigated area in the developing world will have to be increased by 23 million hectares by 1985, requiring investments of about 38,000 million dollars, and, in addition to this, existing irrigation systems for 46 million hectares will have to be renovated and improved by 1985, costing about 21,000 million dollars. (The World Food Problem, E/CONF. 65/4, August 1974).

In a special resolution, entitled "Scientific Water" Management, Irrigation, Drainage and Flood Control, the World Food Conference urged governments and international organizations to make new efforts for the rapid expansion of irrigation, giving particular attention to the assessment of irrigation potentials, the development of ground-water resources, reclamation of waterlogged and saline lands, use of brackish water, water conservation, flood protection, and energy requirements for irrigation. The World Food Conference also decided to create an Agricultural Development Fund to assist developing countries to meet the increasing needs for investments in agriculture.

The fundamental importance of irrigation and drainage for the solution of the world food problem has thus been recognized. It is now the responsibility of the organizations and institutions dealing with irrigation and drainage to see that these plans will be given effect in the best possible way, in accordance with high technical standards, and with the most benefit for those for whom these plans have been made: for the millions of farmers on whose efficient work the solution of the food problem ultimately depends. This work will require the wide application of improved knowledge of irrigation and drainage technologies and their economic, ecological and social impacts. International co-operation on research, transfer of technology, information collection and dissemination, and training will have to provide the technical and scientific backstopping of the world-wide programme of irrigation and drainage development.

During the first 25 years of its existence, the ICID has been active in most of these fields and has acquired the experience and an established system of international co-operation by which it could provide essential and most important inputs to this programme. At its 26th Meeting in Moscow in 1975, the ICID Executive Council expressed the strong desire to direct ICID's work during the second 25 years period of its existence towards the maximum contribution that irrigation, drainage and flood control measures could give to the solution of the world food problem. With this in mind,

* Tehran Special Session 1977.

the Executive Council decided to hold at its 28th Meeting in Tehran, 1977, a Special Session devoted to this idea, which will provide a forum for the discussion and analysis of the expected development of irrigation and drainage in the world and the formulation of guidelines to ICID and its National Committees on concrete measures and works that should be undertaken in support of this development.

Forecasts of the role of irrigation and drainage in the growth of agricultural production have to be based on national and country-wide forecasts or plans for the development of the overall agricultural sector. Such forecasts or plans have not yet been developed systematically; some have been prepared for periods of five or ten years and only very few forecasts have been made at the national level for periods of twenty to twenty-five years. The reason for this can be found in the comlexity of the methodology and inputs and in the limited period of validity of long-term forecasts for agriculture. Short forecasting periods might be acceptable for the overall planning of the agricultural sector of national economies; however, they are not acceptable for the water sector, because of the high investments and long gestation periods required for irrigation, drainage and flood protection measures and the need for the long-term planning of water allocation for the different uses. So far, long-term forecasts of the water development required for expansion of agricultural production have been made only in the form of country, regional and global estimates; but it is more and more recognized that reliable projections are needed for sound water development planning at the national level. It is expected that a new impetus for the development of reliable long-term projections will come from the irrigation and drainage field.

The Special Session will study the work presently undertaken in ICID Member Countries and elsewhere in the field of forecasting the requirements of water development for agriculture. This will be done with the intention to clarify the methodology to be usefully applied, data to be collected, and international co-operation which might be needed to arrive at universally accepted projections of irrigation and drainage development. This will enable the Special Session to identify gaps in the overall planning work for irrigation and drainage and to determine guidelines for future action by ICID and its National Committees in support of long-term forecasting and planning of water development for agriculture, also with regard to the requirements of and assistance to developing countries which are particularly affected by the food problem. Rather than producing another set of global estimates, the Special Session will concentrate on the study of the elements of water development projections, such as assessment of demands and development potentials, application of advanced technology, improved water management, and development constraints, as well as identified trends in these fields. This will be done on the basis of reports and papers requested from the National Committees which should be prepared in accordance with the following *paragraphs*:

1. Long-term planning of water development and water use for the expansion of agricultural production.

1.1 Assessment of demand for horizontal and vertical expansion of irrigation and drainage: forecasts and trends at the country level. Information on the criteria and methodologies used, progress made so far and summary of the information already available, and organization of work. In particular the reports should refer to:

(*a*) The present land use pattern in agriculture as an indicator of the role of irrigation, drainage and water control within the overall agricultural sector which should include the benefits from water control (irrigation, drainage, flood control, water conservation, erosion control and other land reclamation measures) as well as the ill-effects caused by water and its use (waterlogging, salinity, erosion, floods).

(*b*) Trends toward changes in land use which indicate possible changes in water use, such as increase/decrease in the demand for local production of staple food, changes in cropping intensities, changes in employment requirements, changes in market conditions, competition with other economic activities—in particular, competition in water use (influence of agricultural, social and economic development on water demands).

(*c*) Criteria and methods used for long-term projections of water development and use for agriculture and as they are related to policy objectives such as providing food supply for population growth, increase of per capita income, employment, earning and saving of foreign exchange, improving regional balance of development.

1.2 Assessment of the potential for horizontal and vertical expansion of agricultural production by irrigation, drainage and water control. Information on areas, type of development, costs, people involved, expected agricultural benefits, expected contributions to reaching policy objectives, criteria and methodologies, and organizations involved. In particular the reports should refer to:

(*a*) The known potential for bringing new land under cultivation or increasing production from cultivated land by irrigation, drainage and other land reclamation measures, including type of water resources development measures.

(*b*) The potential for vertical increase of production from irrigated areas by improved water management, additional agricultural inputs and control of soil degradation, including investments required, training and services needed.

(*c*) The capacity to develop the identified potential, the annual rate of development for new (*a*) and improvement (*b*) projects, and expected constraints (financial, personnel and training, organizational, infrastructural).

(*d*) The plans for final assessment of the long-term development potential for irrigation, drainage and land reclamation at the country level, including existing and planned systems for data collection and evaluation, planning (criteria, methodologies, organizations), and constraints for carrying out such work.

2. Contributions expected from advanced technologies and improved water management. Information on the prospects for an increase in the contribution which could come from irrigation, drainage and flood control

to the solution of the food problem by the application of known advanced technologies and improved water management. The reports should refer particularly to:

(*a*) The increase in the efficiency of water use and the decrease of cost for irrigation and drainage by the use of advanced technologies such as improved water application techniques for surface, sprinkler, drip or underground irrigation, automated irrigation, reduction of water losses, improved construction techniques and energy saving (expected importance, results, constraints).

(*b*) The prospects of increasing the effectiveness of water control for agriculture by improved water management systems and practices with regard to basin water management, project operation and management, and field water management (organization, administration, training, extension services).

(*c*) Identification of research needs, transfer of know-how and international co-operation in the above fields.

3. Expected constraints and problems.

If not covered by items 1 and 2 above, information is requested about particular problems and constraints for irrigation and drainage development with regard to physical, social and economic aspects.

SESSION SPECIALE DE TEHERAN
1977

Thème : **Contribution probable à partir de l'irrigation, du drainage et de la maîtrise des crues pour faire face aux besoins de la production agricole vers l'an 2000—Rôle et activités de l'ICID et de ses Comités Nationaux**

(Courtoisie: Dr. H.M. Horning, FAO)

Cette note de prévisions constitue essentiellement une refonte des paragraphes 1, 2 et 3 du Contenu* sous forme d'un questionnaire. Néanmoins, ce qu'on compte obtenir, il faut se rappeler, c'est un rapport national qui présente l'avis et les estimations des experts des Comités Nationaux: on voudrait recevoir les réponses détaillées aux questions et un nombre limité de données de base statistiques. Toutes les questions ne s'appliqueront pas pour un pays; d'autre part, tous les problèmes et contraintes n'auraient pas trouvé leur place dans une question. En conséquence, les questions ne peuvent que guider et ne doivent pas être de ce fait considérées comme un cadre restreint au cas où les Comités Nationaux estimeraient nécessaires d'élargir leurs rapports, au delà des limites de ces questions, en vue de présenter les problèmes particuliers auxquels ils font ou feront face dans leurs pays quant aux développements futurs. En cas de doute, il serait préférable de se reporter aux paragraphes 1, 2 et 3 du Contenu plutôt qu'à la formulation plus étroite et détaillée du questionnaire.

Les questions suivent le texte des paragraphes 1, 2 et 3 du Contenu:

1. PLANIFICATION A LONG-TERME DE LA MISE EN VALEUR DES RESSOURCES HYDRAULIQUES ET DE L'UTILISATION DES EAUX POUR L'EXPANSION DE LA PRODUCTION AGRICOLE

1.1 EVALUATION DE LA DEMANDE POUR L'EXPANSION HORIZONTALE ET VERTICALE DE L'IRRIGATION ET DU DRAINAGE

1.1.1 Disposition actuelle des utilisations des terres et le rôle actuel de l'irrigation et du drainage [Section (a) du Contenu]

Cette section constitue une base pour l'alinéa 1.1 et par conséquent décrit la situation actuelle de l'irrigation, du drainage et de la maîtrise des crues, et sa valeur et son importance pour l'agriculture. On pourra le faire en répondant aux questions suivantes:

1.1.1-1. *Surfaces* (hectares, indiquer es chiffres relatifs à l'année 1975 ou l'année à laquelle ils se rapportent)

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* Voir ce Contenu à la page (xxv).

1.1.1-1.1 Surface totale cultivée (on ne tiendra pas compte des étendues de terrain réservées au pâturage extensif)

1.1.1-1.2 Surface totale de l'étendue destinée au pâturage extensif

1.1.1-1.3 Surface totale munie des facilités d'arrosage

1.1.1-1.4 Surface totale munie des dispositifs de drainage

1.1.1-1.5 1.1.1-1.3 et 1.1.1-1.4 : Surface munie des facilités d'irrigation et de drainage

1.1.1-1.6 Indiquer si une surface importante couverte aux points 1.1.1-1.3 à 1.1.1-1.5 est destinée au pâturage permanent

1.1.1-1.7 Surface non convenable à l'agriculture, en l'absence des mesures de protection contre les crues.

1.1.1-2. *Zones d'irrigation*

1.1.1-2.1 L'irrigation et le drainage (*a*) sont-ils plus ou moins prévus d'une façon uniforme dans tout le pays, ou (*b*) sont-ils concentrés dans certaines régions ou zones écologiques? Si la réponse est affirmative pour (*c*), le rapport national doit indiquer le cas échéant les zones d'irrigation/de drainage, dans la mesure du possible. S'il convient d'utiliser les données statistiques disponibles, une telle zone écologique pouvait être, si possible, identifiée par les unités politiques (provinces, pays compris dans une fédération, etc.)

1.1.1-2.2 Décrire les zones d'irrigation/du drainage de votre pays en signalant les caractéristiques essentielles de chaque région et les raisons pour lesquelles l'irrigation et le drainage occupent une importance dans chaque région particulière.

1.1.1-2.3 Décrire l'importance respective de chaque région par rapport à l'ensemble du pays, en fournissant les chiffres demandés aux points 1.1.1-1.1 à 1.1.1-1.7 ci-dessus pour chaque région si possible, ou le rapport des surfaces cultivées région/pays.

1.1.1-3. *Rendements agricoles*

1.1.1-3.1 Indiquer pour les cultures essentielles du pays ou chaque zone d'irrigation, les surfaces et les rendements à la fois pour la production irriguée et non-irriguée. Indiquer les rendements en t/ha (tonnes métriques par hectare) en moyenne pour 1975 et, si possible, la moyenne d'une période de 5 ans. Les chiffres du rendement ne doivent appartenir qu'à une seule culture; les surfaces signifient la surface totale exploitée d'une culture, dans une année.

1.1.1-3.2 Indiquer l'intensité de culture à la fois pour l'agriculture irriguée et non-irriguée pour les cultures essentielles, à nouveau pour l'ensemble du pays ou pour chaque région irriguée, dans le cadre de l'alinéa 1.1.1-2.1 (*b*). Ceci pourrait être fait en précisant la surface (ou son pourcentage) portant plus d'une culture par an en adoptant la rotation normalement respectée.

1.1.1-3.3 Les réponses relatives aux points ci-dessus doivent déjà préciser la valeur de l'irrigation pour les cultures de haute valeur, les rendements plus élevés et pour plus d'une culture par an. S'il n'en est pas le cas, donner plus de précisions pour expliquer la raison pour laquelle on a utilisé l'irrigation; donner notamment les contraintes à la double culture prolongée.

1.1.1-4. *Renseignements supplémentaires*

1.1.1-4.1 Quelles sont les méthodes d'irrigation utilisées dans le pays (zones irriguées) (donner les pourcentages des surfaces desservies par les différents systèmes tels que surface, aspersion et goutte à goutte)? Quelles sont les principales ressources en eau utilisées: dérivation des cours d'eau, stockage de l'eau des cours d'eau, eau souterraine (indiquer les pourcentages)? Quel est le degré de fiabilité de la desserte d'eau : alimentation suffisante pendant toute l'année, manque sporadique, manque régulier limitant la surface arrosée (donner les pourcentages)? Indiquer les chiffres des coûts approximatifs pour les projets typiques de divers niveaux de coûts, tels que projets d'eau souterraine, d'eau de dérivation, d'eau de stockage. Y a-t-il une partie appréciable de l'usage spécial de l'arrosage tel que pour la protection du gel, utilisation des eaux d'égout, application des engrais? Quel est le degré de sophistication d'arrosage, à partir de l'irrigation simple, submersion sporadique, épandage des eaux de crue d'un cours d'eau intermittent, irrigation par gravité, aspersion, etc., aboutisant aux systèmes semi-automatisés ? Formuler un jugement sur la compétence des exploitants dans l'usage approprié de l'irrigation.

1.1.1-4.2 Quelle est l'importance du drainage:

(*a*) dans le maintien de la productivité de la terre irriguée: indiquer la surface, la raison pour l'installation du drainage et le type du drainage—[drains souterrains, collecteurs-fossés (secondaires)]?

(*b*) dans la mise en valeur des terres humides?

1.1.1-4.3 Surfaces pour lesquelles les autres mesures de bonification ont été introduites telles que polders, digues et les autres mesures de protection contre les crues.

1.1.1-4.4 Surfaces dotées des mesures de contrôle d'érosion et/ou des mesures de conservation; et surfaces affectées par l'érosion et la dégradation, résultant de l'utilisation précédente ou actuelle des terres; indiquer le degré de dégradation et les raisons de cette dégradation, telles que terre abandonnée en raison d'une basse productivité, salinisation, etc.

1.1.1-5. *Brève évaluation*

Faire un résumé, sous forme narrative, à partir de votre jugement du présent rôle et de l'importance de l'irrigation, du drainage et de la maîtrise des crues dans votre pays, vous référant notamment aux aspects suivants:

1.1.1-5.1 Pourcentage de la valeur de la production agricole résultant:

(*a*) des surfaces irriguées;

(*b*) des autres surfaces bonifiées;

(*c*) des surfaces protégées contre les inondations.

1.1.1-5.2 Pourcentage de la population rurale de ces zones: préciser selon (*a*), (*b*) et (*c*) ci-dessus.

1.1.1-5.3. Valeur de l'irrigation, du drainage et de la protection contre les crues qu'on trouvera et appuyée par les autres facteurs tels que revenus d'exportation, développement régional équilibré, développement économique équilibré, etc. (ajouter si possible des chiffres indicatifs).

1.1.2 Tendances vers les changements dans les utilisations des terres [section (b) du Contenu]

Dans le Contenu, on a parlé de la nécessité d'une base sur laquelle les prévisions de la demande pour la mise en valeur hydraulique s'appuyeraient: une base telle que politiques ou projets nationaux et/ou régionaux de développement agricole; l'on a mentionné la difficulté qui résulte du fait que de tels projets de développement couvrent des périodes plus courtes qu'il soit nécessaires, pour la planification des eaux, ou de tels projets n'existent plus. Si nous devions prévoir le besoin en développement de l'irrigation et du drainage jusqu'à l'anée 2000, nous dépendrons donc essentiellement de l'estimation des tendances. Quand nous parlons des tendances dans ces circonstances, nous entendons par celles qui ont été déjà constatées, ainsi que les changements qui peuvent être raisonnablement prévus, mais qui ne sont pas encore aigus. Il faut toujours se rappeler du but de ce rapport, et accorder une importance égale à l'extrapolation des tendances connues et à des estimations des experts sur les tendances envisagées.

Les rapports des Comités Nationaux relatifs à cette Section seront rédigés sous forme narrative et couvriront les sujets énumérés au paragraphe 1.1(*b*) du Contenu. Il y aura une grande variété d'alternatives qui peuvent être appliquées de façons différentes par les divers pays:, par conséquent, les questions suivantes ne peuvent qu'être de nature indicative, visant à aider à préparer cette section, où la raison pour laquelle une réponse particulière est choisie pourrait être plus décisive-pour le rapport que la réponse elle-même (fournir les chiffres et/ou les rapports, le cas echéant).

1.1.2-0 *"Explosion démographique" prévue, pouvant affecter les tendances actuelles*

—le contenu doit s'appuyer sur la croissance démographique anticipée jusqu'à l'an 2000, par les projections des statistiques démographiques de 1975, séparément pour les secteurs ruraux et urbains;

—population rurale embauchée dans l'agriculture alimentée par la pluie et sa future tendance;

—population agricole embauchée, dans l'agriculture irriguée et sa future tendance;

—populations rurale et urbaine embauchées dans les industries agricoles.

1.1.2-1 *Nécessité et politique de l'expansion de la production agricole*

1.1.2-1.1 Indiquer l'augmentation/la diminution prévue dans la demande de la production locale suivante, et en fournir les motifs:

(*a*) cultures alimentaires principales;

(*b*) cultures de haute valeur pour la consommation locale;

(*c*) cultures destinées à l'exportation;

(*d*) matière première agricole destinée aux industries pour la consommation locale et l'exportation;

(*e*) divers.

Exemple: (*a*) le déficit actuel dans l'auto-suffisance en blé est de 10 pour cent; compte tenu de la croissance démographique continuelle de 2 pour cent actuel par an et du besoin supplémentaire estimé de la croissance de la production agricole d'un pour cent par an, grâce au standard de vie en amélioration de la population, on pourra prévoir que le déficit en blé sera intolérable bien avant l'an 2000, et l'on estime qu'au moins 70 pour cent des besoins supplémentaires (tonnes) proviennent de la production nationale accrue.

(*c*) expansion de la production des cultures destinées à l'exportation (à savoir, fruits) pour accroître les emplois ruraux et les recettes de devises étrangères: l'on estime que le niveau actuel de production des cultures destinées à l'exportation doit être doublé dans les dix prochaines années; les estimations pour une période supérieure à dix ans ne sont pas possibles à cause de l'incertitude du développement du marché pour ces cultures pareilles.

Pour répondre à cette question, les exemples suivants des raisons probables pour l'expansion de la production peuvent être utiles (on pourrait évoquer une ou plusieurs raisons en même temps):

—meilleurs approvisionnements des produits agricoles;

—meilleur standard de vie;

—croissance de la population;

—meilleur équilibre alimentaire;

—rendement agricole élevé;

—emploi rural;

—stabilisation du mouvement de la population;

—développement économique équilibré:

—développement des régions sous-développées;

—revenus des exportations;

—réduction des importations.

1.1.2-1.2 Comment ces demandes se reflètent-elles dans les politiques à long terme du gouvernement? On peut citer, par exemple, les politiques du plan quinquennal actuel qui ont un rapport avec la planification à long terme, telle que emploi rural ou promotion de l'exportation des produits agricoles.

1.1.2-1.3 Quelles sont les ressources assignées dans le présent plan quinquennal, en vue de réaliser les buts de cette politique à long terme? Quelle est l'augmentation/la réduction de ces ressources pour les périodes des plans suivants?

1.1.2-2. *Tendances en changement de l'utilisation des terres*

Les tendances visées à changer l'utilisation des terres peuvent être un autre index du développement anticipé des demandes pour la production agricole, notamment dans les pays d'économie à marché libre.

1.1.2-2.1 Quelles sont les tendances observées pour (*a*) l'intensification de la production des terres cultivées à présent, (*b*) l'expansion de l'agriculture aux nouvelles terres? Répondez aussi pour chaque zone irriguée séparément, le cas échéant, en vous référant aux indices typiques tels que pour (*a*) l'utilisation des engrais, la mécanisation, les changements des cultures ou des systèmes agricoles, l'infrastructure et le remembrement des terres, et pour (*b*) surface de nouvelle terre par an, coût d'un hectare, type d'exploitation agricole, mesures destinées à la mise en valeur (à savoir, conversion des prairies en sol arable), cultures, peuple installé, etc. Identifier les raisons pour (*a*) et (*b*).

1.1.2-2.2 Indiquer également les tendances vers l'abandon des terres cultivées ou le changement de la production intensive en production extensive, s'il en est le cas de certaines régions ou types d'agriculture dans votre pays. Donner les surfaces affectées et les motifs pour ces tendances. On peut trouver les raisons dans (*a*) le domaine socio-économique, mais également dans (*b*) les contraintes physiques (à savoir, salinisation).

1.1.2-2.3 Comment le gouvernement influence-t-il ces tendances mentionnées au 1.1.1-2.1 et 1.1.2-2.2 ?

1.1.2-3. *Brève évaluation*

Donner une évaluation de la demande prévue en production agricole vers l'an 2000, en résumant les aspects ci-dessus des tendances et la politique du gouvernement et en ajoutant, selon votre propre jugement, les autres aspects qui soient importants, tels que changements qui pourraient avoir leur origine dans les autres secteurs de l'économie (à savoir, industries accrues, ressources limitées et/ou main-d'oeuvre pour l'agriculture), marchés en variation, développement de l'infrastructure, pression apportée par les mutations sociales, etc. Résumer en particulier les deux tendances principales: (*a*) vers l'intensification de la production, et (*b*) vers l'expansion des surfaces en cours d'exploitation.

1.1.3 Demande de mise en valeur hydraulique et d'utilisation des eaux [Section (c) du contenu]

Il faut maintenant convertir les renseignements ci-dessus sous forme d'une prévision de demande de mise en valeur hydraulique et de l'utilisation des eaux pour l'agriculture. Comme nous souhaitons enquêter séparément dans le chapitre 1.2 le côté approvisionnement de la prévision, c'est-à-dire, les ressources disponibles pour satisfaire la demande, il suffit d'indiquer seulement ici les principales incidences, en répondant par exemple aux questions suivantes:

1.1.3-1. *Expansion horizontale de l'irrigation/du drainage*

1.1.3-1.1 Quelle serait la contribution probable d'une expansion horizontale de l'irrigation et du drainage envers les solutions des problèmes indiqués aux alinéas–1 et–2 ci-dessus? Déterminer les surfaces qui doivent être soumises à l'irrigation et les surfaces qui doivent être drainées, séparément pour les regions d'arrosage et pour chacun des points (*a*) à (*e*) du paragraphe 1.1.2-1.1 ci-dessus.

1.1.3-1.2 Quelles sont les tendances actuelles orientées vers l'expansion de l'irrigation/du drainage et les initiatives prises par les exploitants/par les associations des exploitants et des autorités locales des eaux? à savoir, nouvelles surfaces pour lesquelles les facilités d'irrigation sont requises, cultures à prévoir, gens qui vont participer etc.

1.1.3-1.3 Quel est l'appui gouvernemental accordé à ces tendances, à savoir, tel qu'il est traduit dans le présent plan quinquennal? La bonnė volonté du gouvernement dans l'octroi des droits d'eau, l'appui des projets de mise en valeur hydraulique, la fourniture de l'infrastructure pour les nouveaux projets d'irrigation et de drainage. Critères de ces appuis et méthodes utilisées pour la prévision des besoins.

1.1.3-2. *Expansion verticale de l'irrigation/du drainage*

Cette partie se rapporte à l'intensification de la production des terres déjà irriguées/drainées mais nécessitant des facilités modernes d'approvisionnement en eau, de distribution et d'utilisation, de réhabilitation des anciens projets, etc. Les Questions 1.1.3–1.1, 1.1.3–1.2 et 1.1.3–1.3 doivent être répondues de la même façon.

1.1.3-3. *Diverses mesures de mise en valeur*

Les Questions 1.1.3–1.1 à 1.1.3–1.3 doivent être également répondues de la même façon pour les autrès mesures de mise en valeur des marais, etc.

1.1.3-4. *Brève évaluation*

Donner une évaluation de la demande prévue pour accroître et améliorer l'approvisionnement en eau pour les buts agricoles, d'arrosage, de drainage et des autres mesures de mise en valeur, car cela a trait à la demande pour l'accroissement de l'agriculture; et citer les raisons pour accroître/décroître les demandes pour l'utilisation des eaux en agriculture, si cela est applicable.

Note : Le thème évoqué au paragraphe 1.1 du Contenu a été traité d'une façon assez détaillée en vue de proposer un modèle selon lequel les rapports des Comités Nationaux puissent être rédigés. Les autres paragraphes doivent suivre le même modèle et être identiques au paragraphe 1.1. Cet aperçu est donc limité à la présentation de certains mots-clef pour chaque sous-paragraphe du Contenu.

1.2 EVALUATION DU POTENTIAL POUR L'EXPANSION HORIZONTALE ET VERTICALE

(Pour les questions 1.2.1, 1.2.2 et 1.2.3, les renseignements sollicités dans le paragraphe d'introduction 1.2 du Contenu doivent être fournis, le cas échéant, selon les régions d'irrigation).

1.2.1 Potentiel connu pour accroître l'irrigation [point (a) du Contenu]

Il s'agit essentiellement d'une liste de projets qui ont été approuvés pour exécution et/ou qui seront probablement acceptés. Au cas de l'expansion de l'irrigation par les exploitants eux-mêmes, individuellement sur leur propre terre, il serait seulement possible de répondre grosso modo en ce qui concerne le potentiel de terre supplémentaire qui sera arrosé. Pour répondre à cette question, il faut vous reporter aux questions posées à l'alinéa 1.1.1., les réponses doivent être plus explicites quant au type des systèmes d'irrigation prévus, aux ressources hydrauliques à développer, et les renseignements nécessaires pour juger les difficultés techniques des nouveaux projets de votre pays, et les incidences agricole, sociale (installation, participation de la population, organisation, etc.) et économique, suivant l'aperçu tel qu'il est fourni à la Section 1.1.2–1.1.

1.2.2 Potentiel pour accroître l'intensité de l'utilisation des eaux dans l'agriculture [point (b) du Contenu]

Il s'agit essentiellement des possibilités d'accroissement de la productivité des terres irriguées par une technologie perfectionnée et/ou une gestion améliorée des eaux. Quand on répond au même jeu de questions comme celui 1.2.1 ci-dessus, une attention particulière doit être accordée au côté technique (à savoir, préparation améliorée des terres, irrigation par aspersion, drainage pour le contrôle de la salinité, etc.), aux coûts de ces mesures, à la formation nécessaire, à l'acceptation par les exploitants, relative à leur contribution à l'accroissement de la production agricole, emploi, etc.

1.2.3 Capacité de développer le potentiel [point (c) du Contenu]

Ce point vise à estimer d'une façon réaliste le facteur temps requis pour la mise en valeur des eaux pour l'agriculture, comme une contribution essentielle à l'accroissement agricole; le potentiel de développement peut être favorable mais le futur progrès pourraît être limité à cause (*a*) du manque de fonds et/ou (*b*) manque de capacité technique pour l'exécution des projets. Il sera nécessaire de se reporter au passé et de donner quelques exemples de temps nécessaire pour exécuter les projets, à partir de l'inception jusqu'à la phase de mise en service, en identifiant les contraintes rencontrées. On peut ensuite procéder à l'extrapolation du temps qui serait nécessaire pour développer le potentiel donné aux alinéas 1.2.1 et 1.2.2 ci-dessus. Les mesures souhaitables destinées à améliorer la situation (à savoir, capacité accrue pour la collecte de données, planification, financement, construction, manufacture de l'équipement) doivent être identifiées, en donnant aussi une idée sur leurs coûts. Le rapport doit suivre le même modèle que les points 1.2.1 et 1.2.2.

1.2.4 Plans pour l'évaluation finale [point (d) du Contenu]

Le rapport doit fournir ici la description du mécanisme existant de planification pour la mise en valeur des ressources hydrauliques dans le pays, des enchaînements entre les différents secteurs d'eau (énergie, approvisionnements municipaux, agriculture et autres) et du lien avec le plan économique général. Le rapport doit préciser comment la planification hydraulique à long terme s'effectue et porter sur les améliorations éventuelles. Finalement, le rapport doit fournir une évaluation générale de la mise en valeur de l'irrigation, du drainage et de maîtrise des crues envisagée dans le pays, des pénuries d'eau anticipées et des mesures pour les surmonter, y compris leurs coûts.

2. CONTRIBUTIONS ATTENDUES DES TECHNOLOGIES MODERNES ET DE LA GESTION MODERNE DES EAUX

Le chapitre porte sur l'introduction des technologies modernes et de leur utilisation perfectionnée dans la gestion des eaux en agriculture. Il doit établir les tendances et les besoins futurs et évaluer d'une façon réaliste les besoins pour introduire les techniques avancées et les pratiques de gestion, les coûts de participation, les justifications, les résultats escomptés (soit positifs ou partiellement négatifs). Il faut préciser surtout le point (*c*) du Contenu qui suscite un grand intérêt à l'ICID. Il faut noter que le rapport sur (*c*) doit trouver justification dans les points (*a*) et (*b*).

3. CONTRAINTES ET PROBLEMES ESCOMPTES

En dehors du Contenu, il est suggéré que les rapports des Comités Nationaux donnent. dans ce chapitre, un résumé de toutes les contraintes qu'ils avaient pu envisager, qu'elles soient mentionnées déjà ou non. Ainsi, le chapitre 3 sera une évaluation sommaire des problèmes et des contraintes qui risquent d'influencer le développement et l'utilisation de l'irrigation, du drainage et de maîtrise des crues dans votre pays pendant la période de 25 prochaines années.

Les contraintes physiques peuvent être manque d'eau, absence de terre convenable, salinité, crues, à savoir, elles peuvent être soit de nature permanente soit maîtrisées au moyen de gros investissements.

Les contraintes sociales peuvent être d'ordre éthnique (transmigration de la population), éducatif (le temps requis pour former les exploitants ne doit pas être sousestimé) et les autres.

Les contraintes économiques peuvent être dues au coût élevé de développement, chances de faible commercialisation, manque d'infrastructure, etc.

Les contraintes juridiques imposées par les lois, sur la terre, l'eau et l'environnement.

CONTENU

La communauté mondiale a été secouée par une série de graves pénuries alimentaires affectant particulièrement les zones susceptibles aux risques de sécheresses et de crues. Il faut considérer cela avec la nécessité d'accroître la production alimentaire à une allure sans précédent pour subvenir à la demande d'une population mondiale sans cesse croissante. De telles crises alimentaires pourraient éventuellement se produire à des intervalles de plus en plus brefs. La Conférence Alimentaire Mondiale de l'ONU a reconnu, à Rome, en Novembre 1974, que la solution à long terme du problème alimentaire mondial exigera le développement accéléré et l'efficacité accrue de l'utilisation des ressources naturelles qui sont fondamentales à la production agricole: terre et eau. En particulier, l'irrigation doit être augmentée rapidement; à ce propos, il a été estimé que la surface irriguée du tiers monde soit portée à 23 millions d'hectares d'ici à 1985; évidemment, le montant total des investissements pourrait atteindre environ 38.000 millions de dollars. Or l'amélioration des systèmes d'irrigation existants pour 46 millions d'hectares, est estimée, vers l'an 1985, à quelque 21.000 millions de dollars (Le Problème Alimentaire Mondial, E/CONF. 65/4, Août 1974).

Dans une résolution spéciale, intitulée "Aménagement Scientifique des Eaux, Irrigation, Drainage et Maîtrise des Crues", la Conférence Alimentaire Mondiale a exhorté les gouvernements et les organisations internationales de faire de nouveaux efforts pour l'expansion rapide d'irrigation, en accordant une attention particulière à l'évaluation des potentiels d'irrigation, la mise en valeur des terres salines et rendues incultivables par une teneur excessive en eau, l'utilisation des eaux saumâtres, la conservation des eaux, la protection contre les crues, et les besoins en énergie pour l'irrigation. La Conférence Alimentaire Mondiale a également décidé de créer un fonds de développement agricole à l'intention des pays en développement pour satisfaire les besoins accrus de fonds pour l'agriculture.

L'importance fondamentale de l'irrigation et du drainage pour la solution du problème alimentaire mondial a donc été ainsi reconnue. Il revient maintenant aux organisations et institutions traitant de l'irrigation et du drainage, de voir que ces plans soient mis en exécution en respectant les normes techniques élevées et en faisant bénéficier le plus ceux à qui ces plans ont été dressés: les travaux efficaces des millions d'exploitants desquels dépend à la longue la solution du problème mondial. Ceci demandera évidemment une mise en application élargie de la meilleure connaissance de technologies d'irrigation et du drainage et de leurs impacts social, économique et écologique. La coopération internationale sur la recherche, le transfert de technologie, la collecte et la diffusion de renseignements, et la formation auront à fournir l'arrière-plan technique et scientifique du programme universel de développement de l'irrigation et du drainage.

Pendant ses 25 années initiales d'existence, s'occupant activement de ces domaines, l'ICID a acquis l'expérience et un système établi de coopération internationale grâce auxquels elle peut pourvoir les essentiels et les plus importants intrants à ce programme. Le Conseil Exécutif de l'ICID a exprimé, lors de sa 26ème réunion tenue à Moscou en 1975, un vif désir d'orienter les travaux de l'ICID au cours des 25 futures années de son existence en vue d'une contribution maximale que les mesures d'irrigation, du drainage et de la maîtrise des crues pourraient accorder à la solution du problème alimentaire mondial. C'est dans cette optique que le Conseil Exécutif décidât de tenir à l'occasion de sa 28ème réunion prévue à Téhéran en 1977, une Session Spéciale consacrée à cette idée, qui offrira une tribune pour discussion et examen d'une mise en valeur escomptée de l'irrigation et du drainage dans le monde; cette Session Spéciale aidera aussi à formuler les directives pour l'ICID et les Comités Nationaux, afférentes aux mesures concrètes et aux travaux qui doivent être entrepris à l'appui de ce développement.

Les prévisions du rôle de l'irrigation et du drainage dans la croissance de la production agricole doivent être fondées sur les prévisions faites au niveau national ou du pays ou sur les plans établis pour le développement de l'ensemble du secteur agricole. De telles prévisions ou plans n'ont pas été systématiquement élaborés encore; quelques-unes ont été préparées pour des périodes de cinq ou six ans, et au niveau national il n'existe que très peu de prévisions pour les périodes de 20 à 25 ans. On peut retracer le motif pour cela, dans la complexité de la méthodologie et des intrants et dans la période restreinte de la validité des prévisions à long terme pour l'agriculture. De brèves périodes de prévisions pourraient être acceptées pour une planification générale du secteur agricole des économies nationales; elles ne sont pas cependant acceptées pour le secteur de l'eau, en raison d'investissements élevés et de longues périodes de gestation nécessaires pour l'irrigation, le drainage et les mesures de protection contre les inondations et de la nécessité d'une planification à long-terme d'allocation d'eau pour les divers usages. Jusqu'ici, les prévisions à long terme de la mise en valeur des ressources en eau exigée pour l'expansion de la production agricole ont été seulement faites sous forme d'estimations nationale régionale et globale; or il est de plus en plus reconnu que les projections fiables soient nécessaires à une planification de mise en valeur hydraulique solide au niveau national. L'on s'attend qu'une nouvelle impulsion pour une élaboration de projections fiables à long-terme provienne du domaine de l'irrigation et du drainage.

La Session Spéciale étudiera les travaux maintenant entrepris par les pays membres de l'ICID et ailleurs, dans le domaine de la prévision des besoins en mise en valeur hydraulique pour l'agriculture. Ceci sera exécuté dans l'intention d'éclaircir la méthodologie à appliquer d'une façon utile, les données à réunir, et la coopération internationale qui serait nécessaire pour arriver à des projections universellement acceptées de mise en valeur de l'irrigation et du drainage. Il sera ainsi permis à la Session Spéciale d'identifier les lacunes dans les travaux de planification générale pour l'irrigation et le drainage et de déterminer les lignes directrices pour une action future à entreprendre par l'ICID et ses Comités Nationaux à l'appui de la prévision à long terme et de la planification de mise en valeur en eau pour l'agriculture, compte également tenu des besoins et de l'aide à apporter aux pays en voie de développement, notamment touchés par le problème alimentaire. Au lieu d'établir un autre jeu de devis généraux, la Session Spéciale portera son attention à l'étude des éléments de projections de mise en valeur en eau, tels que évaluation des demandes et de potentiels de développement, ainsi que tendances identifiées dans ces domaines. Ceci sera accompli à la base des rapports et écrits invités des Comités Nationaux qui doivent être préparés en conformité avec les aspects suivants de l'ordre du jour envisagé:

1. Planification à long terme de mise en valeur en eau et de l'utilisation d'eau pour l'expansion de la production agricole.

1.1 Evaluation de la demande pour l'expansion horizontale et verticale de l'irrigation et de drainage: prévisions et tendances au niveau du pays. Renseignements sur les critères et les méthodologies utilisés, progrès faits jusqu'ici et sommaire des renseignements déjà disponibles, et organisation du travail. Les rapports doivent traiter notamment:

(*a*) La disposition actuelle des utilisations des terres en agriculture comme un index du rôle de l'irrigation, du drainage et de maîtrise de l'eau dans le cadre général du secteur agricole (irrigations drainage, maîtrise des crues, conservation d'eau, contrôle d'érosion et diverses mesures d'amélioration foncière) ainsi que les effets nocifs provoqués par l'eau et son utilisation (teneur excessive en eau, salinité, érosion, crues).

(*b*) Tendances vers les changements dans l'utilisation des terres qui indiquent les changements probables dans l'utilisation d'eau, tels que augmentation/diminution de la demande pour la production locale d'aliments principaux, changements dans les intensités de cultures, changements dans les besoins du personnel, changements dans les conditions du marché, concurrence avec les diverses activités économiques — notamment, concurrence dans l'utilisation d'eau (influence du développement agricole, social, et économique sur les besoins en eau).

(*c*) Critères et méthodes utilisés pour les projections à long terme de mise en valeur et d'utilisation des eaux pour l'agriculture et comme ils sont associés aux objectifs de la politique tels que approvisionnement alimentaire pour la population en croissance, accroissement du revenu individuel, emploi, gain et économie de devise étrangère, amélioration du bilan de développement régional.

1.2 Evaluation du potentiel pour l'expansion horizontale et verticale de la production agricole par l'irrigation, le drainage et la maîtrise des crues. Renseignement sur les territoires, type de développement, coûts, les gens intéressés, profits agricoles escomptés, contributions escomptées pour atteindre les objectifs de la politique, critères et méthodologies, et organisation intéressée. Les rapports doivent notamment porter sur:

(*a*) le potentiel connu pour mettre en production de vastes superficies jusqu'à présent inexploitées ou pour accroître la production des terres cultivées grâce aux mesures d'irrigation, de drainage et d'autres mesures de bonifications, y compris le type de mesures de mise en valeur des ressources hydrauliques.

(*b*) le potentiel pour l'accroissement vertical de la production des terres irriguées au moyen de la gestion améliorée des eaux, des intrants agricoles supplémentaires et contrôle de la dégradation du sol, y compris investissements nécessaires formation et services nécessaires.

(*c*) la capacité de développer le potentiel identifié, le taux annuel de développement pour les projets (*i*) nouveaux et (*ii*) en cours d'amélioration, et les contraintes prévues (financières, personnel et formation, organisationnelle, infrastructurale).

(*d*) les plans pour l'évaluation finale du potentiel de développement à long terme pour l'irrigation, le drainage et les améliorations foncières au niveau de pays, y compris les systèmes existants et envisagés de collecte et d'évaluation de données, planification (critères, méthodologies, organisations) et contraintes dans l'exécution de ces travaux.

2. Les contributions attendues des technologies modernes et de la gestion moderne des eaux. Renseignements sur les perspectives d'une augmentation dans la contribution qui pourrait résulter de l'irrigation, du drainage et de la maîtrise des crues à la solution du problème alimentaire, moyennant l'application des technologies avancées connues et de la gestion moderne des eaux. Les rapports doivent notamment traiter:

(*a*) Le perfectionnement de l'efficacité de l'utilisation d'eau et la diminution du coût pour l'irrigation et le drainage, grâce à l'emploi des technologies avancées telles que techniques modernes d'application d'eau pour l'irrigation de surface, aspersion, goutte à goutte et souterraine, l'irrigation automatisée, réduction des pertes d'eau, techniques modernes de construction et économie d'énergie (importance préconisée, résultats, contraintes).

(*b*) Les perspectives d'accroissement de l'efficacité de la maîtrise des crues pour l'agriculture par les systèmes et pratiques de gestion moderne des eaux avec référence particulière à la gestion des eaux du bassin, exploitation et gestion du projet, et gestion des eaux d'irrigation (organisation, administration, formation, services de vulgarisation).

(*c*) Identification des besoins en recherche, transfert du savoir-faire et coopération internationale dans les domaines ci-dessus.

3. Contraintes et problèmes escomptés.

S'ils ne sont pas couverts par les points 1 et 2 ci-dessus, les renseignements sont sollicités sur les problèmes particuliers et contraintes pour le développement de l'irrigation et du drainage eu égard aux aspects physique, social et économique.

Organisation de la Session Spéciale

Les rapports et les écrits sollicités des Comités Nationaux doivent parvenir au Bureau Central quatre mois avant la Session et en nombre suffisant de copies pour distribution aux participants. Les rapports et les écrits seront passés en revue par un Comité désigné par le Conseil Exécutif, qui établira le projet de conclusions pour une étude ultérieure. Après avoir entendu et discuté les brefs exposés sur les rapports des Comités Nationaux, la Session Spéciale examinera le projet de conclusions et formulera ses propres conclusions et recommandations pour présenter au Conseil Exécutif.

DISCUSSIONS

At the opening of the Session, President Prof. Milos Holy, Sc. D. presented his following paper.

SPECULATIONS ON THE DEVELOPMENT OF IRRIGATIONS, DRAINAGES AND FLOOD CONTROL AS RELATED TO THE DEVELOPMENT OF WATER MANAGEMENT AROUND THE YEAR 2000

1. INTRODUCTION

The year 2000 is usually the year for various futurological forecasts which are made of the population growth and possibilities of providing sufficient food for the world population, the development of society with regard to the utilization of existing natural resources, the possibilities of their exchange and replacement, the development of new technologies in the use of these resources, namely changes in the quality of these resources, development trends in power production, the development of the environment and the adaptability of man to its changes, the use of planetary and interplanetary space, etc. Forecasts based on scientific data and on a realistic view of the future development of society are extremely valuable and may become the basis for drawing up concepts of the scientific and technical development in all countries regardless, of their current levels.

The year 2000 is not, however, a milestone at which the said problems will give rise to sudden qualitative changes. These changes take place continuously with the development of science and with the practical application of scientific knowledge. The year 2000 is, however, a significant year at the turn of a millenium an impulse for looking into the history of the development of human society and its future prospects and for considering the possibilities of positively contributing to this development.

One of the fundamental questions to be considered on this occasion is the potential exhaustion of the resources of the biosphere which determine the development of society (Holy, Říha 1975). Most significant in this respect are the fundamental resources of the biosphere, namely, solar radiation, soil, water, air, mineral wealth, plants and animals.

The International Commission on Irrigation and Drainage (ICID) whose work significantly contributes to the solution of outstanding problems related to water management and to the use of water for feeding the world population devotes great attention to water which is one of the mentioned basic resources of the biosphere.

2. DEVELOPMENT OF WATER MANAGEMENT

Water resources occurring on planet Earth are limited and unevenly distributed in space and in time (Holy, 1971). Their consumption in the reproduction process is not physical but economic which means that changes take place in their properties, namely in their chemical composition, colour and temperature. The increasing demands on water resources ensuing from the development of the economies of the individual countries result in a situation when regions requiring water suffer from a water shortage or have low-quality water.

The solution of this grave situation lies in

—acquiring new water resources,
—in the purposeful use of existing water resources and in protecting their quality.

The acquisition of new water resources depends on the development of non-conventional methods and technologies and on solving their practical application. These problems were dealt with in a paper presented by the ICID at the UN Water Conference in Argentina last March (Holy, Framji, 1977).

There are various methods of acquiring new water resources, namely:

—desalination of sea water,

—weather modification

—solar distillation

—ground water mining

—reuse of waste water, etc.

The acquisition of new resources using the said methods, some of which have technically been solved, is limited by economic problems because the costs of water acquisition are in many cases considerably high. Technical progress will therefore have to go hand in hand with cost reduction in order to make feasible the effective inclusion of these new methods in the water management systems of country. Until this is possible greatest attention will have to be devoted to the purposeful use of existing water resources.

The purposeful use of water resources results from the necessity of overcoming the growing discrepancies between the demand on water quantity and quality and the available water resources. These discrepancies gradually enforce the building of multipurpose water management systems in watersheds using complex controlled outflow regulators, controlled mains and control systems and securing the operation of initially single-purpose water systems in accordance with the requirements of the whole system. Latest developments show that it will not be possible to confine water management systems within watersheds but that they will have to be interconnected to secure the water supply for water deficient watersheds with water. In this respect we shall certainly be hearing new ideas at the Special Session on the Mass Transfer of Water which will be held within the Tenth ICID Congress in Athens in 1978.

Water management systems are expanding and their consistent solution is becoming one of the principal conceptual, theoretical and practical problems of the current world development of water management. Assessing this development up to the year 2000 it may be said that in a number of advanced countries this development will have been completed in relation to the urgency of the water supply, the level of scientific progress and the economic possibilities of the respective countries while in other world regions it will be nearing solution. The concept of such development must be adopted in time because the construction of the individual elements of such systems is usually costly and time-demanding and in many cases determines the future operation of the system. The draft concept must be drawn up considering not only the technical aspects of the system but also with regard to the inter-actions and impacts of the system on economy, on the individual branches of the national economy and on the environment, this not only as concerns immediate needs but also with a view to long-term development. The complexity of the problem is increased not only by uncertainty in determining the future demands on the system but also by probability nature of the regime of natural water resources. Thus the systems approach is the only possible method of solving the complex problems of water management systems. Considered as the elements of the system, i.e., the water management system, are the water resources (the watercourse, ground water) and equipment for the use there of (dams and reservoirs, pumping stations, water transfer equipment, irrigation equipment, flood control dams, etc.). Next to the said material elements there are the significant elements of management and information. Relations between the elements of the system are of a material nature (materialized through water supply or take-off) and of the nature of management and information.

On the basis of the above stated facts the water management system may be defined as a system of natural and artificial elements comprising natural water resources and installations and equipment serving the comprehensive use and protection of the water resources with the aim of the optimal use of water in the interests of society.

Demands on water management systems may basically be divided into demands on securing

—the potable water supply

—water for irrigations

—water for industry

—pollution control of water and water resources

—flood control

—recipient of drainage water

—the use of water energy

—water routes and the canalization of watercourses

—minimal flow rates

—conditions for fish farming

—conditions for recreation

—conditions for environmental improvement, etc.

The ICID is involved in solving the problems of water management systems in that it puts forward requirements for securing irrigation water, flood control, drainage water recipients and partly also for pollution control of water resources and for securing conditions for environmental improvement.

Securing water withdrawal for large-scale irrigations, whose problems the ICID has been solving very successfully, is one of the principal tasks of water management systems. This is brought out by the envisaged development of the area under irrigation. According to data published in 1975 (Zonn, 1975) the total area under irrigation was 240 million hectares of land which is 16·5 per cent of the 1,473 million hectares of cultivated land. Considering the current state and development trend of irrigation it may be assumed that by the year 2000 there will be an annual increment of 10 million hectares of irrigated land (Zonn, 1976), i.e., an increase of 250 million hectares of irrigated land by the year 2000. It may therefore be expected that by the year 2000 the total world area under irrigation will be about 500 million hectares, i.e., double that of 1975.

Considering the moisture requirements of plants in different climatic zones (FAO 1975), the world distribution of precipitation and the assumed indispensable increased efficiency of irrigation schemes (M.G. Bos, J. Nugteren, 1974) we find in very general terms that some 4,500 m^3 of water are needed for the irrigation of one ha of land per year. At the assumed growth of 10 million hectares of irrigated land per year this means that on the world scale we shall be needing an increased supply of 45,000 million m^3 per annum.

The above is but a rough estimate serving basic information. A more detailed consideration would have to include the planned increase of the efficiency of current irrigation systems (which was done in the FAO document presented at the UN Water Conference in Argentina) a detailed analysis of the moisture requirements of plants by species, the spatial distribution and climatic zones, a more accurate consideration of ways of increasing the efficiency of irrigation water uses, of the uses of water resources in the different regions, the trend of the development of irrigation as related to the food requirements of the populations of the individual regions, etc. It is no easy matter to draw up such a study. Yet it is believed that it is within the possibilities of our Commission if all National Committees are intensively involved in the work.

Considering the relations between irrigation water requirements and water resources one has to bear in mind that irrigations have an irretrievable water consumption which at correctly applied technology comes close to 100 per cent. Demands on withdrawals of irrigation water in the static concept moreover represent demands that are closely linked with the area because considering the use of all the soil in the area which is potentially suitable for irrigation it is not possible to transfer the users to another locality which would be more advantageous as concerns water resources. In the dynamic concept, i.e., the gradual provision of water supply for the individual irrigation areas, coordination with the development of water resources which secures these withdrawals is possible and necessary. The dynamic concept makes it possible to loosen dependence on area and to draw up a schedule of the construction of irrigation systems.

Flood control and the necessity of acquiring recipients for water from drainage systems are in a certain sense demands on the water management system which conflict with securing withdrawal for irrigation water. Demands on withdrawals for irrigation require that the biggest possible amount of water be retained in the reservoirs for covering the following dry season. On the other hand flood control requirements and the demand for a drainage water recipient are quite contradictory: this function is best fulfilled by empty reservoirs.

The importance of flood control in the water management system is determined by the hazard of floods in the respective area, i.e., the danger which floods represent to the economy and to the life of the population. It will certainly be extremely important in areas with repeated flood disasters such as certain areas in India, Bangladesh, etc.

Pollution control of water is a very important funcion of the water management system. The use of water of prescribed quality is an important factor in water withdrawals for irrigation. In water management system this consideration is reflected in the choice of resources and in securing the minimal flow rate at which the required water quality standard may be maintained. Another possibility of attaining the target water quality in water management systems is the construction of wastewater treatment plants, changing unfavourable technologies in industry, restricting the use in agriculture of chemical substances with unfavourable effects.

The improvement of the living environment may be considered as a supplementary objective of water management systems. Its attainment is often very difficult and frequently becomes the factor limiting the maximal economic use of the system.

Water management systems designers must know the behaviour of the system. Modelling may be used to advantage for this purpose. The model makes it possible to ascertain the response to input variables. These responses do not, however, respond to the input values in the water management system. They are affected by long-term changes which proceed in water management systems in time, such as changes in hydrological conditions. Processes which proceed in time, i.e., the stochastic processes, are random functions whose argument is time. They may be modelled using stochastic models.

Long-term changes in water management systems are usually manifested only in the period which exceeds the time for which the function of the system is planned, i.e., mostly 40–50 years. It is not possible to forecast the function of the system for a longer period of time even though water management installations, e.g., dams will have a much longer physical life-span. In this respect what is important is not the behaviour of the system defined in the water management system for a period of, for instance 500 years in a stretch but in the individual 50 years periods.

And here again we come to the year 2000 because a wide range of the existing water management systems were constructed between 1950 and 1960 which means that their function for the following period will have to be defined in the year 2000. This is a very responsible task for water management expert. The great amount of demands placed on water management systems, their variety and variability and in many cases the given quality and quantity of the water which makes it impossible to fully meet all demands lead to attempts being made at optimizing the use of the systems.

In order to achieve maximum economic efficiency it is necessary on the basis of an economic analysis to optimize the level and time distribution of the water withdrawals by the individual users. This distribution is based on modelling the time sequence of changes which express the state and operation of the water management system in periods whose initial state and changes which occur or will most probably occur are known. This makes it possible to assess the requirements for water and the possibilities of meeting them in such a period and allows the economic assessment of costs and profit. If the water management system is not able to meet all requirements for water the necessity arises of assessing the losses.

The required affect for the service-life of the system is the standard function for the optimization of the water management system. Its value, however, only corresponds to the selected system of draft variables. It is therefore necessary to select a large number of combinations of individual withdrawals and by processing these input data to obtain a number of standard functions of which the maximal value of the standard function gives the optimal use of the whole water management system. The types of material functions differ according to the applied economic criteria and expected economic benefit.

In solving the optimization of water withdrawals from the water management system it is useful to calculate the model of the system with a adequately large number of demands put by the individual users on the time distribution of water withdrawal.

The static model considers the constant water withdrawal and the static capacity of the individual elements of the system without regard to future development. The higher level model, the dynamic model, seeks the optimal time sequence of the construction of new storage spaces on the basis of the expected development of the whole water management system, in relation to changes in demands on water and possibilities of meeting these demands by water resources and in dependence on input development conditions.

The result of the said solution is the optimal distribution of water to the users (consumers) i.e., the establishment of a distribution system which determines the water storage and its distribution in time and quantity to the users, including irrigation systems (Holy, 1976).

The solution of contradictions in demands placed on multi-purpose water management systems should be the main objective of the development of irrigation, drainage and flood control because only such demands should be given priority, which guarantee the efficacious use of water with regard to economy and to social needs (Holy, 1976).

This is not altered by the fact that the acute need of food in certain areas requires the extensive building of irrigation works having conveyance and distribution systems which owing to the inevitable speed at which the systems are built and to prevailing economic conditions do not prevent high losses of water and low irrigation efficiency. The growing need of water not only for irigation but also for the comprehensive development of the economy in the developing countries and the proven necessity of building multipurpose water management systems will enforce the transition to highly efficient systems with minimal losses in conveyance and in the distribution mains. Current development shows that such systems will be prevalent after the year 2000.

Greatest attention should be devoted to the conveyance of irrigation water. Losses of water by seepage in unlined earth canals take the biggest share of wastage in the use of water for irrigation, namely because these canals are usually built in arid zones, in highly porous soils, often in sandy soils.

The high losses in unlined canals are brought out by data published in the ICID publication "Controlling Seepage Losses from Irrigation Canals. A World-wide Survey (1967 edition)". These losses may be prevented by various measures which were discussed in the ICID paper for the COWAR Symposium on Irrigation on Arid Lands in Alexandria last year.

Water losses during distribution in the irrigated area are similar to losses occurring in the conveyance system. In this case it appears advantageous to prevent these losses by distributing all water in the irrigation system by pipe conduits, usually placed underground. In arid and semi-arid regions this technique has not hitherto been widely used owing to the relatively high capital costs involved. The pipe conduit system for conveying smaller quantities of water and especially for the distribution of water to the irrigated area is a promising project. The construction of such systems is an economic problem. It should not, however, be assessed only in relation to the irrigation system but in broader context, i.e., with regard to the whole water management system. The amount of available water, storage costs, costs of building and operating the conveyance and distribution systems, the economic and social effects of the non-delivery of irrigation water all have to be considered. The large savings of water effected by the installation of the pipe conduit will certainly not be negligible in the future water balance, namely if we consider the planned development of irrigation whose area is to increase from 250 million hectares in 1975 to 500 million hectares of land by the year 2000 (Framji, Mahajan, 1969, Zonn, 1976). Social factors whose importance will increase in the future should be considered even though not all social factors can be economically assessed applying current economic criteria. According to H.A. Rafatjah of the WHO (Rafatjah, 1975) surface water offers suitable conditions for breeding and for the development of disease vectors and intermediate pests.

Water losses on irrigated land include the loss of water in the soil profile, return flow, evapotranspiration and losses to the atmosphere.

The said losses determine the so-called field application efficiency (Bos, Nugteren, 1974). The field application efficiency depends to a considerable extent on the used irrigation system. The most frequently cited coefficients of field application efficiency are 0·85 for sprinkler irrigation, 0·75 for furrow irrigation, 0·65 for border irrigation and 0·50 for flooding.

The most frequently used irrigation in arid zones is irrigation with gravity water feed.

Sprinkler irrigation beyond doubt has certain advantages as compared with other irrigation methods. It is technically very efficient making possible the accurate distribution of irrigation water thereby reducing water losses by return flow and by infiltration into the non-vegetation subsoil.

Some experts believe that certain other surface irrigation methods can be as efficient as sprinkler irrigation. In practice it has, however, become evident that losses of water in sprinkler irrigation are as a rule lower owing to various technical and human factors.

Sprinkler irrigation is the prevalent irrigation method in advanced countries with limited soil resources, namely in the semi-humid zone. In recent years sprinkler irrigations are ever more frequently being installed in arid and semi-arid zones, mainly due to the high application efficiency of irrigation water. The trend is to introduce highly efficient high-capacity sprinkler sets as for example in the USSR, USA, etc.

In advanced countries fully automated sprinkler irrigation systems are ever more frequent. These systems use computer technology and automatic control systems. Such fully automated systems are expected to be in operation in most advanced countries by the year 2000.

Considerations on sprinkler irrigation in arid and semi-arid zones should include the environmental aspect. Contrary to surface irrigation sprinkler irrigation eliminates the danger of the propagation and spread of dangerous microbes in the irrigated area.

The wider decision-making process will usefully be applied in taking decisions on the implementation of sprinkler irrigation projects. The wider decision-making process should consider all economic and social aspects which may in many cases affect the decision in favour of sprinkler irrigation in which in arid and semi-arid zones water is supplied from water management systems.

Trickle irrigation is very promising irrigation method. It has been introduced on a wider scale in recent years. It raises the efficiency of water use and enables good control over the quantity and distribution of water. Trickle irrigation minimizes surface standing water which breeds mosquitoes, increases waterlogging and creates anaerobic conditions. Trickle irrigation is beyond doubt a promising and prospective technique whose great advantage is high water application efficiency. To enable the wider application of this method operating difficulties caused by clogging of tricklers salt accumulations near the edges of the wetted area and on the soil surface will have to be removed.

The State-of-Art the Paper which is being prepared by the ICID will make it possible to fully assess this irrigation technique and to estimate its future development. In any case it may be used to advantage in areas with very limited soil and water resources where maximum application efficiency is required for food production.

Economic and social criteria will be applied to decide on the introduction of trickle irrigation.

It will also prove necessary to concentrate on other progressive irrigation methods, such as impulse irrigation, etc.

Problems have arisen in recent years in operating traditional systematic drainage systems in waterlogged areas owing to the shortage of water resources. These drainage systems are technically uncontrollable and are only able to regulate the moisture regime of soils by drainage, i.e., by reducing soil moisture. This shortcoming is criticized by water management experts who often view the construction of drainage systems in the region of water resources to be a potential danger especially in the dry seasons when the artificial lowering of the ground-water level has unfavourable consequences. In many cases serious contradictions arise which cause doubts about the very construction of the drainage system. Such controversies have been known to exist in many European countries in recent years. In such cases it will be useful to suggest the building of a control drainage system which allows for lowering, elevating or maintaining the ground-water level as required. The system operates as follows: in critical periods water is supplied from the water resource at higher pressure than is the piezometric level of the ground water in the area of the water resource. Due to the pressure difference infiltration of water will start from the drains into the soil thereby attaining the required ground-water level. The process of elevation is terminated when the piezometric outflow of groundwater is levelled with the constant water pressure in the control drains. In case the ground-water level is higher than optimal the control drainage system will operate like a classic drainage system provided the pressure in the drains will be equal to atmospheric pressure.

The full application of the system requires an investigation to be made of the hydrodynamic aspects of filtration flow induced by the pressure infiltration of water from the drains into the soil medium. It also requires that the economic problems be solved of the broad practical use of the system. Steps in this direction were taken already at the 9th ICID Congress in Moscow in 1975 (Radcenko, 1975 and others), but I think the ICID has to continue in solving these problems.

The development from traditional systematic horizontal drainage to control drainage may be anticipated for areas with alternating humid and dry periods, i.e., especially for the European countries.

The water discharge will have to be controlled also in open drainage canals to secure that the ground-water level be continuously maintained at optimal height by the retention of outflowing water or by supplying water from the water resource.

Drainage systems may thus be expected to develop into fully controlled systems.

The combination of drainage and irrigation is inevitable in irrigation systems where there is the danger of soil salination. In such cases leaching is required to keep the entire salt concentration in the root zone of plants. The quantity of water introduced is higher than the moisture need of plants. The excessive water leaches the soil. In case the ground water is not saline and may be used for supplying the vegetation the purpose of the drainage is to retain and quickly divert the excessive water from the root zone of plants and to maintain the ground water level at a favourable depth to supply vegetation by capillary water. In such a case drainage will be used to maintain the said optimal ground-water level.

In case the ground water is brackish the objective of drainage is to check its movement to the root zone and to the soil surface. In such cases the main task of the drainage is to maintain the critical ground-water level with regard to the root zone of vegetation.

More than 900 million hectares of cultivated land, i.e., 56 per cent of the world total, are salinated which makes salination a serious problem and makes it necessary to consider drainage as an integral part of irrigation systems (Symposium of COWAR on Irrigation in Arid Lands, Alexandria, 1976).

It is necessary that irrigation systems be reconstructed, i.e., be completed with efficient drainage systems, in all areas of potential soil salination where drainage has not been carried out. In newly designed systems the combination of irrigation and drainage should be understood. By the year 2000 irrigation systems allowing soil salination should be non-existent.

Floods are still a threat to the lives and property of populations of many countries. Flood control must further be developed and expanded and must become one of the elements of comprehensive water management systems as has been emphasised recently. This is the main task of the ICID in this sphere. The ICID must strive for integrated water management plans of water basins, including irrigation, drainage and flood control and environmental and ecological amelioration (K.K. Framji, B.C. Garg: Flood Control in the World, A Global Review (Vol. I, 1976 and Vol. II, 1977).

The inclusion of flood control in multi-purpose water management systems requires the building of five basic elements, namely channel improvements, levees and flood walls, diversions and by-passes, detention reservoirs and retarding basins, land treatment should be carried out. Each estimation should be made with regard to the frequency of occurrence and to optimizing the respective measures based on economic and on social considerations. Methods of flood forecasting and flood warning should be developed. Flood forecasting is extremely important because the multipurpose water management system should be able to capture and reduce the flood wave and at such a time this function is prevalent over all others. By the year 2000 all countries affected by floods should have operating flood forecasting systems based on the observation of meteorological and hydrological phenomena by high-quality apparatus, on the quick data processing and transfer and on perfect warning systems connected to water management systems controls. The National ICID Committees should play a significant part in introducing and improving the quality of flood control systems.

3. CONCLUSION

The ICID is the only non-governmental organization dealing with the integrated water management systems in relation to irrigations, drainage and flood control and most recently also in relation to the human living environment. The results of its work are evident in science, technology and practice. With regard to the past work and to the current development and expansion of the ICID and its growing importance on a world scale it may rightly be expected to play an important role in the future development of water management namely in irrigation, drainage and flood control in all the above mentioned spheres. Together with the other respective UN agencies especially with the FAO the ICID, will promote qualitative changes in irrigation, drainage and flood control to pave the way for the efficient use of soil and water resources after the year 2000 such as would help raise the standards of the life of society in countries which today have to tackle many problems.

Dr. S. Hajrasuliha, General Reporter, in introducing his General Report, informed that at the time of preparation of the General Report, 12 reports were received from 11 member countries: Canada, Sudan, USA (2 papers), Iran, Great Britain, Bulgaria, Ethiopia, Mexico, Czechoslovakia, France and India. Later on four more reports were received one each from Greece, Portugal, USSR and Morocco and the Moroccan report was made available in Tehran only.

Dr. Hajrasuliha, reviewed the world food situation, available arable land and water resources in the global perspective for the year 2000 A. D., as elaborated by him on pages G1 to G3 of his General Report.

Continuing, he said that the information presented in the reports varied widely in content and data and only a few countries had attempted to provide the desired data and information as prescribed in the draft Questionnaire kindly prepared by Dr. Horning of FAO. The data and information presented in the reports were of great interest and value.

Dr. Hajrasuliha then highlighted the positive trends that were clearly noticeable from the reports and given by him on pages G14 to G15 of his General Report. These trends, he thought, would help in organizing the future efforts of the member countries of ICID to meet the challenge of 2000 A. D. in the field of irrigated agriculture in the context of the world food problems.

In the end, **Dr. Hajrasuliha** added two more points to the conclusions on pages G14 to G15 of his General Report:

(1) In the year 2000 there would be a deficit of foodstuff in some countries and as a result import of cereals, vegetables, fruits, meat, milk and other agricultural products would have to be continued.

(2) It might be of great interest to note that amongst the 16 reports reviewed there was only one example from Greece which indicated the tendency of decrease in the agricultural land area from the present 3·9 million ha to 2·5 million ha in the year 2000; the 1·4 million ha of the cultivated land, mountainous and semi-mountainous, was assumed to be transformed into pasture land. The irrigation development would, however, continue in the country and it is estimated that the irrigated area would increase from the present 844,000 ha to 1,600,000 ha by the year 2000.

Prof. Dr. Holy, the Chairman, thanked Dr. Hajrasuliha for his General Report and especially for the valuable conclusions made on the basis of the submitted reports.

Dr. Hajrasuliha, the General Reporter, thanked all the participants who partook in the deliberations of the Special Session. Very important and useful data and information had been given by the participants and these would be reported under "Discussion" in the proceedings of the Special Session and would also be taken into consideration in post sessions in the future.

Dr. H.M. Horning (FAO) thanked the Chairman for giving him the floor on this important subject and said that he would first like to correct a possible wrong impression caused by wrong sequencing in the presentation of the theme and scope of this Session which put the commentary before the law—a practice common to the legal profession but not to the engineers. The scope should have come first with proper acknowledgement to the Secretary-General of ICID, Mr. K.K. Framji, who insisted that ICID, after 25 years of successful work, should move forward to the next 25 years and identify the problems ahead and direct its work towards their solution. Then the commentary (theme) should have followed in the form of questionnaire which was to provide guidance for the answers of the questions which had actually been asked in the scope of this Special Session.

He further emphasised that the theme of the Special Session was essentially concerned with the problems of developing countries where food production was a problem. The food production per capita in the developing market economy had not increased at all in 1965-1975 decade. About 484 million people at present suffered from hunger and their number, as estimated, would continue to increase by 12 million yearly. Increase of food production in these countries, in which irrigation had played an important part, was set off by the population increase in the same period. Even the system of food aid established by World Food Conference recognised that the increased production of staple food essentially must come from the countries concerned.

In regard to the two identified problems of food at global level—the population growth, and the improvement of diet—he differentiated between the two problems and stated that the agricultural production in relation to population growth could be studied in global perspective, but the improvement of diet being essentially a local/regional problem warranted study on national level. The latter study involved a number of considerations bearing on national economy and other policy decisions for agricultural growth and was thus an intricate problem. Contribution from irrigation and drainage, per se, was even more difficult.

Dr. Horning clarified that, furthermore, a borderline between irrigated and non-irrigated agriculture was not possible. For crop production, besides irrigation (a physical requirement), consideration had to be given to crop yield, cropping system, economic returns, security in crop production and stabilization of farmers income. Determination of irrigation potential and its use for agriculture was however an important point. All these questions related to the national development planning and, therefore, the questionnaire was directed to the National Committees of ICID for answers on two broad aspects of resource utilization: assessment of demand and assessment of resource potential.

He then broadly summarised the FAO paper "Water for Agriculture" prepared for the UN Water Conference, Mar del Plata, March 1977 and quoted the projected figures for irrigation and drainage development. Among the different areas of water development, he made special mention of rural water supply which was closely related to the work of irrigation and drainage and cautioned that it should not be overlooked in future.

In summarising the action programme which had been submitted to the UN Water Conference in Mar del Plata and adopted as a special resolution on water for agriculture, **Dr. Horning** referred to the need for the improvement of the existing irrigation systems with the objectives of raising productivity with minimum costs and with least delay and improving the efficiency of water use and preventing waste and degradation of water resources. The other objectives are the development of efficient new irrigation systems for further expansion of productive areas, the improvement in the extension of rain-fed agricultural livestock production through better soil moisture management, opening up of new lands through the provision of water supply to human settlements and livestock, protection of agricultural lands against the harmful effects of flooding and waterlogging and reclamation thereof, and finally the introduction or expansion of fish yield in conjunction with overall rural development activities. With the exception of the last point, the fish yield, all other fields as outlined above were covered by the ICID and its activities.

Dr. Horning then posed the question "where to go from here?"

Concluding his intervention, he emphasised that further knowledge, information and concepts in planning must come from the national level and that was why ICID had requested its National Committees to answer the questions put in the scope of this Session. But certainly a national approach to these problems had to be worked out further and it was not possible to solve these questions in one session. He was, however, confident that ICID during its next operational session would take up this matter again.

Before closing, **Dr. Horning** briefly explained why this exercise was carried out for the year 2000. The figure 2000 might mislead to a certain extent because living in 1900 and so and so gave the feeling that the year 2000 was far faraway, but for the engineers working in the field of irrigation, drainage and flood control the year 2000 was just 23 years ahead. It should not be forgotten that the industries being planned now would bear fruit only within this 20-year period. The available knowledge and means of today must therefore be used and the tendency of getting into side-tracking dreams must be avoided.

Prof. Dr. Holy thanked Dr. Horning for the excellent preparation of the scope of the Special Session. **Prof. Holy** stated that it is necessary to help these countries in solving their problem but foı this far more information was needed than was available. The information on scientific and technical progress and the problems to be solved in general were known but sufficient local information, e.g. irrigation potential, available water resources, etc., was not known. It would, therefore, be very useful to discuss as to which data were needed for the further work by the countries to solve this problem at local level.

Mr. C.J. McAndrews (Canada) highlighted some points from the Canadian report. Water and land use in Canada was extensively developed as was stated in the report. Intensive development was the trend to meet future increases in production. Agriculture production in Canada was rainfed with irrigation being only one per cent of the total cultivated area. It was only in few isolated areas where crop production would not occur if the land were not irrigated. However, the economic production of some crops such as sugar beets, fruits, tobacco and grapes was dependent on irrigation.

Canal irrigation system, he said, was most common. The source of water was mainly from river storage of spring snow melt. The mechanized sprinkler systems are used extensively to reduce labor and to increase the effectiveness of water application. Surface methods were, however, also very common.

Water supply was very reliable. Recharge period was about 230 days and the growing season was about 130 days. Most irrigation districts could expand their irrigated areas without increasing their storage system. Some additional dams were, however, planned to solve some water deficiency problems.

Drainage was, **Mr. McAndrews** stated, essential for crop production on more than one half of the crop land in the cool, humid climatic regions of Canada.

Mr. McAndrews then referred to the potential expansion of irrigation and drainage in Canada to the year 2000 A.D. Irrigation would increase from 400,000 ha to 800,000 ha. This might, however, be optimistic as priority in irrigation was for rehabilitation of the existing projects. The rehabilitation did include enlargement and, therefore, irrigable area increases would occur. Drainage would increase from 1·2 million ha to 2·7 million ha.

Continuing, he said that the major contribution to increasing food production in Canada would come from the land that was neither irrigated, nor drained and nor even protected from floods. Production would double due to intensification as Canada was organizing its production to help the need of increasing global population. Technological advances would be in labour savings, improving plant varieties of crops and cultural techniques. The efficient use of water would probably not increase until pressure on the available water supply was more acute. Research in irrigation would occur in land classification, consumptive use of water, evaporation losses, control of aquatic weeds, design of micro-irrigation and drip systems, irrigation scheduling and application rates. Research in drainage would occur for more economic drain tiles or tubing, weed control in open drains, bank stabilization and maintenance, depth and spacing of drains, land use on drained lands and control structures.

Mr. A.M. Ibrahim (Sudan) said that his report presented to the Special Session covered the present and future developments of irrigated agriculture in Sudan.

Continuing, he summarised the physiographic and the climatic conditions of Sudan from pages 23-24 of his report.

The main source of irrigation in Sudan was the Nile which had an average flow of about 84 millard m^3. The discharge fluctuation in the Nile was very marked seasonally and from year to year and that was why it was necessary to construct control works for storage to be used for irrigation.

Agriculture was the backbone of the economy of the country accounting for 40 per cent of the gross domestic production and almost all export earnings. The traditional agricultural sector which was primarily subsistence-oriented consisted mainly of the farming and pastoral activities which depended upon rainfall for growth of crops and forage. Rainfed agriculture constituted 75 per cent of the 17 million acres annually cropped but accounted for only 30 per cent of the agricultural production, while the pastures produced an additional 20 per cent. Cash-crops farming (irrigated agriculture) which now amounted to about 4 million acres or about 25 per cent of the yearly cropland, produced about 50 per cent of the total production.

Mr. A.M. Ibrahim then reiterated the long-term development of irrigated agriculture in Sudan as given on pages 28 to 30 of the report.

Mr. W.G. Schulz (USA) said that the General Reporter had made an excellent summary of Report No. 3 "Impacts of climatic fluctuations on food-producing ecosystems", pages 31-36, and the US National Committee would have no additional comments on that Report.

Mr. Clifford I. Barrett (USA) said that he would like to preface his remarks by saying that the booklet containing Report No. 8 showed U.S. Bureau of Reclamation as the author of the report, but the report was generally authored by a number of government and private individuals and the US National Committee.

Continuing, he said as the report pointed out USA is basically a country which produced surplus of food and is a major exporter of basic foodstuff of wheat, corn and rice. Currently American agriculture can feed about 50 million more people than lived in the United States. The 14 per cent of the agricultural area that is irrigated contributes about 20 per cent of the total agricultural production of the United States. In United States only 17 to 18 per cent of the average personal income is used to purchase foodstuffs. The United States with an annual birth rate of 15 per 1,000 and a death rate of 9 per 1,000 appears to be in the latter stages of transition with a growth rate of 0.8 per cent per year. As a result from a nutrition standpoint, pressure for increased food production is not expected in the United States over the next 25 years. As to exports, the prices of wheat, corn and rice in the world market are now such that there is no incentive for large capital investment needed to bring land under irrigation for these crops. The net result of all these factors would indicate there will be no large or dramatic expansion of irrigated areas between now and the year 2000. There will be considerable irrigation developments but mainly to take place of currently cultivated lands which will be lost to other uses or for which the supply of ground water is diminished. There will be in the United States some very serious competitions for the use of the limited water supply. Irrigation will necessarily compete for water with other important users including municipal and industrial users.

Mr. Barrett further remarked that it is interesting to note that several largest growing regions and population in the United States were in the desert areas where water is even now being taken away from agriculture to be used for drinking and other city uses. Another major competition for water would be energy. The United States has a plan to develop large amounts of coal resources to convert into energy. All of these conversions require large amounts of water and by circumstance the vast majority of these coal deposits are also found in the desert arid regions where they will compete with water for agriculture.

He went on to state that there is also in United States a very significant and growing concern for the environment. Environmental needs will require a great deal of water for such things as instream flows, recreation and to preserve water quality.

In summary, he stated that it is expected that there will be significant construction of irrigation and drainage projects in the next 25 years. However most of these will be to replace or increase the efficiency of currently cultivated lands. Large increase in the total cultivated land in the next 25 years cannot be seen if the current incentives and restrictions are continued.

M. Dj. Keyvanfar (Iran) "En ce qui concerne la planification des cultures irriguées en Iran, jusqu'à l'an 2000, nous avons publié une brochure en anglais et en français et nous en avons assuré la diffusion à tous les participants. J'ajoute ici que d'après la révolution blanche, nous avons nationalisé nos ressources en eau pour les bien contrôler et depuis 15 ans nous avons construit 15 grands barrages et 31 barrages de dérivation et 600.000 ha de réseaux d'irrigation moderne. Nous espérons que ce sera doublé en l'an 2000. Les délégués trouveront les autres détails et statistiques dans notre brochure qui se trouve déjà dans leurs mains."

Vice-President Mr. W.R. Rangeley (Great Britain) said that first he would explain that the Report No. 5 from the British National Committee had focused on the contribution expected from advanced technology and improved water management. This approach had been adopted, instead of a country report on irrigation development, because the total irrigated area of Great Britain was very small indeed and even by the year 2000 any expansion of it was unlikely to make a significant contribution towards world need in food and fibres. The expansion and advance in British irrigation now seemed more likely to be in micro-irrigation and in hydroponics with controlled atmospheric conditions. So with the smallness of the contribution that British irrigation might make to world need in food and fibre, it was thought appropriate to concentrate on the contribution that research—and in particular British research—might make to irrigation by the year 2000.

Continuing **Mr. Rangeley** stated that the report focused particularly on the estimation of crop water requirements. From world-wide studies it was clear that there was an urgent need to improve and modernize the existing systems in many of the ICID member countries. In fact it had been variously estimated that in the countries represented by ICID there was at least 50 million hectares of land which urgently required modernization in order to permit greater efficiency of water use and this in turn meant better control of water use. But before one could think of control it was necessary to provide the management to exert that control and to give them the necessary tools to do it.

The British report, he went on to say, concentrated particularly on the first stage in any management procedure which was to estimate or calculate the crop water need in a dynamic way, that was to say on a weekly or day to day basis. It was felt that much could be done towards this even now with present day tools particularly with the neutron probe and the use of modern tensiometers. A systematic method of estimating crop water requirements in the field could indeed be applied in practice, given additional control works in the irrigation system. However, many constraints are known to exist.

Many irrigation systems of the world have been designed on what was known as regime or the almost constant flow principle. To introduce control systems into the canals, therefore, created difficulties of siltation but these difficulties were becoming less because the rivers which fed the canals were now being controlled by storage dams. The storage reservoirs are retaining silt which previously entered into the system. This new situation offered more scope for water control than was permissible with regime flow conditions.

The British report postulated that a move towards better methods of measuring crop water requirements on a dynamic basis should be made and that the necessary management should be put into the field to ensure that the deliveries to the farms could be regulated more frequently—instead of the present system whereby the most farmers had the task of trying to optimize crop production against a given rate of water flow. One approach to this objective would be to introduce for measuring devices for crop water requirement and this meant measuring not only the climatic conditions but also the soil moisture conditions. The engineers or other auhorities who had the responsibility for controlling the water delivery would do so by applying variations from the normalized demands, the latter having been worked out much perhaps in accordance with existing practice but he would suggest that there was scope for refinement. The engineer in the field should have the authority to vary water deliveries by certain margins according to the current measurements of soil moisture and climatic conditions. Any variations outside the given margins would require the approval of higher authority within irrigation system of management.

Mr. Rangeley said that unfortunately new irrigation systems were still being built in the world today without any real provision for flexibility in the control of water deliveries. In fact many systems were being designed with little better degree of control than they had seventy or eighty years ago.

Mr. Alexander Ivanov (Bulgaria) introduced Report No. 8 on behalf of Mr. Dimiter Davido and highlighted the points as giver on pages 72-73 of the report.

Vice-President Honoraire, Mr. Amaya Brondo (Mexico) informed that Mr. Fernando J. Gonzalez Villared who was the author of Report No. 9 presented by Mexico was in complete accord with the General Report.

Prof. Dr. Holy (Czechoslovakia) said on behalf of the authors of Report No. 10 that he had nothing to add to that report.

Vice-Président Monsieur R. Darves-Bornoz (France) Le rapport français a été volontairement centré sur les perspectives non de notre pays mais du monde et sur le rôle que peut et doit jouer la C.I.I.D. pour améliorer la situation de l'alimentation du monde.

Quelques mots tout de même sur la France : Petit pays mais gros exportateur de produits agricoles disposant d'une grande variété de sols et de climats du sub humide au sub aride, 50 pour cent des terres cultivées sont déjà irriguées—hors vigne—dans le midi méditerranéen; nous doublerons, au moins, d'ici l'an 2000 les surfaces irriguées et (ou) drainées de façon intensive avec 2 millions d'ha de plus avec maîtrise de l'eau. Le but: régulariser la production à la source même, permettre une meilleure adaptation des cultures aux besoins du marché et aux structures agraires.

Quelques points du rapport français seront soulignés, d'autres seront développés :

Nous devons avoir une vision claire de l'évolution à long terme : l'aménagement des eaux sera de plus en plus dominé par l'extension des usages agricoles, d'où une responsabilité paticulière de la C.I.I.D. (les "besoins" en eau de l'industrie baisseront par recyclage et l'épandage des eaux usées des villes devra être conçu pour l'usage agricole: donc pas de pénurie d'eau, ni de pollution inéluctables).

D'autre part, l'agriculture au sec cherche, c'est normal, à mieux utiliser l'eau de pluie en la stockant sur place dans le sol: ceci provoque des changements du régime des eaux sans doute significatifs quoique peu étudiés.

D'où la nécessité d'avoir, autrement qu'en paroles, une conception unifiée de l'aménagement des terres et des eaux.

Beaucoup de pays paraissent, d'ici l'an 2000, approcher les limites des possibilités offertes par les ressources en eau. Cela serait vrai si on ne modifiait pas, radicalement et rapidement, l'emploi de ces ressources: recyclage, épandage pour l'industrie et les villes mais aussi diminution des débits et volumes effectivement apportés à chaque ha d'irrigation. 25 ans c'est court. D'où la nécessité d'un changement qualitatif de l'effort mené jusqu'ici par la C.I.I.D.

Cet effort doit s'orienter vers l'étude des problèmes difficiles que nous avons en partie éludés jusqu'ici, de façon à ce que la C.I.I.D. soit à même d'assumer sa responsabilité à l'échelle même de la gravité des problèmes de l'alimentation du monds.

Nous avons commencé en ce sens à attaquer courageusement certains problèmes difficiles: rendement de l'irrigation à divers niveaux, évaluation économique, grande transferts d'eau.

Il faut aller plus loin et plus vite.

Quand dans beaucoup de pays la quantité d'eau réellement utilisée par les plantes irriguées n'est que la moitié ou le tiers, voire moins, de la quantité d'eau introduite dans les réseaux.

Quand dans nombre de périmètres irrigués équipés de façon classique de l'amont vers l'aval, l'utilisation effective des équipements est négligeable ou nulle au bout de 10-20 ans.

Quand le tour d'arrosage tend dans nombre de pays quise modernisent à disparaître dans le fonctionnement des réseaux anciens sans que nous le disions ou l'analysions.

Nos ingénieurs, nos agronomes ne peuvent-ils pas en débattre entre eux?

Certes, ils n'ont pas à décider de la politique qui a conduit à cet état de fait ni même à en juger, mais il me semble qu'il est de leur rôle de préparer les solutions qui permettraient de mettre un terme à cette situation. De toute façon, on leur donnera tôt ou tard la responsabilité de l'échec. La C.I.I.D. elle aussi est responsable, en la matière et à son échelle.

La question certes, n'est pas uniquement d'ordre technique, qui en est souvent même un aspect secondaire. Elle est surtout d'ordre social, culturel, économique. Croire ou faire croire qu'on peut résoudre ces problèmes par la technique seule peut même mener à des erreurs.

Le problème est interne à chaque pays et ne peut être résolu de façon spécifique dans chaque pays. La coopération ne peut qu'accompagner l'effort propre du pays et toutes les techniques plus généralement s'insérer dans un ensemble de mesures concernant l'aménagement des terres et des eaux et l'effort culturel préalable ou parallèle.

La question des pertes d'eau d'irrigaion par exemple ne peut avoir de solution purement technique, surtout au niveau du champ où, contrairement aux idées courantes, se situe la majorité des pertes.

La question des pertes ne peut être vue non plus comme un gaspillage à combattre à tout prix: elle est à voir comme un élément à prendre en compte progressivement dans le développement des irrigations et du drainage sur chaque périmètre.

Cette idée de progressivité est d'ailleurs à mieux utiliser: nous construisons de nouveaux réseaux qui vont durer 100 ans ou plus. Quelles que soient les techniques à y introduire, traditionnelles ou modernes la conception des réseaux doit permettre de s'adapter à l'évolution prévisible des techniques dans le futur et non pas figer cette évolution. Il y a là un type de recherche dans la flexibilité des projets qui paraît répondre aux impératifs de l'époque.

Citons d'autres types de problèmes difficiles qu'il nous faut plus et mieux aborder.

—Il est de bon ton de parler de micro-climat créé par les périmètres irrigués, mais, si on veut sortir du domaine de l'affirmation sans portée, il faut mettre en place des réseaux d'observation climatologique avant, pendant et après le projet. Peut-être pourrons nous valablement, alors, diminuer les besoins en eau des plantes cultivées compte tenu de la réduction du potentiel d'évapotranspiration.

—Nous affirmons aussi la nécessité d'étendre les surfaces irriguées sur des terres nouvelles. Cette mise en valeur de terres nouvelles a un visage concret qu'il faut explorer par delà des chiffres globaux. En particulier:

—sols lourds qui peuvent grâce au drainage souterrain devenir hautement intensifs,

—sols de collines et de montagnes, d'ailleurs souvent bien drainés, que l'irrigation avec de nouvelles techniques et avec des précautions spéciales peut doter d'un potentiel productif élevé

—surtout peut-être, terres salines et alcalines et plus généralement mise en valeur conjuguée des eaux et des terres chargées en sels qui nécessitent un effort plus grand de notre part

—utilisation pour l'agriculture des eaux usées des agglomérations à l'échelle de grands périmètres.

Il faut aussi nous préoccuper de la baisse nécessaire du coût des investissements à service égal ou supérieur, car contrairement aux idées courantes, il n'est pas évident que ce coût doive augmenter. En France, en 10 ans, le coût du drainage souterrain a baissé en francs constants de 50 pour cent et celui de l'irrigation de 10 pour cent au moins. Le coût des barrages malgré des sites défavorables tend à se stabiliser avec l'augmentation de la productivité du travail.

Nous devons, d'autre part, être très attentifs à l'évolution de la productivité d'ensemble des facteurs de production dans l'agriculture irriguée, éviter que la substitution capital-travail ne se traduise pas par un coût final égal, voire plus élevé qu'avant maîtrise des eaux.

Pour atteindre ces objectifs ambitieux partant des grands problèmes réels et difficiles, il nous faut sanssoute utiliser des moyens et des méthodes nouvelles ou renouvelées.

Dans le rapport français certains d'entre eux sont cités: réaliser un effort plus grand et mieux adapté de coopération en matière de formation de spécialistes de tous niveaux, selon des méthodes d'ailleure en partie à repenser. Mener la recherche en commun sur des sujets précis avec des protocoles expérimentaux élaborés en commun afin d'avoir des informations homogènes et comparables pour divers contextes pédoclimatiques.

Pourquoi ne pas étudier aussi tous ensemble, un problème difficile concret dans un pays si celui-ci le désire ou un ensemble de problèmes à l'échelle d'un bassin fluvial concernant un groupe de pays si ceux-ci le souhaitent.

Mr. S.P. Bhat (India) on behalf of his National Committee, said that the Report No. 12 was on probable contribution from irrigation, drainage and flood control to meet the requirements of agricultural production towards the year 2000 A.D. The report reviewed the present status of irrigation in the country and he reiterated the information given in the summary of the report on pages 151-152.

President Honoraire Mr. G. Papadopoulos (Greece) introduced Report No. 13 on behalf of its author Mr. C. Salapas and summarised the contents of the report compiled under five sections: the first section deals with the soil resources in Greece including existing balance between land resources and land resources balance in 2000 A.D., the second section presented water resources availability and their use till the year 2000, the third section was devoted to population trends, the fourth to agriculture and economic development with assumed evolution of plant production and basic problems of agriculture and the fifth section dealt with irrigated agriculture which inter alia included information on present development and the perspectives for the year 2000.

Mr. Papadopoulos said that he would be glad to answer questions during discussions.

Mr. Santos Antonio (Portugal), presenting the summary of Report No. 14, said that they had divided Portugal in three regions (North Atlantic, North of Tràs-os-Montes and South Mediterranean) according to the hydrological conditions and consequently to irrigation and drainage requirements. Dry farming, in general was not possible in Portugal all the year round.

In the North Atlantic which included the west part of the country and situated north to the river Tagus, there were high mountains and the rainfall during Autumn, Winter and Spring was excessive and in most part of that territory it was over 1,000 mm per year. Irrigation requirements were small, just occurring in Summer and in the low lands. The river supplies for long periods and the high water table were often enough for the irrigation. The rivers, even the less important ones, did not get dry in summer. Irrigation supplies were most of the time made available by simple temporary diversion of river waters. There were few dams for irrigation purposes in that part of the country. The largest irrigated areas about 500,000 ha were however in that part. They were in general small collective irrigated areas and the official services had been trying to improve them by reducing irrigation water losses and by enlarging the irrigated areas. The other two regions were on the contrary very dry with an average annual precipitation around 500-600 mm and the precipitation concentrated specially from November to February. The greatest irrigation problems were faced in those regions where the Autumn and Winter cultures were many times damaged by excess of soil water causing great problems of drainage owing to the referred irregular monthly distribution of annual precipitation. Summer cultures were absolutely impossible without irrigation and the Autumn and Winter cultures were often damaged by the lack of Spring precipitaion.

The development of irrigated agriculture had been one of the greatest problems for which the government nowadays had been devoting its full attention and efforts to improve the agricultural food production and consequently to reduce its importation which in the year 1975 had been about thirty million contos what meant about forty per cent of the external commercial balance deficit.

Horizontal and vertical expansion of irrigation and drainage were the main subject of the report. 'Problems of reclamation of saline soils and flood protection and some considerations about contributions expected from advanced technologies, improved water management and expected constraints and problems were also dealt in the report.

Dr. I. Zonn (USSR), introducing Report 15, said that the guidelines for the Development of the National Economy of the USSR for 1976-1980 incorporated the main objective of agriculture for the given period which was to ensure further growth and stabilization of agricultural production, its comprehensive intensificaion as a means of better meeting the demands of population for food and those of industry for raw materials, as a way of providing the required state reserves of agricultural produce.

Nearly 80 per cent of the USSR agricultural lands were situated in the moisture-deficient zone. Two-thirds of commodity grains were produced in such arid regions as the South Ukraine, Povolzhiye, the North Caucasus and Kazakhstan.

Lands under reclamation covered about 15 million ha under irrigation and 10 million ha under drainage. In the recent years, the irrigated and drained lands had accounted for about half the increment of the gross agricultural produce. Lands under irrigation and drainage supplied 100 per cent of the gross output of cotton and rice, 65 per cent of vegetables and cucurbits, some one-fourth of fruit, over one-third of grapes. Fodder from reclaimed lands, and watered pastures provided two-thirds of wool, almost all Karakul, much milk, meat and other products of animal husbandry.

In the current Five-Year Plan period the area of lands under reclamation would grow from 25 to 35 million ha. Additional 37·6 million ha of pastures would be irrigated. About 40 billion roubles would be allocated to the reclamation and agricultural development of lands; this equalled the amount total for the preceding 10 years. In order to set up large zones of secured grain production, work would be hastened on land irrigation in dry Povolzhiye, the North Caucasus and South Ukraine, as well as in the drained areas of the Baltic republics, Byelorussia, the Ukraine, the RSFSR non-chernozem zone and in other regions. The total annual production of grains on lands under reclamation would make up 20 million tons by the end of the Five-Year Plan period. By the same time, rice production would rise close to the level of three million tons and the production of corn grain on irrigated lands would be doubled.

Continuing, he said that the analysis of potentialities for further increase of the agricultural production in the USSR, showed the reserves for expanding plowlands and areas under fodder crops without drastic reclamation to be practically exhausted. Land reclamation potential, implying the area of lands requiring (and suitable for) irrigation and drainage, was assessed at 150 million ha. The long-term forecast-plan to land reclamation development for 1985, approved by the Government, envisaged bringing the area of lands under reclamation up to 48 million ha. As a result, the reclaimed lands would yield—47 million tons of grain, 10 million tons of raw cotton, 28 million tons of vegetables and cucurbits, 7.5 million tons of meat, 48 million tons of milk and above 500 thousand tons of wool.

Monsieur Lahlou Othmane (Maroc) "Notre rapport comporte quatre parties: la première réservée à la participation actuelle de l'aménagement hydro-agricole à la production agricole; la deuxième est réservée au développement de l'agriculture irriguée; la troisième à la contribution des techniques avancées à l'aménagement hydro-agricole et en quatrième partie les contraintes et problèmes posés par cet aménagement hydro-agricole.

"Au Maroc, nous disposons actuellement dans les 16 milliards de m^3 mobilisables, desquels 9 milliards de m^3 sont actuellement irrécupérables (crues exceptionnelles, ou survenant pendant l'hiver). Sur ce total de 16 milliards mobilisables, 8 milliards, soit environ 50 pour cent, sont exploités en 1972. On estime qu'en fin de l'an 2000, le Maroc peut utiliser 12 milliards des 16 milliards mobilisables. L'agriculture utilise à elle seule actuellement, 7,5 milliards de m^3 et elle passera en l'an 2000 à 10 milliards de m^3. La surface des terres utilisées directement par l'agriculture représente environ 8 millions d'hectares; sur ces 8 millions, le projet d'aménagement hydro-agricole du Maroc prévoit l'irrigation d'un million d'hectares environ d'ici l'an 2000. Ce million d'hectares sera irrigué en neuf grands périmètres irrigués qui comporteront environ 700.000 hectares et les 300.000 ha restants sont distribués dans une multitude de petits périmètres en petite et moyenne hydraulique.

"Sur les superficies irriguées, nous comptons 25 pour cent de céréales, 25 pour cent de superficies irriguées en cultures industrielles, betteraves à sucre, la canne à sucre, coton, etc..., 25 pour cent de cultures fourragères et 25 pour cent de maraîchages et arboriculture. Il est à signaler que dans les trois plans passés, le Maroc a réservé de 28 à 43 pour cent de ses investissements globaux pour l'agriculture irriguée, c'est-à-dire pour la construction des barrages, et pour l'aménagement hydro-agricole. Dans le futur plan quinquennal (1978-1982), le Maroc réservera encore entre 30 à 35 pour cent de ses investissements à l'équipement hydro-agricole.

"Cette politique poursuivie par le Maroc vise 4 objectifs principaux :

—le premier est de satisfaire ses besoins en produits alimentaires de base;

—le deuxième est d'améliorer le niveau de vie de la population rurale, qui compte actuellement plus de 65 pour cent de la population marocaine;

—le troisième est d'augmenter la participation du secteur agricole par l'exportation de produits agricoles;

—enfin, le quatrième est que cet effort serve de support à l'industrie.

"On peut remarquer sur les tableaux présentés dans le rapport que deux cultures ont connu un développement très important depuis leur introduction au Maroc. Il s'agit des agrumes et de la betterave sucrière. Une troisième culture va prendre une très grande importance à partir des années 78-80: il s'agit de la canne à sucre.

"Le Maroc est actuellement le troisième exportateur d'agrumes parmi les pays producteurs du Bassin Méditerranéen. Le verger marocain couvrait en 1972 plus de 66.000 hectares. Il a produit, ainsi, en 72-73, un million douze milles tonnes environ.

"Par ailleurs, le Maroc produit annuellement 250 à 300.000 tonnes de sucre pour ses besoins nationaux. Actuellement, le Maroc couvre 65 pour cent de ces besoins par sa production betteravière et le début de la production de la canne à sucre qui est productive depuis 1975.

"Il est à signaler, aussi, que les cultures maraîchères prendront de plus en plus d'importance au Maroc puisque parmi les efforts fournis pour l'équipement hydro-agricole, il a été retenu à côté des objectifs primordiaux déjà cités, l'exportation de produits maraîchers, de produits fruitiers et particulièrement du maraîchage de primeurs.

"Cette politique d'équipement hydro-agricole est régie au Maroc par un code des investissements agricoles qui est approuvé par l'Etat depuis 1969. Les principales dispositions de ce code relatives aux périmètres irrigués dont l'application doit avoir un effet déterminant pour le développement agricole se trouvent exposées dans notre rapport.

"L'Etat réalise l'ensemble des équipements d'irrigation et d'assainissement, c'est-à-dire, les équipements externes et internes. L'Etat fabrique, donc, pour l'agriculteur un outil complètement achevé. Il en assure la plus grande partie du financement: 60 pour cent de tous les équipements sont assurés directement par l'Etat. Le reste est recouvert par les bénéficiaires en deux parties: la première partie en tant que participation directe à l'équipement dès la troisième année jusqu'à la vingtième année (soit une durée de 17 ans) après l'équipement, et la seconde participation indirecte est celle de la redevance de l'eau.

"L'Etat en réalisant ces équipements hydro-agricoles oblige les bénéficiaires de cette aide publique à respecter certaines règles, dont les principales sont: le respect des plans d'assolement établis par l'Etat, le respect des techniques culturales recommandées par l'Etat, la règlementation des modes d'irrigation et de la discipline de l'utilisation de l'eau, et enfin l'introduction d'une spéculation animale.

"Quant aux modes d'irrigation jusqu'à présent utilisés au Maroc, nous pouvons noter que c'est le mode gravitaire qui a été utilisé depuis 1932 jusqu'à ce jour. Cependant, depuis trois ans ou quatre ans environ, l'aspersion commence à marquer le pas et prendra un développement très important dans les années à venir. L'irrigation par aspersion n'a été adoptée jusqu'à ce jour que lorsque l'irrigation gravitaire n'était techniquement pas possible parce que le terrain était principalement sablonneux, ou alors les terrains étaient très lourds et ne pouvaient supporter l'irrigation gravitaire sans dommage pour les sols. Cependant, depuis 1976 une nouvelle orientation est donnée pour le mode d'équipement et je pense que l'aspersion prendra le pas sur le gravitaire dans les années à venir et sera le mode d'irrigation essentiel au Maroc.

"Pour le drainage profond: jusqu'à présent un seul périmètre d'irrigation, celui du Gharb, et qui comporte une superficie irrigable de 250.000 ha est équipé en drainage profond. C'est le seul périmètre qui nécessite un drainage profond; un second périmètre nécessitera aussi une partie de sa superficie irriguée aménagée en drainage profond. Cependant, pour l'ensemble des autres périmètres, le drainage superficiel est toujours jumelé à l'irrigation tant gravitaire que par aspersion.

"Nous pouvons noter que pour l'évolution de l'aménagement hydro-agricole, l'effort consenti par l'Etat Marocain jusqu'à présent a permis d'équiper depuis environ 8 à 10 ans, en moyenne, 18 à 23.000 hectares par an. Cependant, depuis 1975, un nouvel effort consenti par l'Etat permettra au Maroc d'équiper environ 45.000 à 50.000 ha par an, d'ici jusqu'en l'année 1985.

"La contribution marocaine à l'irrigation en l'an 2000 pourrait être formulée sous forme de la création d'un centre d'expérimentation très important. Actuellement, le Maroc étudie cette éventualité. Il est possible qu'un grand centre d'expérimentation soit installé au Maroc d'ici 2 ou 3 années, dont les objectifs se trouvent exposés dans notre rapport.

"Dans le quatrième chapitre du rapport "contraintes et problèmes", je souhaite insister sur un problème important qui intéresse le Maroc. Ce problème est constitué par le grand décalage qui existe entre les superficies dominées par les équipements hydro-agricoles et les superficies réellement mises en valeur. Il est toujours facile d'équiper un terrain, mais il est toujours difficile d'amener l'agriculteur, qui dispose de ce terrain, à le mettre en valeur en conformité avec le projet qui interesse ce terrain.

"Les prévisions de résorption ou de limitation du déficit de production faites sur l'an 2000 ne peuvent se faire que si effectivement les taux de croissance de la production escomptés se réalisent. Or, ceci ne peut se faire que s'il y a mise en valeur effective, donc que si le décalage entre zones équipées et zones mises en valeur est résorbé.

"Il en résulte que si dans les pays développés, les questions techniques dominent les débats, chez nous et dans d'autres pays en voie de développement, ce sont les questions socio-économiques qui, en tant que problèmes majeurs de la mise en valeur, paraissent les plus préoccupantes. Ceci nous amène à faire deux suggestions:

—la première est que, dans les manifestations de l'I.C.I.D. et ses publications, les questions à caractère socio-économiques figurent en bonne position à côté des questions techniques;

—la seconde est que, les problèmes n'étant pas universels, mais pouvant (tout au plus) être communs à des pays géographiquement voisins ou dont les niveaux de développement sont équivalents, l'I.C.I.D. devrait organiser (ou aider à organiser) des conférences ou journées détudes régionales en liaison avec le groupe de pays concernés.

"A ce titre, je suis très heureux que Monsieur DARVES-BORNOZ ait fait des propositions très similaires à celles que fait le Maroc actuellement.

"La contribution de l'I.C.I.D. et de son Comité National Marocain (A.N.A.F.I.D.) à la réalisation de ce programme est indirecte et limitée: participation de techniciens marocains aux manifestations nationales et internationales organisées par l'I.C.I.D. et l'A.N.A.F.I.D., participation aux groupes de travaux, etc...

"Le Comité National Marocain souhaite que l'I.C.I.D. organise en collaboration avec les Comités Nationaux des Journées d'études régionales sur des thèmes intéressants plus particulièrement les pays de certaines régions, Bassin Méditerranéen par exemple, Afrique, Moyen Orient, etc.... ou les pays en voie de développement. De même, il souhaite que les questions à caractère économique et social (notamment dans les pays en voie de développement) figurent en bonne place à côté des questions techniques dans les manifestations de l'I.C.I.D.".

Mr. W.J. van Liere (Mekong Secretariat) introduced a paper entitled: "World Food Production in Southeast Asia". This paper was prepared some time ago, but it was hoped that the thesis expressed in it might contribute to the discussions. He would like to emphasize one aspect of irrigation, which had mentioned already in passing in the introduction speech of the Chairman (Dr. Holy), namely, the role irrigation could play for the conservation of natural resources in its widest sense. He referred specifically to the tropics, i.e., to areas that generally received high rainfall.

At present modern technology was rapidly destroying the tropics.

Forests disappear, he continued, at an incredible rate; millions of ha are cleared for growing transitory crops under systems that he would like to group together as extractive agriculture.

Of course, the pressure to produce was great, since the entire world would become monetized; even in the remotest areas crops were saleable on the markets.

However, the result was that entire countries in the tropics become deforested and defaunated. By 2000, millions of ha will revert to much lower production levels. Therefore, it was imperative to develop *sustained yielding* farm systems.

But for the tropics most *sustained yielding* farm systems are largely hypothetical, only one could be applied on a general scale and that is *irrigated farming*.

Thus, irrigation in the tropics had also the major role to stabilize land use. Intensify the plains and lowlands in order to protect some of the watersheds and uplands.

Thus, paradoxically, large dams and ancillay irrigation can conserve natural resources. This was generally not realized by environmentalists.

The disadvantage of this approach was that it costs money and that it costs time. All the more reason to make an all-out effort now since he firmly believed that for the tropics it was 5 minutes to 12; we have 5 minutes left to catch up. Yesterday somebody expressed the view that great engineering works were really only decided upon after a catastrophy. Well, for the tropics, the catastrophy was there.

For the Lower Mekong Basin there had been 20 years of data collecting and planning by the four riparian countries—Laos PDR, Democratic Kampuchea, Thailand and Viet-Nam with the assistance from 25 co-operating countries and 15 international organizations. One main stream dam was now fully planned and ready for execution. This dam could completely change the economic horizon of the lower Mekong basin and, in addition, stabilize land use for generations to come. The main thesis, developed in the paper, namely that the 2-ha tropical farm could become a reliable producer for the world market was rather contrary to general opinion and it was not necessarily the view of governments concerned. It was a view formulated in the Mekong Secretariat, which was the technical apparatus of the Mekong Committee, whose terms of reference were the co-ordination of the development of water resources of the Lower Mekong Basin.

Prof. Dr. Holy thanked Mr. Van Liere for his valuable paper and remarked that it showed a very good example of how to solve water management problems in a large river basin and how the solution of water management problems in a basin can solve the irrigation problems and the problem of food production in a region. The collaboration already existing between the Mekong Secretariat and ICID would also prove useful in the future.

The Chairman, opening the discussions to the participating delegates, hoped that the results of these deliberations would help the Commission in understanding the problems of common interest and which in turn would help in the solution of many regional (water basins) problems in the future not only in the water basin regions but also in individual countries. Perhaps, he said, the discussions could be held on general problems, e.g.—complex use of water resources to meet irrigation needs; inclusion of irrigation, drainage and flood control systems into the complex water management systems; mass transfer of water from interrelation of two or more water basins; simplification and modernization of water management systems for the development of irrigation; optimization of the use of water; the possibility of increasing the efficiency of irrigation schemes; improvement of existing irrigation systems; the question of need of energy for irrigation.

Vice Président Dr. H. Grubinger: "Avant tout je voudrais bien remettre les compliments cordiaux du Président de la CIGR, M. Coolmann. Au mois dernier les sections I et III de la CIGR ont organisé un symposium en Espagne sous le titre: "Etude de tous les facteurs qui influencent le type et la dimension des exploitations rurales". Si l'on étudie les rapports présentés ici à Téhéran en connaissance des études faites en Espagne, des conclusions semblables vous frappent et vous rendent pensifs. Ce qui surprenait le plus au Symposium en Espagne était le rang important donné à la mécanisation et à l'augmentation de la production respective. D'autre part des effets négatifs graves étaient ignorés, par exemple le sort des mains-d'oeuvres dégagés et les changements écologiques qui pourraient avoir des conséquences dévastatrices.

"Le rapporteur général de notre session de l'ICID récapitule les conséquences des rapports particuliers, comme suit:

> "Les tendances positives qui permettraient de mobiliser les futurs efforts des pays membres de l'ICID pour faire face aux défis de l'an 2000 dans le domaine de l'agriculture irriguée dans le contexte du problème alimentaire mondial."

"A côté des chiffres et pourcentages concernant l'augmentation du rendement les points suivants sont brièvement ressortis:

—certainement il faudrait et on pourrait agrandir la surface agricole utilisable ainsi qu'intensifier l'irrigation.

—aussi le développement de la mécanisation et beaucoup d'autres mesures feront possible d'augmenter encore les rendements.

—De nombreux pays ont établi des plans de développement à long terme pour l'agriculture ainsi que pour l'utilisation de l'eau. L'on aperçoit des buts très ambitieux mais ce qui manque est l'analyse des conflits de but.

—On prend connaissance que la population agricole diminue continuellement.

—L'on parle de certaines restrictions respectives aux réserves d'eau.

—Finalement on nous rappelle le calcul global de la conférence mondiale pour l'alimentation de 1974 et les prognostics relativement favourables d'après lesquels il serait possible de nourrir même une population de 8700 millions d'hommes.

Des calculs globaux comme les publie par exemple la conférence mondiale pour l'alimentation sont attractifs que du premier coup d'oeil et pour les hommes politiques. Strictement parlant ils sont dangereux parce qu'ils font miroiter une sûreté aux yeux des gens. C'est pourquoi je vous mentionne ci-après quelques problèmes graves et des conclusions erronées:

1. L'on ne tient toujours pas assez compte de la limitation et la répartition inégale des réserves d'eau considérée soit sur le plan continental, régional ou seulement local.

2. Une optimisation de tous les facteurs nécessaires pour la croissance des plantes (lumière, air, chaleur, eau, engrais/sol) qui s'étend sur le monde entier est impossible, on ne pourra jamais les mettre à profit maximal.

3. A part du besoin d'eau pour l'agriculture celui d'eau pour les industries ainsi que d'eau potable n'augmente pas proportionnellement à l'accroissement de la population mais exponentiellement. Cela doit à coup sûr mener à des conflits d'intérêts dans lesquels aussi bien la quantité que la qualité d'eau joue un grand rôle.

4. Tous les efforts faits pour intensifier et étendre l'agriculture sont directement et indirectement débités d'investissements d'énergie très importants. La production d'outils techniques pour, par exemple, l'irrigation coûte autant d'énergie que le fonctionnement des machines elles-mêmes et l'exploitation mécanique. Les systèmes utilisant peu d'eau, consomment beaucoup d'énergie.

5. Les interventions massives dans le paysage qui s'étendent sur le monde entier gênent l'équilibre écologique. Là ou celui-ci est déjà instable cela conduira vite à des catastrophes écologiques comme par exemple au SAHEL, et au Nepal dans l'avenir proche..

6. Nous savons que dans l'expiration du temps et du climat de zones ils se produisent des instabilités périodiques de plusieurs années. Lié avec des dérangements du système écologique par une utilisation du sol forcée cel peut produire des pertes de récoltes, des destructions de forêts par la sécheresse, le feu ou des inondations et l'érosion du sol. Tout ça est aussi sous la responsabilité de l'ingénieur.

7. Enfin il faut indiquer d'autres réflexions erronées:

   Avec fierté l'on proclame que toujours moins de personnes arrivent à cultiver toujours plus de produits agricoles; qu'on peut occuper ailleurs les gens qui ne travaillent plus dans l'agriculture. On se demande seulement où? La banque de développment interaméricain vient à la conclusion qu'en année 2000 l'accroissement général de la population en Amérique latine mènera à des agglomérations gigantesques (Mexico City 32 millions, Sao Paolo 25 millions d'habitants). C'est la raison pour laquelle, malgré une mécanisation avancée il ne faut pas seulement maintenir les places de travail mais en créer de nouvelles dans les zones rurales. En plus il faut bâtir, des appartements et créer l'infrastructure nécessaire. Il serait une grande erreur de croire qu'on peut transférer des travailleurs en surnombre d'un secteur de l'économie à un autre. Les conséquences d'une telle migration sont l'appauvrissement d'une masse d'hommes déracinés, les "slums".

Pour l'ICID, il en résulte entre autre les taches suivantes:

1. Ingénieurs et agronomes mais également planificateurs et économistes doivent réaliser que nous exploitons aujourd'hui, et d'après les plans aussi à l'avenir, la nature et ses trésors d'une façon abusive.

2. La façon de penser en catégories écologiques doit devenir un comportement naturel, doit devenir une partie de notre philosophie, sinon la grande catastrophe sera là, sans que nous nous en aperçevons.

3. A part cela nous devons continuer à améliorer les méthodes d'irrigation, défricher de nouvelles terres et les protéger de la destruction, développer l'infrastructure et ne pas oublier les ainsi dites zones périphériques. Cette dernière tâche est tout particulièrement importante. L'instrument connu de la technologie adaptée et la biologie peuvent être mises en fonction comme cela a été étudié, il y a quelques jours lors de la réunion régionale à Rome. Ce qui veut dire que le but principal doit être: assurer à long terme l'accroissement nécessaire de l'agriculture par un engagement économique des moyens; protéger le sol et l'environnement par l'établissement de systèmes écologiques résistants et finalement de stabiliser la population dans les aménagements ruraux originaux. Le but de tous nos efforts doit être l'assurance de l'existence humaine et de son environnement.

Vice President Dr. H. Grubinger "I should like in the first instance to convey to you the compliments of the President of C.I.G.R. Mr. Coolmann.

"Section 1 of the CIGR organised a Symposium in Spain last April with the topic "Factor analysis which have effects on type and size of the agricultural management". While studying the abstracts of the Special Session here, in Tehran and remembering those reports from Cordoba, it is quite interesting to notice that in spite of the subject variation there are similar but doubtful conclusions. Most remarkably in the Cordoba-Symposium was the fact to see that importance was given to mechanisation and therefore to the consequently expected productivity in the factor analysis, whereas little notice was paid to the serious negative effects, e.g, the fate of the spare labour and to the catastrophical ecological transformation.

"The General Reporter of the ICID Session summarizes the individual abstracts as follows :

Positive trends are clearly noticeable from the reports which would help in organizing the future efforts of the member countries of ICID to meet the challenges of 2000 A.D. in the field of irrigated agriculture in the context of world food problem:

"Special attention is drawn to the following points, besides figures and percentages on the yield increase:

—Agricultural ground and irrigation can still and must be expanded considerably.

—Continuous mechanisation and other various measures will also permit to increase the output furthermore.

—Numerous countries established long-term development plans in agriculture and in the use of water; ambitious targets are noticed, but analysis of objective conflicts are missing.

—Note has been taken of the decreasing agricultural population.

—Generally, discussions deal with certin restrictions according to the water supply.

—Finally, we are reminded of the global calculations of the World Food Conference in 1974 with the relatively favourably prognosis. Consequently it will be possible to feed about 8,700 million people.

"Nevertheless, it seems doubtful. Global computations as published by the World Food Conference, are only of interest at first sight and for the politicians. Strictly speaking, they are dangerous, they make false promises what security is concerned.

Therefore, some important problems and false conclusions are noticed here.

1. Looking at the continental, regional or only the local scale, little notice is paid to the limitation and the unequal distribution of the water supply.

2. It is impossible to use the worldwide optimum of all the factors for the growth of the plants (such as light, air, heat, water, nutrients/soil), it's never possible to use them all on the maximum.

3. Beside the water supply in agriculture, increases also in the supply of drinking water and industry not only proportional to the growth of the population but also exponentially. This *must* lead to conflicts in interest in which not only the quantity but also the quality of the water play an important role.

4. All efforts to intensive and expand the agriculture are directly or indirectly encumbered with a very significant energy consumption. The manufacture of a technology e.g., irrigation, costs just as much as the plant itself with the technological management. Water saving procedures require much energy.

5. The worldwide massive trespasses on landscape interfere with the ecological balances. Where they are already unstable, it easily leads to ecological catastrophes, e.g. Sahel, or in Nepal in the near future.

6. We know that in the lapse of weather and regional climate, several years old periodical fluctuations can appear. In connection with the interference of ecological systems, by forced land use, dryness firebrands or flooding may lead to crop losses and wood ruins, and soil erosion. The engineer is responsible of all these factors.

7. Finally, with emphasis one must point out to further wrong considerations:

   It is announced with pride that continually less people are able to produce more agricultural products. Those who are not working any more in agriculture can be employed elsewhere. But the only questions is: where?

   The Interamerican Bank concludes from this that the general population growth of Latinamerica will lead to gigantic agglomerations in the year 2000 A.D. (e.g. Mexico City with 32 millions, Sao Paulo with 25 millions inhabitants). Therefore it is absolutely necessary to maintain and provide jobs in the rural regions even in spite of the extensive mechanisation. Houses with the corresponding infrastructure should be established. It would be false to believe that it would be easy to displace the spare labour from one economical sector to another. The results of such migrations are progressive deterioration of the eradicated human beings, are the slums.

For ICID derive furthermore the following problems:

(*a*) Engineers and agronomists but also planners and economists will have to realize that they continue to exploit ruthlessly the nature and the resources according to the designed plans.

(*b*) Reflections in ecological categories will have to become obvious attitudes, and part of the philosophy otherwise it quickly becomes chaotic.

(*c*) At the same time, they furthermore have to amerliorate the irrigation methods, cultivating new land, protect it, develop the infrastructure and should not forget the so-called periphery too. The last task is eminently important. The known instruments of the applied technology and engineering biology may be employed here, as it partly was discussed during the regional session in Rome some days ago.

"Accordingly, it should be the main goal to guarantee the necessary long-term agricultural growth applying economically the available means and to protect the land, the environment by structuring resistant ecological systems, to stabilise its population in the proper rural settlement area. The most important efforts should be made to guarantee the existence of the human being together with the environment.

Prof. Dr. Holy thanked Prof. Dr. Grubinger for his valuable contribution which dealt with fundamental problems of the development of irrigated agriculture from several points of view, and remarked that ICID was ready to collaborate with CIGR in problems of common interest.

Vice President Honoraire Prof. H. Fukuda (Japan) said that one of the conclusions reached by the General Reporter indicated an upward trend towards intensification of agricultural outputs.

In his understanding this intensification should be mainly directed to the so called vertical expansion of two productivities: one was land productivity, and the other was labour productivity and these led to the modernization of agriculture. Horizontal expansion was, of course, important but at the present acute situation the vertical one seemed more desirable to a great extent.

The vertical expansion necessitated an efficient use of water and land in connection with the efficient water management, which must play a key role for successful irrigated agriculture.

The irrigated areas in South East Asia, where paddy cultivation was dominant, water management must be more and more intensified.

A canal density (m/ha) in irrigated areas can be an indicator for the efficiency of water management. At present 20–30 m/ha is common in SE Asia and is being increased to about 70–80 m/ha.

It is proposed that the canal density should be levelled up to about 100 m/ha as a target in paddy cultivated areas by the year 2000 A.D.

Monsieur Jose Liria (Espagne) : L'Espagne est un pays à climat sub-aride, d'une superficie de 504.000 km.^{2} La pluviométrie moyenne est d'environ 650 mm par an, mais étant donné qu'elle est très mal distribuée dans l'espace, certaines régions reçoivent moins de 150 mm par an de pluie. Pour cette raison l'irrigation est indispensable si l'on veut avoir la possibilité de cultures agricoles dans ces régions en question.

Par ailleurs le régime hydraulique des rivières est très irrégulier par rapport au temps, ce qui exige de disposer d'un grand nombre de réservoirs pour pouvoir garantir la disponobilité d'eau en été, lorsque règne une grande sécheresse.

La capacité actuelle des réservoirs est de 40 milliar'ds de m^3, avec lesquels on irrigue 2.250.000 ha et on fournit également l'eau pour l'industrie et les villes. En ajoutant à ce chiffre les 400.000 ha qui sont irrigués par des eaux souterraines, on obtient un total de 2.650.000 ha irrigués.

Deux facteurs fondamentaux limitent l'accroissement de cette superficie: d'une part, il semblerait que, du point de vue agricole, il n'existe que 6.000.000 ha susceptibles d'être irrigués, et d'autre part, la construction de nouveaux barrages n'est guère facile, étant donné que tous les emplacements possibles ont déjà été utilisés. Ceci obligera à améliorer les techniques d'utilisation de l'eau.

La population espagnole était en 1900 de 18,6 millions d'habitants, en 1950 de 28,1 millions et en ce moment de 35 millions. Les prévisions supposent une population de 45 millions pour l'an 2000. Il est très important de signaler que la population habitant la campagne et dans les petites villes tend à diminuer; par contre ce sont les grandes villes qui supportent l'accroissement de la populatiom.

La totalité des terres cultivées est de 20,8 millions d'hectares, desquelles 2,6 millions sont irrigués. La superficie des pâturages et prairies est de 7,2 millions d'ha et le reste jusqu'aux 50 millions du total du pays, est occupé par les forêts, rivières, etc.

En 1962 la dimension moyenne des exploitations agricoles était de 14 ha actuellement cette superficie moyenne est passée à 17 ha. Ceci indique une tendance vers la concentration des petites propriétés, qui est d'ailleurs préconisée par l'Etat.

En 1950 la superficie irriguée était de 1,5 millions d'hectares. En 1975 elle est de 2,65 millions et actuellement l'accroissement moyen de la superficie irriguée est de 45.000 hectares par an.

En 1974 la valeur des produits agricoles était de 6,4 millions de dollars, c'est-à-dire 54 pour cent de la production agraire totale. La valeur des produits d'élevage était de 4,4 millions de dollars, c'est-à-dire 40 pour cent de cette même production agraire totale. Le reste, qui correspond à la production forestière, était de 0,5 millions de dollars.

PERSPECTIVES FUTURES

La population augmentera et il faudra augmenter également la production agricole.

Le nombre d'hectares irrigués devra croître à un rythme plus rapide, tout en étant contraint par la limitation de l'eau disponible; ceci provoquera une amélioration des techniques de distribution et d'irrigation.

Etant donné qu'on a constaté que les redevances des personnes et des entreprises du secteur agraire n'augmentent pas au même rythme que celles d'autres secteurs, il se fait nécessaire de corriger cette tendance. Cela obligera probablement à avoir des exploitations plus grandes et, par conséquent, à mécaniser le système d'exploitation et à perfectionner les méthodes d'irrigation.

Prof. Dr. Holy, Chairman of the Session remarked that the problem of Spain was similar to the problem of many European countries where the water was stored in reservoirs and was used for many purposes. The question was how to get water for the expansion of irrigation schemes and its solution lay in the optimization of water use and to which was closely related the problem of irrigation efficiency, the latter had been receiving attention by ICID.

President Honoraire Mr. G. E. Papadopoulos stated :

"The questions of the present session are connected with:

(1) the existing prospects as regards the evolution of irrigation in the member-States of the ICID and the problems resulting thereof,

(2) the contribution of ICID in facing and resolving these problems.

"Although the number of the countries which have submitted papers is relatively small and the material thus collected cannot be considered as illustrating fully the subject, yet this material provides some data and sound forecasts about the evolution of irrigation during the next 25 years which enable to draw conclusions and to formulate proposals both of general and of particular nature.

"The first conclusion is that the expansion and intensification of irrigation all over the world is a matter of essential importance because it concerns not only the agricultural field of the National Economy of each country, but also the overall development of the countries with direct effects on their future progress.

"This decisive role of irrigation on the economic structure of a country, with direct political and national ramifications, explains the importance which is generally given to the proper approach to the general subject of the expansion of irrigation and to the solution of all the problems involved.

"The data provided by the General Reporter show that the water resources available the world over are sufficient to meet the requirements of the mankind at the year 2000. However, the history of mankind does not finish that year and the prospects for the year, say 2500 or later, will definitely be different if we take into account the increase of the population and of the respective water requirements.

"We do not deny that the progress of science and technology can change, even radically, the present prospects as regards the availability of sufficient water resources for the production of foods and fibres to meet the needs of mankind. However, the dependence of agricultural production on available water resources will always exist and will become more and more acute.

"The second conclusion is that the expansion of irrigation, coupled with combined efforts for the conservation of water and land resources, constitutes the correct approach to many problems of technical, economic, social, political and other nature.

"The timely and efficient approach to these problems in each country is a basic requisite for the successful use of its water potential.

"This subject is of outstanding interest and as such it cannot be fully covered by the discussions of the present session. However, the point which, at this stage, is of prime importance for us is the role that the ICID can be required to play in that field and in all others in which our Commission can be of efficient help to the common efforts that may be undertaken by its member-States.

"We, therefore, think that it is precisely on that point of ICID's contribution to the efforts made by member—(or even non-member) States for the correct approach to the problems arising out of the expansion and development of irrigation that the present session can be of help and can proceed to the formulation of some conclusions and proposals.

"The French paper which deals, by order of priority, with the question of ICID's contribution makes a lot of proposals which surely merit attention and should, in principle, be accepted.

"In this connection, however, we would like to draw your attention to the manner of intensifying ICID's activity through the medium of international cooperation. Nobody can deny that to-date activity of our Commission in the field of granting technical aid on various matters related to agriculture is really praiseworthy. This task is performed within the framework of international co-operation between our various National Committees through the Technical Committees, the Working Groups, etc., but we think that this activity and even the borders of such cooperation can be broadened considerably by taking some organizational measures. We believe that ICID's contribution can considerably be widened if its work is performed not within the framework of its present, rather restricted, possibilities, but through joint efforts with other international etc. organisations.

"We already have laid stress on the importance of broadening ICID's contribution on the occasion of the CENECA International Conference on "Water for agriculture" which was held in Paris in 1976. At that time we made the proposal for a broader scheme of international cooperation with various State-controlled or non-Government organisations on the basis of specific plans, securing the financing of such plans by certain State Organisations (FAO, UNESCO, etc.). This paper was published in the last issue of ICID's Bulletin, so that we shall only mention here the salient points of the proposed system of such cooperation.

This system provides for:

(*a*) The institution of Central Organisation of International Cooperation in the field of Hydraulics (COICH), with the aim of coordinating the programmes in question and the activities of the executing agencies involved, and granting of technical and financial assistance to these agencies.

(*b*) The institution of Special Finance Fund (SFF) of international cooperation in the water resources sector for the entire or part-financing of certain programmes approved by COICH.

"In the meantime we suggested the institution of a Provisional Committee of International Cooperation (PCIC) for the elaboration of a scheme of organisation of the system in question.

"Reverting now to the same subject, we propose that the matter be taken into consideration by the present session, so that our Commission may afterwards pursue the matter and take the necessary steps for the materialization of our proposal.

"We feel confident that a combined and coordinated action on the part of all interested factors (Government or private) will result in solving to a very great extent a good deal of problems which arise all over the world from the expanded use of irrigation and will also furnish the opportunity for the optimization of ICID's contribution in such an important field of its activity."

Prof. Dr. Holy, thanked Mr. Papadopoulos for his imortant contribution and desired the Review Committee to take note of it.

Dr. Marvin E. Jensen (USA) said that the U.S. National Committee wished to call attention to a very important parameter that would become increasingly more important in the future. The parameter was the energy requirement of irrigation, especially for sprinkler irrigation. This subject was given little attention in the papers that were presented.

The large expected increase in irrigated land, particularly by sprinkler irrigation, would create a corresponding large increase in energy demand.

Energy costs for irrigation in the USA had doubled in some areas during the past few years, and probably would double in all areas during the next 6 to 8 years. Spiralling energy cost had created a new incentive to improve irrigation water management practices. Also, spiralling energy cost had been reducing the apparent advantage of the sprinkler irrigation in arid area on land that was suited for either method, when compared with improved and modern surface irrigation.

Prof. Dr. Holy, Chairman concurred totally with Dr. M.E. Jensen on the question of importance of energy requirements for irrigation and especially for sprinkler irrigation. The Chairman thought this question very suitable for discussion at a future technical session/congress, etc.

Prof. Pietro Celestre (Italy) expressed that the Italian National Committee felt it useful to report briefly on Italy's irrigation development programme. The Italian Government was in the course of approving a vast irrigation programme as the principal means of boosting agriculture. In fact the Italian Government intended to allocate 50 per cent of the total expenditure for agriculture to irrigation.

The irrigated area was currently 3·4 million ha. It was expected to reach 4·7 million ha in the first stage. The corresponding irrigation water requirements would vary from 26 billion m^3 to 32 billion m^3. In order to meet these requirements water would have to be more efficiently utilized, new resources will have to be built, the aquifers recharged and the waste water will have to be recycled.

It must be stressed that the recycling of waste water fulfilled three aims: water was saved, fertilizing substance was used and the pollutants were eliminated. Of course this programme—as pointed out by Mr. Darves-Bornoz—still required a great deal of experimentation as there had been little experience in this field so far. ICID could and should promote this activity at least at a regional level.

The two other fields of research that might help solve the huge food problem, mankind was likely to face, were: water desalination and pisciculture. The first one was receiving only moderate consideration within the ISES—Sez. Italiana (Intern. Solar Energy Soc.) and other national institutions, while the second one covered already an important role in the Italian food supply, as our fish production in fresh water is already on top levels in the European region and as that in salt water has already a prominent position.

Nations like Italy with a large shore development and the existing fertile plains near shores had a considerable prospects in desalination developments. Pisciculture represented already for many countries a significant source of food and was worth of major consideration.

ICID could enter these promising sectors.

Mr. R.H. Clark (Canada) said that his intervention on irrigated agriculture in the year 2,000 was more of a comment on previous discussion and on the papers presented.

In forecasting irrigated agriculture for the next 20 years, it seemed to be that one of the most important problems to be dealt with in such expansion through irrigation and intensification of production—not only through irrigation but also through fertilizers—was that concerned with the effects on the environment and this had hardly been touched upon. There would undoubtedly be a great effect on the environment and water quality also, through the reclaiming of land, construction of dams, canals, etc.

Another comment pertained to a matter raised by Mr. Papadopoulos and by Prof. Grubinger relative to energy. In particular, Prof. Grubinger had indicated the large quantities of energy required in sprinkler irrigation. Perhaps it would be a propitious time for the ICID Council to consider an invitation to the International Commission on Large Dams (ICOLD) and the World Energy Conference (WEC) to hold a joint technical session since ICID would have to become more concerned with conserving water for energy as well as for irrigation.

Prof. Dr. Holy thanked Mr. Clark and stated that the Commission was fully aware of the importance of the environmental problems. This problem, as would be recalled, had already been discussed during the Special Session in Moscow in 1975 and there were recommendations of the Review Committee that feasibilities studies be made in connection with all irrigation, drainage and flood control projects. It was also mentioned already several some time here that consideration had to be taken of the influence of environment on all these projects.

On the collaboration with other international organizations such as ICOLD and WEC in the field of water etc., **Dr. Holy** observed that ICID was represented in the Congresses of these organizations and Commission participated in all international events especially the events where water progress are discussed. He mentioned the COWAR Conference of Alexandria which was organized by COWAR and which was attended by the representatives of many international organizations.

Dr. Holy stressed the need of maintaining in the future the closest collaboration with FAO and UNESCO because it was very useful not only for ICID but for the governmental organizations too.

Mr. K.K. Framji, Secretary of the Special Session added in regard to the concrete suggestion made by Mr. Clark (Canada) that at the forthcoming meeting of COWAR (Scientific Committee on Water Research) in June in Paris, one of the subjects for discussion was the organization of joint conferences or joint symposia by the water oriented constituent members. He thanked Mr. Clark for his valuable and thoughtful suggestion which he felt sure would be taken up.

Dr. Bankole Martins (Nigeria) presented a brief review of the situation in his country. He informed the Conference that Nigeria extends from the coastal rain forest to the Northern Sudano-Sahelian area. Nigeria has an estimated population of about 60 million people. The Government of Nigeria is aware of the need to increase food production to feed its teeming population. In this regard, he stated that the Government has launched a nation-wide programme called "Operation Feed the Nation" (OFN). Under the programme, every citizen is encouraged to farm, hence a sort of mobilisation of the entire population in land farming.

He further stated that efforts were not limited to OFN alone. The entire country had already been divided into 11 River and Lake Basins Development Authorities. These authorities have, among other tasks, the rational and systematic development in agriculture (both by irrigation and rain-fed techniques), Forestry, Fisheries, Livestock, Energy, and Water Supply based on optimised water resources development.

He mentioned that a few of the Authorities were already in the implementation stage while others were still either in the reconnaissance, prefeasibility, feasibility, or design phase. Therefore, it was difficult to assess the hectarage that would be under irrigation by the year 2000 A.D. As a matter of fact, he stated that for those already implementing projects more than one million hectares are to be irrigated, and additional five hundred thousand hectares would be cropped through rain-fed agriculture.

While these projects are going on, he said, other Government agencies like Federal Ministry of Water Resources and the Meteorological Services are active in the accurate assessment of the surface and ground-water resources of the entire country.

This assessment according to him will be the only accurate base for optimum development. As part of the active efforts, new hydro-meteorological networks are being set up and existing ones upgraded.

The efforts go beyond Nigeria's frontiers. The country actively participates in International Sub-regional Commissions like Lake Chad Basin Commission (comprising Nigeria, Niger Chad, and Cameroon): and the River Niger Commission (comprising the nine riparian states). He made mention of the constraints affecting the realisation of the set objectives. The major one being lack of adequately trained manpower both at the Upper and Middle cadres. He thus solicited for cooperation from developed countries in order to solve this problem. He pledged Nigeria's interest in close cooperation with ICID member countries. He pointed out that Nigeria continues in her efforts to exchange experiences with other sister African Nations who have identical problems. He expressed the profound happiness of the Nigerian delegation in learning that similar efforts exist between Sudan and Morocco; and Nigeria's preparedness to join hands with them.

He seized the opportunity of the conference to express Nigeria's desire to actively participate in the various activities of the ICID.

Prof. Dr. Holy said that he appreciated the problems mentioned by Dr. Martins and thought that the collaboration of National Committees in the African region would be a very important factor in solving the problems. As the Nigerian National Committee were to organize the Fourth Afro-Asian regional meeting in 1982; it would be good to discuss these problems there.

Dr. Davoud Hariri (Iran) said that the General Report is a valuable one but we would like to say that it is more on an optimistic side because the question of capital investment for water resources development and also land preparation for irrigated agriculture was very important, it could not be overlooked and it could not be disposed of with a simple discussion in a small forum. A careful consideration for project evaluation was therefore needed as many countries could not afford the immense capital and the technical know-how to convert the present dry-land farming areas or new lands to irrigated lands.

The other important problem that needed attention was the proper training of farmers to work in the irrigated lands. In many of the developing countries of the world the customs and traditions of the farmers come in the way of progress of irrigation because the farmers unlike industrial labour did not want to change their way of work and way of life easily unless they were certain or trained that this was going to change their life for betterment.

Dr. Hariri suggested that these problems should be discussed thoroughly in a permanent Committee or a Working Group since ICID had initiated this important subject. The International Commission on Irrigation and Drainage could play an important role for updating and flow of information regarding the irrigated agriculture for the year 2000 and this could be a basis for other governmental, non-governmental or other international organizations.

Prof. Dr. Holy thanked Dr. Hariri for his valuable remarks and informed that there was already a proposal to form a post-Tehran Special Session Working Group to take note of the future situation. He further remarked that the problem of capital investment was a very important problem today in connection with water resource development and this was also referred in his introductory report in connection with multipurpose water management systems vis-a-vis optimizing water use.

Mr. A.M. Ibrahim (Sudan) referred to the paper "Water for Agriculture" prepared by FAO and stated that two major priorities for water resources and land development up to 1985 were identified—one was the improvement and rehabilitation of about 50 per cent of the 90 million ha of land in developing countries and the other was the horizontal increase in irrigated agriculture by about 50 per cent, both involving a colossal amount of money. A question of concern specially to the developing countries, as the previous speakers had also mentioned, was the question of high cost of irrigation projects.

Continuing, **Mr. Ibrahim** said that today the developing countries were faced with the problem of meeting their food needs by rehabilitating and extending their irrigated areas, e.g., in Africa, which had vast water resources, not more than three per cent of its water resources were developed. The hydropower could be of great use in irrigation development. The hydropower potential in Africa constituted about 30 per cent of the world at present, but not more than 5 per cent potentials were developed. The main problem facing the developing countries, in his opinion, was the question of cost of irrigation projects. At the time when the agricultural produce of the developing countries was fetching very low price in the international market, the financing was rather expensive and the rates of interest were high. That was, in his opinion, the great hindrance to the expansion of irrigation. Unless certain measures were undertaken to provide financing facilities to the developing countries, he was afraid to mention that the targets earmarked by the several UN conferences for the turn of the century would not be materialized.

Taking up the case of the Sudan he stated that during the last ten years the cost of irrigation had risen by about 500 per cent. The only way that was tried to solve this problem in the Sudan was the intensification of the irrigation systems. In the fifties the irrigation intensity ranged from 45 to 50 per cent and today no irrigation scheme would be profitable unless, at least, 87 per cent of the area was under crops.

He further furnished the latest figures of cost of irrigation in the Sudan from the development of a 300,000 acres irrigated scheme in the Rahd area served by the tributary of the Blue Nile. The cost of development of the 300,000 acres scheme was about £ 120 million including irrigation works, agricultural equipment and facilities, buildings, services and utilities, settlement, administration, overhead and consulting fees. The irrigation works comprised the water supply, the distribution system, drainage works and installation. Drainage work constituted about 35 per cent of the total investment. The project cost per *hectare* including everything was about \$ 3,040. Irrigation cost per hectare was \$ 1,050. The economic rate of return was expected to be about 14 per cent. This, in brief, was the situation with regard to cost of irrigation in the Sudan.

Mr. Ibrahim continued and said that it was still not certain that the targets would be achieved unless adequate extension services were provided and training to personnel imparted. This brought him to the problem of training of personnel in developing countries. There was a tendency in the developing countries to send their engineering and agricultural administrators to the developed countries for higher academic education. But the problem was that the education imparted in the developed countries did not very much suit the requirements of the developing countries. He therefore felt that there was also a need for the developing countries to co-operate among themselves for which there were big possibilities in the field of irrigation because their experiences were rather more related and of common type. It would, therefore, be more useful, he thought, if the co-operation between developing countries was strengthened.

Prof. Dr. Holy remarked that it would be very interesting to know the experiences and methods by which the Sudan had succeeded in raising the irrigation intensity to 87 per cent, as it was very important matter for the developing countries. The question of economy, he thought, needed more attention and discussion by ICID as these questions were very important especially for new irrigation developments and for the expansion of the existing irrigation systems in the developing countries.

As to the training of specialists mentioned by Mr. Ibrahim, **Dr. Holy** stated that he recognised the importance of the exchange of experiences on regional basis and it was why ICID was trying to organize the regional conferences and it was pity that no conference so far could be organized in African region. But he was hopeful that in the near future it would also be possible to organize regional conferences in the African continent and to discuss problems of mutual interest and to exchange experiences on regional basis.

Dr. Karlheinz Loffler (GDR), presenting his country report, said that they had prepared the report for the Special Session but too late. He was however glad that he had the opportunity to explain the extracts from his report. According to the vote of the IX Congress of the Socialist Unity Party, the irrigation of crops had to be expanded in order to control soil water regime and to make the agricultural production more independent of the atmospheric conditions and the measures were oriented to guarantee the increase in the supply of main foodstuffs by indigenous production for the population. Moreover, GDR contributes to the solution of world food problem supplying further agricultural products, specially the animal products for export.

Continuing, he said that in 1975 the total irrigated area in GDR was 610,000 ha out of which sprinkler irrigation comprised 310,000 ha and sub-surface irrigation by simple methods 300,000 ha. The total drainage area was 1,220,000 ha of which sub-surface drainage constituted 800,000 ha. Irrigated area in GDR accounted at present for 10·5 per cent of the cultivated area. The yield, on an average, from irrigated area was about 50 per cent more as compared to non-irrigated area. The drainage area in GDR was 19·5 per cent of the cultivated area. About 850,000 ha were protected from floods.

About 52 per cent of the total irrigated area was under sprinkler irrigation and nearly 48 per cent under other different systems. Among the sprinkler irrigation methods the semi-portable sprinkler methods dominate and among them at times the sideroll type system with more than sixty per cent. Portable sprinkler method has secured the second place with more than thirty per cent. Since 1974, the central pivot systems of the FREGAT type produced in USSR had an increase of about 4 per cent and this would increase in the future years. The permanent sprinkler method at present accounted for less than 1 per cent. Micro-irrigation methods are not spread as yet. The sub-surface irrigation by simple methods would be of special importance. Flooding and furrow irrigation methods almost did not exist. Some 70 per cent of the irrigation systems required clear water supply predominantly from the surface water and only a small portion from ground water. The waste water and liquid manure irrigation systems accounted at present 15 per cent for each.

The annual rate of utilization of irrigation facilities by the Socialist farms had increased during the recent years and had reached a level of 90 to 95 per cent. It was planned to develop the irrigated area by 1980 to reach 1·13 million ha, i.e., twenty five per cent of the arable land and 520,000 ha more than in 1975. In 1980, sprinkler irrigation systems would cover 630,000 ha. The further development of irrigation and drainage would follow a long term and complex plan.

For the 5-year plans from 1981 to 1985 and 1986 to 1990, a similar growth in irrigation area was planned as from 1976 to 1980, i.e., about 100,000 ha per year. The heads available for crop production will decrease in the future. Therefore, sprinkler irrigation methods with an operation need of less than 1 head/100 ha, and if possible 0·5 head/100 ha, were most important to improve the tendency of the yield efficiency per head. New irrigation techniques had to be suitable for a three-shift operation by a high degree of automation. Semi-portable methods with electric motors, lateral steering, and hydro-switching circuit of sprinklers would greatly increase the movability. In future their demand would be met by improved central pivot systems and straight roll move sprinkler lateral systems.

Planned irrigation techniques, he said, were not expected to require much water. The specific water demand for crop production was to be decreased by 10 to 30 per cent by the optimum combination of fertilization, irrigation, and cropping systems. Water saving sprinkler irrigation techniques and the new techniques of sub-surface irrigation developed in GDR were used for that. Further work, however, was being done for their improvement.

In GDR, 2,370,000 ha or 38 per cent of the cultivated area needs drainage of which 1,850,000 ha would be drained by 1980 and the remaining by 1990/1995. In order to solve all the problems it was important to watch the progress with regard to usable water resources, new techniques, technology and agronomic parameters as well as the interchange of scientific experiences and there would be, he hoped, good opportunity for that.

Prof. Ir. A. Volker (Netherlands) referred the problem of training of professionals and technicians in the field of irrigation, drainage and flood control.

As a first step the ICID National Committees, he said, could be asked to prepare a list of existing training courses and on-the-job training facilities both at the professional and the technician level which are suitable to foreign participants and trainees.

These lists could be made available to interested National Committees.

ICID could then review the curriculae of such institutions and courses.

As a second step ICID could promote the establishment and operation of national or sub-regional training courses for technicians.

Also the promotion of national seminars could be considered.

M. Bui Huu Tuan (Mékong Secrétariat/ESCAP), "Je vous remercie de me donner la parole pour souligner l'importance de la pisciculture dans le développement à buts multiples des ressources hydrauliques. Je crois que dans le rapport de la FAO à la Conférence sur l'Eau, elle avait mentionné ce point, et nous voudrons seulement prendre quelques minutes pour dire que dans le développement du bassin inférieur du Mékong, nous avons aussi mis l'importance sur la pisciculture.

"Je vais parler des 3 points suivants: (1) l'utilisation de l'eau d'irrigation pour la pisciculture dans le périmètre de l'irrigation; (2) le développement des lacs naturels pour la pêche, et (3) l'utilisation des zones soumises à l'intrusion saline, qui ne sont pas appropriées pour le développement agricole et l'irrigation pour la pisciculture.

"Tout d'abord, basé sur l'expérience dans le bassin du Mékong avec les barrages déjà construits, tels que Nam Pong et Nam Ngum, on a des résultats surprenants: des fois les bénéfices provenant de la pisciculture sont plus grands que les autres bénéfices, même les bénéfices dérivés de l'énergie. C'est pourquoi, je crois que dans l'avenir il faut donner l'importance à la pisciculture, et surtout en Asie où la population consomme beaucoup de poissons. Le poisson, c'est l'élément essentiel des repas quotidiens des paysans, des fermiers, et aussi des gens dans les villes.

"Je veux maintenant revenir à mes 3 points:

Premièrement c'est l'utilisation de l'eau d'irrigation pour la pisciculture. Je vous donne un exemple concret. Dans notre projet de Pa Mong, visant à construire un barrage pour l'énergie principalement (4.800 MW), et pour irriguer 800.000 ha de terre, mais dans le plan de développement, nous avons inclus le développement de 50.000 ha pour la pisciculture dans le périmètre d'irrigation de 800.000 ha, en tant que projet pilote expérimental.

En ce qui concerne le deuxième point, nous avons dans le bassin du Mékong, le Grand Lac au Cambodge, d'une superficie de 300.000 ha environ. Un lac d'une telle grandeur devra être développé, bien sûr pour l'irrigation et l'agriculture dans les zones de fluctuation du niveau d'eau du lac (drawdown zone of the reservoir area). Mais on a un projet de barrage—le barrage de Tonle Sap—qui va régulariser le niveau du lac, et l'on peut développer la pêche dans le lac naturel. Les poissons, en ce moment dans le bassin du Mékong, et surtout au Cambodge et dans la partie sud du Viet-Nam, proviennent de ce lac. Donc, vous voyez que le développement de lacs naturels pour la pêche d'une manière générale, ou pour la pisciculture, est très important.

Le dernier point, qui est très important, concerne l'utilisation des zones soumises à l'intrusion saline pour la pisciculture. Dans le bassin du Mékong, le delta du Mékong, est d'environ 5 millions d'hectares. Il y a des zones côtières soumises à l'intrusion saline qu'on ne peut rien faire jusqu'à maintenant. C'est à peu près 300.000 à 500.000 ha. On n'y peut rien faire; si, on peut faire endiguer, faire comme en Hollande, endiguer et puis irriguer et faire de l'agriculture et puis même penser à l'urbanisation; mais je crois que nous n'avons ni de fonds, ni de moyens;

on préfère notre politique d'utiliser au maximum les conditions naturelles. C'est pourquoi on a un plan pour développer ces zones soumises à l'intrusion saline, qui ne sont pas du tout adaptées à l'agriculture irriguée, qui est très chère. On y développe la pisciculture, ici ce n'est pas du tout des poissons d'eau douce parce qu'il y a l'intrusion saline ; et à cause des eaux saumâtres on devra développer des poissons aptes à ces zones des eaux saumâtres, surtout des crevettes. Actuellement le Viet-Nam exporte beaucoup de crevettes. Pour les crevettes, on a déjà des projets pilotes de 50 à 60 ha. Avec la pisciculture axée sur les crevettes, et les langoustines géantes, je pense que ce serait une bonne politique d'utiliser les zones soumises à l'intrusion saline pour la pisciculture."

REPORT OF THE REVIEW COMMITTEE—SPECIAL SESSION ON LIKELY IRRIGATED OF AGRICULTURE OF 2000 A.D.

TEHRAN, 16-17 MAY, 1977

For various reasons it was not possible for all National Committees of the Commission to present statistical data on the subject of potential irrigation in their countries by the year 2000 A.D. Therefore one of the aims of ICID should be to obtain these data, bring them together as a sample of the world situation and supplement the study with additional information as deemed necessary for assessing the potential production of food relative to requirements in 2000 A.D.

In particular the Review Committee thinks it advisable to collect the information under four main topics:

1. Horizontal Expansion

(*a*) Potential irrigable areas.

(*b*) Planned and/or possible irrigable areas by 2000 A.D.

(*c*) Availability of water for the planned areas.

(*d*) Contribution of these added irrigated areas to the world food supply.

2. Vertical Expansion

(*a*) Efficiency of water use within drainage basins, and within distribution systems. Particular attention should be paid to canal lining, the use of closed systems, weed control in canals and prevention and control of silting systems.

(*b*) Efficiency of irrigation methods and new irrigation methods including such items as land levelling, low energy systems, efficient on-farm distribution systems, and efficient use of water by crops.

(*c*) Efficient agronomic practices including land preparation, use of correct seeds and crop varieties, adequate fertilization and crop protection, and efficient harvesting and storage methods.

(*d*) Efficient land use from the point of view of using those lands best suited to particular uses and crops.

3. Research

Data collection and research is required, amongst others, on the following items :

(*a*) Base line data are needed for many parts of the world including evapotranspiration, meteorological, soil survey and capability and water quality.

(*b*) How can the use of water from a watershed best be optimized for all needs of society?

(*c*) How can the use of water within the farm be optimized considering energy requirements?

(*d*) Problems involved in the mass transfer of water connecting different basins.

4. Extension and Training

(*a*) Considering the social and labour needs of a country, how best can improved technology be introduced to the cultivator.

(*b*) What methods are available to the ICID to improve the interchange of information on irrigation between countries? Is there a need for some countries to help others in the training of technicians? Can this be done through the sponsorship of ICID?

The Council* is/has establishing/established a post session Committee to give further and continuing study to the whole subject in light of its importance. The Review Committee trusts that these comments will be of some help in determining the future course of action by I.C.I.D. on this important subject.

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*The Council has since established a "Post-Tehran Special Session Working Group" comprising the following members of continuing review and monitoring:

1. President Dr. M. Holy (Chairman)
2. Dr. H.M. Horning (FAO)
3. Prof. Dr. H. Fukuda (Japan)
4. Prof. Dr. A. Volker (Netherlands)
5. Mr. C.C. Patel (India)
6. Mr. A.M. Ibrahim (Sudan)
7. Dr. S. Hajrasuliha (Iran)
8. Mr. K.K. Framji, Secretary General (ICID)

RAPPORT DU COMITE DE REVUE DE LA SESSION SPECIALE SUR LA CONTRIBUTION PROBABLE DE L'AGRICULTURE IRRIGUEE EN L'AN 2000

TEHERAN, LES 16-17 MAI 1977

Tous les Comités Nationaux de la Commission n'ont pas pu, pour une raison ou pour une autre, présenter des données statistiques sur le potentiel d'arrosage de leurs pays en l'an 2000. L'ICID doit par conséquent s'efforcer à recueillir ces données, les rassembler et les mettre sous forme d'un modèle de la situation mondiale et à compléter l'étude, le cas échéant, par les études supplémentaires, en vue d'évaluer la production potentielle alimentaire correspondant aux besoins de l'an 2000.

Le Comité de Revue estime notamment souhaitable de réunir les informations relatives aux quatre aspects importants:

1. Expansion horizontale

(*a*) Potentiel des surfaces irrigables

(*b*) Surfaces irrigables envisagées/possibles en l'an 2000

(*c*) Disponibilité d'eau pour les surfaces préconisées

(*d*) Contribution de ces surfaces irriguées supplémentaires à la fourniture alimentaire mondiale.

2. Expansion verticale

(*a*) Rendement hydraulique des irrigations dans les bassins de drainage et dans les systèmes de distribution. L'attention particulière doit être accordée aux revêtements des canaux, à l'emploi des systèmes enterrés, à la lutte contre les mauvaises herbes dans les canaux et à la prévention et au contrôle d'enfouillement des systèmes.

(*b*) Efficacité des méthodes d'irrigation et les nouvelles méthodes d'irrigation, y compris les aspects tels que nivellement du sol, systèmes à faible consommation d'énergie, systèmes efficaces de distribution et consommation d'eau par les cultures.

(*c*) Pratiques agronomiques efficaces y compris préparation de sols, emploi de semences appropriées et variétés de cultures, fertilisation adéquate et protection des cultures et méthodes efficaces de moisson et de stockage.

(*d*) Utilisation efficace de terres du point de vue d'usage de ces terres qui correspondent aux meilleures utilisations et cultures.

3. Recherche

Il est nécessaire de procéder à la collecte de données et à la recherche, entre autres, sur les points suivants:

(*a*) Des données de base sont nécessaires pour plusieurs parties du monde sur l'évapotranspiration, la météorologie, l'étude et la capacité du sol, et la qualité de l'eau.

(*b*) Comment pourrait-on optimiser l'utilisation de l'eau d'un bassin versant au profit de la société?

(*c*) Comment pourrait-on optimiser l'utilisation de l'eau, dans la parcelle, compte tenu des besoins en énergie?

(*d*) Problèmes rencontrés dans le transfert massif d'eau, en liaison avec les différents bassins.

4. Vulgarisation et formation

(*a*) Vu les besoins sociaux et en main-d'oeuvre d'un pays, comment pourrait-on introduire une technologie améliorée à l'intention de l'exploitant?

(*b*) Quelles sont les méthodes disponibles auprès de l'ICID pour améliorer l'échange d'information, entre les pays, sur l'irrigation? Existe-t-il un besoin dans certains pays d'aider les autres dans la formation de techniciens? Peut-elle être coordonnée sous les auspices de l'ICID ?

Le Conseil* établit/a établi un comité postsession pour étudier davantage l'ensemble du thème en vertu de son importance. Le Comité de Revue espère que ces commentaires seront utiles pour déterminer ce que l'ICID doit faire sur ce sujet important.

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* Le Conseil a déjà établi un "Groupe de travail post-Session Spéciale de Téhéran" composé des membres suivants pour une revue et une surveillance continue:

1. Président Prof. Dr. Holy (Président)
2. Dr. H.M. Horning (FAO)
3. Prof. Dr. H. Fukuda (Japon)
4. Prof. Dr. A. Volker (Pays-Bas)
5. M. C.C. Patel (Inde)
6. M. A.M. Ibrahim (Soudan)
7. Dr. S. Hajrasuliha (Iran)
8. M. K.K. Framji, Secrétaire Général (ICID)

TEHRAN SPECIAL SESSION

1977

GENERAL REPORTS

(English and French)

R. 1 to R. 12

Reports R. 13 to R. 17 could not be regrettably included in the General Report as these were not received at the time of preparation of the General Report.

Les rapports R. 13 à R. 17 n'ont pu être malheureusement inclus dans le Rapport Général comme ils n'ont pas été reçus lors de la préparation du Rapport Général.

GENERAL REPORTER / RAPPORTEUR GENERAL — Prof. Dr. S. Hajrasuliha Ph.D.

TEHRAN SPECIAL SESSION 1977

IRANIAN NATIONAL COMMITTEE OF ICID

COMITE NATIONAL IRANIEN DE L'ICID

SESSION SPECIALE DE TEHERAN 1977

GENERAL REPORT (E)

LIKELY IRRIGATED AGRICULTURE OF 2000 A.D.

PROBABLE CONTRIBUTION FROM IRRIGATION, DRAINAGE AND FLOOD CONTROL TO MEET THE REQUIREMENTS OF AGRICULTURAL PRODUCTION TOWARDS THE YEAR 2000—ROLE AND ACTIVITIES OF ICID AND ITS NATIONAL COMMITTEES

PROF. DR. S. HAJRASULIHA*, Ph. D.

GENERAL REPORTER

Twelve Reports have been received from eleven countries (two being from USA). These are categorised mainly into the following three groups dealing with:

—The data and basic information (R. 1, R. 2, R. 4, R. 6, R. 7, R. 8, R. 9, R. 10 and R. 12)

—Advanced technological development and research (R. 3 and R. 5)

—The vital role of ICID and its National Committees (R. 11)

INTRODUCTION

Irrigated agriculture has been practised, at least, since the emergence of civilization in arid regions of the world. It is a historical fact that the ancient civilizations of the Indus Valley, the Nile Valley, the Euphrates and the Tigris Valleys and the Khuzestan plain were built around and along the major river banks and these civilizations flourished under the influence of irrigation. It is also true that many great civilizations were destroyed after irrigated lands lost their productivity due to the accumulation of salts in their soils. This was mostly due to the ignorance of the people about the soil and water management. In the last two decades a fear namely the

* Director and Associate Professor, Institute of Horticulture, University of Isfahan, Iran.

'population explosion' has frightened many a people all around the world and some predicted recurring famines in the future. Their reasoning has been as follows:

—Almost all the land in the world is under cultivation and little uncultivated land is left in the world.

—Higher yields in cultivated lands are costlier because of diminishing returns to fertilizer and other inputs.

—Energy inputs to the farms will be more costly in the future than in the past.

The main point is that this alarmed group of people ignored to review the amount of available irrigable land in the world and also forgot to study the potentiality of many of the lands the worldover to produce twice or even more of food. For example, in North America grain yields have doubled since 1950; and while the real costs of grain production have declined, even though the application of fertilizers and other inputs have gone up to more than twice as much as applied before.

Preliminary assessment of the world food situation prepared for consideration at the second session of the Preparatory Committee of the World Food Conference and the report of the Secretary-General of United Nations World Conference (Bucharest, 19-30 August 1974) opened the gates of hope for the future food production in the world. As it is clear from these and other reports dealing with the question of the future agriculture that if a serious emphasis is laid by all the countries around the world on the improvement of agriculture, and mainly on irrigated agriculture, no basis for fear should exist thereafter.

At present, about 1,500 million ha of land is under cultivation to produce food, fibre, beverages and other non-food products for a human population of about 4 billion.

Although no one yet knows the exact amount of land that can be brought under cultivation, but according to the calculations made in one of the UN reports and because of uneven distribution of runoff, only 30 per cent of the land that is potentially arable with irrigation can actually be irrigated and the potential increase of the gross cropped area through irrigation development is limited to 1,110 million ha. If the world population by the year 2000 A.D. is assumed to be 6 billion then the food needed, on calorie basis, would be 15,000 billion ($1{\cdot}5 \times 10^{13}$) kilo calories/day. This assumption is based on 2,500 kilo calories/day/human being. To include sufficient protein with balanced content of amino acids and protective foods, such as fruits and vegetables, the equivalent of 4,500 kilo calories/person/day is desired. On this basis the total calories per day needed by 6 billion of world population by the year 2000 would be 27,000 billion ($2{\cdot}7 \times 10^{13}$) kilo calories/day. One hectare of agricultural land under good cultural practices, such as those in advanced countries, will produce 60,000 kilo calories/day. As a result, the land required for agricultural purposes to produce food for the world population by the year 2000 would be 450 million ha. Adding 10 per cent needed for fibre, beverages and other non-food products, 10 per cent as unavoidable losses and 3 per cent for seed, a total of 100 million ha should be added to the above and as a result the grand total of agricultural land needed for production of food, fibre and other agricultural products by the year 2000 would be 550 million ha. Suppose no new land is brought under cultivation, the world harvested land (8C0 million ha) with a highly developed agriculture, such as those practised in advanced countries, will produce sufficient food, fibre and other agricultural products for a population of over 8,700 million.

But it should be noted that two very important points remain to be discussed, as follows:

—The gross as well as the net area potentially available to agriculture is far greater than the area under cultivation at present (positive point).

—Lack or limitation of know-how and technology in developing countries makes it difficult for them to believe such high productions (negative point).

The gross cultivable and irrigable areas of the world are estimated to be over 3,500 million ha and 1,100 million ha respectively. This amount of land with high know-how and high technology can produce food, fibre and other agricultural products for over 40 billion human beings which are almost 10 and 6 6 times respectively of the population at present and of the year 2000; but on the other hand we know that in spite of the yield obtained with high technology farming, the average yield of many developing countries is low: compare over 6 tonnes of edible food in practising high-technology farming with only one tonne in some developing countries.

To reach to the production level of the countries practising high-technology farming, know-how, capital and other resources are needed. Technology is not born or grown overnight nor is the capital for investment earned by chance. Large areas of the earth's surface could only be brought under cultivation if the required capital, technology and other necessary tools were in hand.

About 20 per cent of 13,000 million ha of land on our planet is spread in arid and semi-arid zones. Without irrigation successful farming in these zones is almost inconceivable, but of course with full irrigation or supplementary irrigation very good crops, even record crops can be raised. Potential for irrigation agriculture is very large.

At present there is approximately 240 million ha of irrigated agriculture all over the world. There are large opportunities for expanding the irrigation areas in the world. There are also possibilities for improving the existing irrigation facilities. But unfortunately only a part of the water resources in some developing countries have so far been harnessed for agriculture. ICID and its National Committees can play an active role and be a source of light and guidance particularly to the grey solutions of these problems.

SUMMARIES

REPORT 1 : **Water development in Canada to meet agricultural production requirement for 2000** A.D.—by Canadian National Committee, ICID

The report reviews the water supply position and the related agricultural development in Cannda. The demand upon Canada's water resources, being small at present, would increase with time. The population is 22·5 million and is expected to increase between 26 and 32 million by the year 2000. Agriculture is mostly dependent upon rainfall. Less than 1 per cent of the total cultivated land (44 million ha) is irrigated of which 80 per cent lies in the three prairie provinces and British Columbia. In Alberta 20 per cent of agricultural returns come from 4 per cent of cultivated land which is irrigated. Subsurface drainage covers 3 per cent of the cultivated area.

The report states that updating of statistics has not been possible to identify returns to agriculture from irrigation, drainage and flood control developments. The lack of detailed land capability data has hindered the estimation of irrigable potential. This situation has been proposed to be rectified by a computerized land inventory system in the next 10 years.

The report deals with the trends in land and water development. Although Canada has large areas of arable land that could be developed either by clearing and breaking or reclaiming through drainage, the trend is to encourage the use of presently developed areas before moving in to undeveloped areas. Thus, for the present, the population increase will be fed and the world demand for Canadian wheat, barley and rape seed will be met by intensive use of current agricultural lands.

In respect to demand for water development and use in the context of world food supply by the year 2000 A.D., the major contribution will come from non-irrigated crops. At present a Canadian farmer produces enough food for 50 others and with the same land this is expected to be doubled by the year 2000 A.D., through the use of improved technological inputs, e.g., improved plant varieties, management of water and plant nutrients, better seed, disease and insect control, etc.

Normally all combinations of types of irrigation and resources of water are found in Canada. The use of mechanized sprinkler systems is increasing.

In regard to advanced irrigation technology and research direction the report states that the mechanized technologies in farming and water management as labour saving devices will find a quick adoption by Canadian farmers as and when these become available. The research needs for irrigation embrace various aspects like studies on land classification, water requirements and crop suitability under varying ecological regimes, effective evaporation loss control and weed control methods, non-clogging drip system design and improvement of irrigation scheduling. Research needs for better drainage techniques have been spelt over.

The report finally discusses the constraints which hinder the development of irrigation and drainage and points out that the major constraint is the individual farmer who is apt to exercise his own way of assessment of the advantages and disadvantages of adapting himself to developing technologies vis-a-vis his conventional working system admits various agricultural environments. Secondly infrastructure will need intensification with future development of irrigation and consequent increase in population. Other possible constraints include lack of water for development of irrigation potential in Alberta and Saskatchewan and inavailability of basic data. Drainage schemes may be free from constraints unless drainage of swamps is included and this would further cause concern among the environmental and wild life enthusiasts.

REPORT 2: **Likely irrigated agriculture of 2000 A.D. in the Democratic Republic of Sudan**—by A.M. Ibrahim (Sudan)

The report deals with the land and water resources of the country. The Nile River with its tributaries is the most prominent source of water in Sudan. The report describes the discharge and silt characteristics of the Nile which influence the design and operation of irrigation works.

Sudan has a population of approximately 15·7 million, increasing at an annual rate of 2·8 per cent. Some 90 per cent of the population is engaged in agricultural sector. Investment in irrigation development has been given top priority followed by mechanized rainfed agriculture. Out of 6·7 to 7·1 million ha cultivated land 1·7 million ha are irrigated, the rest are rainfed.

The report discusses the water needs and utilization of the Nile water among Egypt and Sudan. These were decided upon by the Nile Control Commission which was set up in 1920 by the Egyptian Government. Sennar Dam enabled Sudan to develop the Gezira Scheme (420,000 ha) and to expand the pump schemes along the main Nile and its tributaries. For further development of irrigation the scheme envisaged the construction of Roseires dam on the Blue Nile; raising of Sennar dam and Jebel Aulia dam on the White Nile to enable Sudan to draw an extra 200 million m^3 of water.

The report presents the post-independence development and the agreed arrangements with Egypt regarding future use of waters which increased Sudan's share of the Nile water from 4 milliard m^3 to 18·5 milliard m^3 as measured at Aswan. The country has planned to increase the water potential of the Roseires dam by constructing its second phase. With a view to obtaining self sufficiency in food production a long-term plan of development of irrigated agriculture is under consideration of the Government.

The report discusses the long-term development of irrigated agriculture in the country. The annual growth rate of agricultural production is set at 4·5 per cent. A 6-year development programme (1977-82) is under preparation. It is envisaged to develop 28·33 million ha of rainfed land cropped with short-staple cotton, oil seeds, millet and other cereals. The Government is also planning to develop by the year 2000 A.D., 3·12 million ha of irrigated-agriculture to ensure a stable production of high value, high yielding crops.

The report discusses the water utilization of its share 18·5 milliard m^3 of the Nile with the established schemes and those under construction. Additional area under irrigation development is expected to be 1·42 million ha bringing the total irrigated area to 3·12 million ha as anticipated by the year 2000 A.D. The future production of irrigated cotton, wheat, ground nuts, fruits and vegetables is expected to be four times the present production while that of sugar will be 25 times. Sudan's ultimate annual water requirement from the Nile will be 30 milliard m^3. It requires 10 milliard m^3 of additional water to implement the long-term plan of irrigated agriculture.

As per the Nile Agreement 1959, Sudan and Egypt are committed to make joint efforts to prevent under losses of water taking place in the Sudd region in the Southern Sudan. The shortage of water needs of the two countries, Sudan and Egypt, would possibly be met out of the possible reclamation of 18 milliard m^3 from the swamps as per indications from the hydrological studies. By completing the joint venture of Jonglei Canal diversion project by 1982, 4 milliard m^3 of additional water will become available to be shared equally by the two countries for their agricultural developments.

REPORT 3 : **Impacts of climatic fluctuations on food-producing ecosystems** —by Dr. A. Dexter Hinckley (USA)

The paper stresses that the climate should not be ignored in planning ahead to the year 2000 A.D., particularly in food-producing ecosystems. Agricultural productivity can well be considered depending upon periods of favourable growing conditions combined with management techniques that protect crops from the impact of unfavourable periods. The vital inputs for food producing ecosystems are solar energy and carbon dioxide on one hand and water through irrigation on the other hand with an additional input of weather modification sometimes under certain circumstances. The nutrient input can be increased by appropriate application of fertilizers. Other possible inputs include herbicides, pesticides, etc.

The paper states that an irrigated ecosystem has been taken up for input-output analysis, as a base, for the study of the plant growth processes to examine the impact of climatic fluctuations. Climatic fluctuations can affect a crop species directly or indirectly.

Moreover crop damage due to disease and pests may also increase under arid conditions resulting from droughts. Having recognized above the retarding and damaging influences of climatic variations on agricultural production it will be appropriate to build better ecosystems and develop an array of protective strategies based on ecosystem concept and plan to meet the situations in the year 2000 A.D.

The paper emphasises the importance of strengthening meteorological networks, regular ecological observations in agricultural areas and use of remote sensing techniques from aircraft and satellites to ground level monitoring. An assumption for severe drought situation in years to come calls for thinking and planning for an accelerated need for irrigation by tapping new water sources in more remote watersheds or deeper aquifers but this would not be free from entailing heavy capital expense and operating costs. Likewise dependence upon weather modification techniques will rest within a limited scope only.

The paper suggests ways to efficiently utilize the scarce water supply e.g., building ecosystem around drought-tolerant crops, changing crop culture suitably by replacing those crops which require greater quantity of water by those which can grow with less water, adopting trickle irrigation technique to reduce evaporation losses, etc.

The paper points out many alternative means to step up plant growth (when there is water shortage) such as recycling water in environments where solar energy is abundant, concentrated use of fertilizers, more efficient use of nutrients, increased dosages of carbon-dioxide to accelerate leaf growth, etc.

REPORT 4: **Likely irrigated agriculture of 2000 A.D.—Role of ICID and National Committees to meet the situation**—by Iranian National Committee, ICID.

The report establishes the importance of irrigation by reviewing the contribution made by it to the total agricultural production which is at present about 64 per cent in terms of the value. Of the 4 million ha equipped for irrigation, 3·7 million ha was irrigated during 1975. About 8 million ha is dry-farmed area.

Iran has meagre water resources. Annual average precipitation is 230 mm. Of the total runoff of 100-110 billion m^3, irrigation consumes 25 to 30 billion m^3, 10-15 billion m^3 are the irrigation losses and the remaining potential is of the order of 60-70 billion m^3 a year, of which a third could hopefully be harnessed between now and 2000 A.D.

The report discusses the various constraints and their influence on irrigated agriculture. The constraints are the climate, water resources, soil, demographic and social aspects and the production centres vis-a-vis the population settlements.

The report reviews the potential development of irrigated agriculture and fixes the irrigation target at 6 million ha and the increase in the net value by three fold by the year 2000. The report presents the actions and measures initiated to achieve the development of objectives of irrigated agriculture. These measures include improved regulation of ground and surface waters, reduction in consumptive water use and introduction of new institutions.

The report reviews the advanced technologies adopted in Iran, among which rain-making techniques, wastewater re-use, telemetry, systems approach, desalination techniques occupy prominent place. Green-house and hydroponic techniques, use of poor quality water, pollution abatement, etc. are also in view.

Finally, the report presents the role of the Iranian National Committee of ICID and the contribution made by it to promote the objectives of ICID.

REPORT 5: **Advances in the technology of estimating crop water requirements—an aid to improved water management**—by British National Committee, ICID.

The report states that many of the traditional irrigated regions of the world are approaching the limit of water resource development in the remaining quarter of this century. Water should therefore be used as efficiently as possible by the year 2000 A.D. Adoption of efficient management of irrigation systems is essential. This in turn requires improved estimation of water requirements of crops, timely application of irrigation water and reduction of conveyance losses in irrigation systems.

The report reviews the research studies that have been devoted in Great Britain especially to the topic of water requirements for crops such as the work of Penman at Rothamsted Experimental Station, Monteith at the University of Nottingham and the work of other research centres.

The report presents a brief historical review of the past trends in development of irrigation systems in India, Egypt, Sudan, and USA and emphasises that up to the present time little has been done to improve the control of irrigation systems and the efficiency of water use.

The report considers first how past and present methods of estimation have helped in setting ranges for the water requirements of irrigated crops grown under particular local climatic conditions. The report continues with a review of current research work which may lead to the development of the more accurate estimation methods which will be needed if irrigation water is to be used more effectively. It concludes with a discussion of the place of these new methods in the better forecasting of irrigation demand.

REPORT 6: **Long-term planning of water development and water use for the expansion of agricultural production in Bulgaria** — by Dimiter Davidov (Bulgaria)

The paper describes the important role of irrigation, drainage and flood control in Bulgaria and stresses that by irrigation, the agricultural production can be doubled. The present assessment has indicated that out of the total cultivated land of about 5 million ha, 1·1 million ha are irrigated and 0·1 million ha are drained. The storage capacity is 2·8 milliard m^3 from 2,047 big and small dams and there are 2,800 pumping stations with a power capacity of 500,000 kW. The potentials of irrigation and drainage areas are respectively 3·5 million ha and 0·2 million ha. To satisfy the programme of social and economic development of the country, an agricultural production increase at a yearly rate of 5 per cent is required which is possible through the horizontal and vertical expansion of irrigation for which an average increase of 0·5 million ha per year is necessary.

Based on the assessment of water supply, labour resources and the increased agricultural production requirements, the report lays down generalized numerical indices during the period to the year 2000. These indices are particularly relevant in determining the amount and degree of reconstruction, growth rate of irrigation and drainage systems, crop varieties on reclaimed lands and the requirement of foreign exchange component.

The report surveys the trends of irrigation methods. The irrigated area under sprinkler irrigation is at present 45 per cent (in 1975). This is expected to increase to 60 per cent by 1985 and 80 per cent by the year 2000 A.D. To increase the irrigation efficiency certain concepts of distribution network, such as use of high pressured pipe network for discharges up to 1 m^3/s, etc., has been mentioned.

The Report outlines social, economic and technical problems confronting the future developmental activities related to the increase in agricultural production by the year 2000 A.D.

REPORT 7: **Likely irrigated agriculture of 2000 A.D.—Role of activities of ICID and its National Committees to meet the challenge**— by Ethiopian National Committee, ICID

The report reviews the situation in regard to the water resources in Ethiopia which have not yet been utilized for scientific irrigated agriculture at the latter has not been introduced in the country. However the continuous drought since the last three years and the increasing population in the highlands of Ethiopia has led the country to recognise the necessity of developing irrigated agriculture and of having an integrated development of valleys.

Only in one valley considerable irrigation development has taken place through pumps and gravity system.

A "Valleys Agricultural Development Authority" for the country has been set up by the Ethiopian Government for intensification of irrigation and agricultural developments. The Authority is charged with the responsibility of making an appraisal of available land, assess water resources, formulate policies, launch feasibility studies, initiate plans and programmes for integrated regional development, identify agro-industries and deal with related aspects of social, economic and environmental nature, seek financial aid for implementation of developmental programmes of water resources and provide necessary technical assistance to state farms, rural corporations, etc.

The report tabulates some known information on irrigated areas and irrigation potential. At present some 87,000 ha land is irrigated in the country. In Awash Valley alone approximately 56,000 ha is irrigated and the potential irrigable area is 148,000 ha.

REPORT 8: **Irrigation and drainage—A country report: The United States of America**—by US Bureau of Reclamation, Department of the Interior.

The report reviews the national position of agricultural production which has always been surplus. Currently American agriculture can feed about 50 million more people than live in the country. The US National Committee of ICID affirms to assist the developing nations of the world in developing their water and land resources for greater food and fibre production.

In regard to the role of irrigation and drainage, the report summarises that 14 per cent irrigated area contributes more than 20 per cent of the total agricultural production in the country, the farm population has steadily decreased from 9·4 per cent in 1959 to 4·4 per cent at present (1975) due to increased mechanized farming. There is increasing trend towards larger farms.

The report summarises the trend towards changes in land use by noting that the cultivated land use may increase somewhat to meet world and national demand as they occur and more intensification of production is expected through technological advances.

As to the demand for water development and use, it is reported that the water demand for agriculture and other uses will expand greatly. Economical and efficient use, extensive major development and the matching technological development and improved distribution of water will be prime thrusts of effort.

As regards to the horizontal and vertical expansion of irrigation, the report states that a National Water and Agricultural Policy formulation might help in future planning. Free operation of market-place, including dispersion of technology, induces high level agricultural production.

The report lists the various new production techniques currently being explored in varying degrees in the country. These are at various stages of development and implementation. The report emphasises that research is needed to determine suitability of these techniques particularly in high population density regions.

Finally the report deals with economic, legal, physical and social constraints. In summary, consideration of the adverse environmental impacts from agricultural production activities may prove to be a major constraint on resource development in the next quarter century.

REPORT 9: **Irrigated agriculture in Mexico in the year 2000 A.D.**—by Eng. Fernando J. Gonzalez Villarreai and Eng. Manuel Contijoch (Mexico)

The report describes the importance of the hydro-agricultural infrastructure which helps the development of land productivity, generation of employment and increase of the added value by the agricultural and livestock production to the country.

At present about five million hectares are equipped with hydro-agricultural infrastructure which represent 30 per cent of the national cultivated area supplying 50 per cent of total farm production and ample variety of basic products.

The report deals with the national objectives of irrigation and drainage which seek to contribute to the increase of agricultural and livestock production and ingredients for national industry and to provide productive employment to the rural people and to take advantage of available opportunities in the international market, to encourage rural development by means of hydraulic works and to utilize to the maximum the built-up infrastructure. The report presents the planned goals for the year 2000 which envisage doubling of the area equipped with hydro-agricultural infrastructure, i.e., from 5 million ha at present to 10 million hectares at the end of the century. According to the regional strategy, 58 per cent of the new land will be selected in the Gulf zone and in the South-East because of minimum social and ecological problems of humid tropics, and pilot projects will be installed as a first step towards accomplishing large project in this area and will be followed by specific investigation programmes of training and publicity which will be undertaken by the Institute of Tropical Development. The report gives the estimated investment and the results to be achieved by the year 2000. An investment of 266,000 million pesos (1975) will enable within the next 25 years to attain an increase in the rate of production of 4 per cent and an opportunity of 820,000 permanent employments at an average unit cost of 185,000 pesos (1975).

It is expected that the area equipped with infrastructure would contribute, in the yeer 2000, as much as 65 per cent of total agricultural production. It will, therefore, be possible to satisfy the demand of agricultural and livestock products, assuming that an increase in the regional production of seasonal crops would coincide with the earlier recorded trends and the present policies.

REPORT 10: **Present and anticipated effect of land reclamation on the agricultural output increase in Czechoslovakia**—by Ing. Tasky Josef and Ing. Heldi Anton

The paper discusses the vital role of land reclamation in stepping up the agricultural production in Czechoslovakia. Out of 7 million ha agricultural land, 44,000 ha are irrigated, 755,000 ha are drained and 76,000 ha are drained and irrigated. Irrigation is mostly supplementary. The potential irrigable area in various river basins has been assessed to be 1·366 million ha. Agricultural production on reclaimed land was evaluated for 1971-75 and the data on annual production increase of main crops on reclaimed soil is presented. The concept of large and medium-area irrigation system is considered suitable as with the introduction of mechanisation it requires less labour.

Czechoslovakian drainage is lined up with regulation of streams. Some 9,500 km length of streams is regulated. The paper describes the working of the drainage systems in the country.

The demographic information about Czechoslovakia (1974) indicates that out of 14·7 million inhabitants, some 1·06 million are employed in agriculture. The present trends in horizontal expansion of reclamation as envisaged in 6th Five-Year Plan (1976-80) are: drainage development of 255,000 ha; irrigation of 64,000 ha; and training of water courses 1,600 km. As a result of this, the increased plant production on reclaimed area will contribute 12 per cent of the total plant production in Czechoslovakia.

The potential horizontal and vertical expansion of reclamation has been estimated. By the year 1990, drainage of 86·5 per cent of land will be accomplished and 38·4 per cent of irrigation systems will be constructed on nation-wide requirements.

The paper briefly deals with the long-term plans of the Czechoslovak agricultural development which envisages increased application of fertilizers, more productive crop varieties and alround automation. An estimate of the intensified reclamation measures up to 1990 has been made which envisages a production increment (by vertical expansion) of 2,880 kčs/ha. The country has planned to provide the entire water demand for irrigation of 525,000 ha in 1990. Irrigation water demand in 1975 was 268 million m^3 and in 1990 it is estimated to be 788 million m^3.

The paper presents trends of development expected as a result of advanced technologies applied in construction and exploitation of reclamation structures. Water use efficiency in irrigation, trends in water management policy and economics, organisational and administrative aspects for policy realisation, research requirements and international co-operation in the sphere of research and application of new knowledge have been briefly dealt with.

The paper very briefly mentions the problems encountered in the co-ordination of various activities relating to land reclamation. Economical and organization constraints may result from inter departmental balances of construction materials and machines in connection with requirements for reclamation construction.

REPORT 11: **Probable contribution from irrigation, drainage and flood control to meet the requirements of agricultural production towards the year 2000—Role and activities of the ICID and its National Committees**—by French National Committee, ICID.

The report puts forward a number of points in regard to the future activities of the ICID and its member countries. These are summarised as follows:

(1) ICID should attempt to enrol new member countries, especially in South America and Africa, south of Sahara.

(2) It is advisable that the ICID follows closely some great world problems. ICID is not a member of "Club of Friends of Sahel" formed in 1976. The French National Committee is in a position, if requested, to represent ICID in the Club.

(3) The Questionnaire for the Special Session also be sent to the governments of non-member countries, in order to have a complete view of the possibilities of development of projects in the world.

(4) ICID has at its disposal certain number of Committees or Working Groups that cover a large part of the questions that the ICID has to study in the years to come. The "Permanent Committee to focus attention on new developments" and the "Permanent Paper Committee" may, in the light of conclusions of the Special Session, propose for study a certain number of new or renewed topics, on the developments of the future, such as those cited in paragraph III of the Report. New working groups will have to be nevertheless set up, but these should be less in number.

(5) The topics selected for next Congresses will have to take into account these foreseeable trends. In addition to general topics, it is advisable, contrary to the existing practice, that some specific topics on the management of large river basins of the world may be selected and proposed to the approval of the member countries, even if these countries are not riparian states.

(6) Bilingual (French and English) courses, under the aegis of the ICID, may be organised once in every year, in the countries which have experience in the fields of irrigation, drainage and flood control. The French National Committee feels that France may organize, starting with 30 fellows chosen by the Central Office, with effect from 1980 some such course once in every 6 years; it will try to obtain from its Government some financial assistance. Aid is to be solicited also from large international organizations.

(7) An exchange of information on the experiences of each country in the field of education of irrigation, drainage, flood control and allied subjects may be undertaken by the ICID in collaboration with the UNESCO and OAA (FAO), concerning all levels of training.

(8) The present Special Session and the Questionnaire that will follow will be the occasion for the National Committees to think about the future of irrigation, drainage and flood control both in their own country and in the world. The interest that has been provoked shall have to be maintained.

National Committees of ICID are of various set-ups more or less supported by governments, and have more or less resources—This state of things may not undergo any change, but there is necessarily a fuzziness about the role that these National Committees might play individually. This role must be above all encouraging and thought-provoking in their own country and of regular information supply to the Central Office.

(9) ICID has over 25 years experience and its words are listened to, though not a governmental organization, it may, in certain cases, contrary to the practice, make recommendations to the governments themselves, with the National Committees following up these recommendations with their Governments.

REPORT 12 : **Probable contribution from irrigation, drainage and flood control to meet the requirements of agricultural production towards the year 2000** A.D.—by Indian National Committee, ICID.

The report reviews the present status of irrigation in the country. The net cultivated area in India at about 140 million ha has tended to become stationary indicating that the upper limit to new land being brought under plough is being approached. The population which was 361 million in 1951 had reached up to 547 million in 1971 and is expected to be around 935 million by the turn of the century. The increasing demand of food and fibre have, therefore, to come essentially from increased yields per hectare under plough. This is possible only if irrigation, which is a basic resource for increased agriculturural production, is made available to more and more areas.

The report presents irrigation potentials and the targets to be achieved up to the year 2000. The ultimate irrigation potential of the country has been estimated at about 110 million ha comprising 70 million ha from surface water schemes and 40 million ha from ground-water schemes. By the end of March, 1974, i.e., by the end of the Fourth Five-Year Plan, the potential developed was estimated to be of the order of 44 million ha which is expected to go up to 86 million ha by the turn of the century comprising 53 million ha from surface water schemes and 33 million ha from ground-water schemes. The anticipated increase between 1974 to 2000 A.D. would thus be 42 million ha. The Fifth Five-Year Plan which ends in March, 1979 envisages creation of an additional potential of 12·2 million ha, an annual increase of over 2·4 million ha. In the subsequent Plans, even if this tempo is maintained, it will easily be possible to touch the target of 86 million ha by 2000 A.D.

The utilisable annual surface runoff has been estimated at 70 million ha. m of which by the end of Fourth Five-Year Plan, the utilization was estimated at 25 million ha. m. The ultimate ground-water potential is estimated at 27 million ha. m of which 13 million ha. m was estimated to have been utilised by 1974. The National Commission on Agriculture has projected a demand of 42 million ha. m from surface water and 21 million ha. m from ground water by the turn of the century, for utilization for irrigation. The demand for other uses such as industrial requirements and domestic water supply are estimated to be 8 million ha. m for surface water and 4 million ha. m from ground water. For developmental activities up to 2000 A.D., there will thus be adequate supply of water resources. The estimated utilisable surface water resources and ground-water resources are likely to undergo an upward revision with advance of technology and development of water resources.

The report gives some of the problems being faced and the solution adopted. Land preparation works and provision of drainage facilities are also expected to be provided in an increasing measure in the coming years. These would also increase the land productivity. Provision of adequate agricultural extension services will have to be ensured on an increasing scale for transferring the improved technological practices to farmers.

Monitoring of important projects has been started recently with a view to ensure the orderly implementation of the schemes and fulfilling construction schedules and there are no slippages in the targets laid down for completion of the projects. The requirement of funds needed for meeting the physical targets is being examined from time to time and steps taken to provide adequate funds. Facilities for loan assistance from International Agencies are also being availed of for supplementing the financial resources.

CONCLUSIONS

The information presented in the reports varies widely in content and data; some countries have attempted to provide the desired data and information as prescribed in the draft questionnaire kindly collated by Dr. Horning of FAO. The data and information presented in the reports is of great interest and value. It is heartening to note that even the newest member to the ICID community (Ethiopia) has arisen to the occasion and has attempted to submit its country report to the Special Session.

The following positive trends are clearly noticeable from the reports which would help in organizing the future efforts of the member countries of ICID to meet the challenges of 2000 A.D. in the field of irrigated agriculture in the context of world food problem:

1. The importance of irrigation, drainage and flood control is clearly established in increasing the world food production. The agricultural production from irrigated land is significantly higher than that of the rainfed area. With the introduction of inputs and mechanisation, the unit yield increases in both the irrigated as well as the rainfed areas, but the trend of increase in yield in irrigated land is steeper and more dependable than in the rainfed area.

The farming population generally shows a decreasing trend with the introduction of mechanisation and agricultural inputs. In some countries the farm sizes are increasing due to labour-saving devices. Subdivision of farm population with respect to irrigation, drainage or flood control does not exist at present.

From the present incomplete data, it is not possible to estimate quantitatively individual value of agricultural production from the three components, i.e., irrigation, drainage and flood control.

In some countries practising high technology the agricultural production is increased to meet their foreign export sales, while in others (developing countries) the tendency is to increase production in order to reduce imports of food stuffs.

2. There is an upward trend of intensification of agricultural outputs by adopting several means such as mechanisation, increased use of inputs, multi-cropping, more scientific cultural practices evolved from research and experience. The degree of intensification in various countries varies depending upon the stage of development (technical, social, economic and environmental) of a country. Urbanisation is on the increase to satisfy the aspirations of the farming population.

The area of cultivation is on the increase in all the countries, but with slower pace in advanced countries who take advantage of research and technology to achieve increased yields in the already cultivated lands.

3. Water demand for agriculture is increasing to meet the horizontal as well as the vertical expansions. The horizontal expansion is however more prominent in developing countries.

4. In most of the countries authorities for formulating water use and agricultural policies exist.

In all the countries planning organisations for water resources development exist. Interlinking of different water sectors has not been mostly covered in the reports. The countries have made preliminary attempt to project their water demands up to the year 2000 for reclamation and other uses.

5. Alongwith the development of agriculture, countries have been taking steps towards research on efficient use of water and land. The value of advanced technology is well recognised. Research on the use of advanced technology is required to identify its usefulness to a country.

6. Physical, social, economic, legal and environmental constraints on agricultural production have been described in all the reports. The constraints vary widely depending upon the state of development, available resources, etc.

7. Greater role is expected of ICID and its National Committees in meeting the challenge of requirements of large agricultural production towards the year 2000. Emphasis on research, training of personnel of developing countries and organisation of technical meetings has been stressed.

TEHRAN SPECIAL SESSION 1977

IRANIAN NATIONAL COMMITTEE OF ICID

COMITE NATIONAL IRANIEN DE L'ICID

SESSION SPECIALE DE TEHERAN 1977

RAPPORT GENERAL (F)

LIKELY IRRIGATED AGRICULTURE OF 2000 A.D.

CONTRIBUTION PROBABLE A PARTIR DE L'IRRIGATION, DU DRAINAGE ET DE LA MAITRISE DES CRUES, POUR FAIRE FACE AUX BESOINS DE LA PRODUCTION AGRICOLE VERS L'AN 2000—ROLE ET ACTIVITE DE L'ICID ET DE SES COMITES NATIONAUX

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RAPPORTEUR GENERAL

Douze rapports ont été reçus de onze pays (deux des Etats-Unis). Ils sont classifiés essentiellement en trois groupes traitant:

—des données et de renseignements de base (R 1, R 2, R 4, R 6, R 7, R 8, R 9, R 10 et R 12),

—du développement et de la recherche technologique moderne (R 3 et R 5),

—du rôle vital de l'ICID et de ses Comités Nationaux (R 11).

INTRODUCTION

L'agriculture irriguée est pratiquée du moins depuis l'émergence de la civilisation dans les zones arides du monde. C'est un fait historique que les civilisations anciennes de la Vallée de l'Indus, de la Vallée du Nil, des Vallées de l'Euphrate et de Tigris et de la plaine de Khuzestan avaient été établies autour et le long des principales berges des cours d'eau et que ces civilisations avaient eu de grands succès sous l'influence de l'irrigation. Il est aussi vrai que plusieurs civilisations importantes avaient été détruites une fois que les terres irriguées avaient perdu leur productivité étant donné l'accumulation de sels dans leurs sols. Cela était vrai car les gens ignoraient alors la gestion des terres et des eaux. Par ailleurs une crainte, notamment "l'explosion démographique" a semé depuis les deux dernières décennies la panique dans le monde entier et certains ont même prédit des famines successives. Voici leur raisonnement:

—Presque toute la terre du monde est en cours d'exploitation et il ne reste que de très peu de surfaces non cultivées dans le monde.

—Les hauts rendements des terres cultivées sont chers car les engrais et les autres entrées ont provoqué des récoltes très basses.

—L'énergie nécessaire à l'exploitation agricole sera plus chère qu'auparavant.

L'essentiel, c'est que cette section alarmiste de gens a manqué de tenir compte des terres disponibles dans le monde et a par ailleurs oublié d'étudier la potentialité de la plupart des terres dans le monde entier, susceptibles de produire deux fois plus d'aliments, et même plus. Par exemple, dans l'Amérique du Nord, la production céréalière a doublé depuis 1950; et les coûts réels de la production ont tombé en dépit du doublement des prix de l'application des engrais et des autres entrées.

L'Etude préliminaire de la situation alimentaire mondiale, mise au point à l'examen de la deuxième session du Comité Préparatoire de la Conférence Alimentaire Mondiale et le rapport du Secrétaire Général de la Conférence Mondiale de la Population de l'ONU (Bucarest, 19–30 Août 1974) nous laissent espérer une bonne production alimentaire mondiale pour l'avenir. Il en ressort de ces rapports traitant de la question de la future agriculture que si tous les pays du monde s'attachaient sérieusement à l'amélioration de l'agriculture, et plus particulièrement à l'agriculture irriguée, on n'aurait rien à craindre pour l'avenir.

A présent, on cultive environ 1.500 millions ha de terre pour produire les aliments, les fibres, les boissons et les autres commodités non-alimentaires à l'intention d'environ 4 milliards d'habitants.

Personne ne sait au juste le chiffre précis de la surface qu'on peut cultiver; mais selon les estimations de l'ONU et étant donné la distribution inégale de l'écoulement, seulement 30 pour cent de terre potentiellement arable grâce à l'irrigation, peuvent être effectivement irrigués et l'accroissement potentiel de la surface brute cultivée par l'arrosage se trouve limité à 1.110 millions ha. Si la population mondiale de l'an 2000 est supposée à 6 milliards, l'aliment nécessaire, chiffré en calories, serait alors de 15.000 milliards ($1{,}5 \times 10^{13}$) de kilo-calories par jour. Cette hypothèse est fondée sur 2.500 kilo-calories par jour par tête. Si l'on tient compte de protéines suffisantes et le contenu équilibré des acides aminés et des aliments protecteurs tels que fruits et légumes, on aura alors besoin de l'équivalent de 4.500 kilo-calories par personne par jour. D'après cette base, on aurait besoin de 27.000 milliards ($2{,}7 \times 10^{13}$) de kilo-calories par jour pour cette population mondiale de 6 milliards en l'an 2000. Selon les bonnes pratiques culturales, un hectare de terre tel que celui des pays avancés, produira 60.000 kilo-calories/jour. Par conséquent, la terre requise en l'an 2000 pour les buts agricoles serait de 450 millions ha. Compte tenu de 10 pour cent pour la production des fibres, boissons et les autres commodités non-alimentaires, d'un autre 10 pour cent pour les pertes inévitables et de 3 pour cent pour les semences, il faut ajouter alors à ce chiffre 100 millions ha. Il en résulte que le grand total de terres agricoles nécessaires pour la production de denrées, fibres et des autres produits agricoles pour l'an 2000 serait de 550 millions ha. Même en supposant qu'aucune nouvelle terre ne soit exploitée, la surface cultivée dans le monde (800 millions ha), douée d'une agriculture moderne telle que celle pratiquée dans les pays avancés, produira suffisamment d'aliments, de fibres et d'autres commodités agricoles pour une population de plus de 8.700 millions.

Il faut cependant prendre note de deux points qui méritent notre attention:

—la surface nette et brute potentiellement disponible à l'agriculture est plus grande que la surface cultivée à présent (point positif);

—le manque ou la limitation du savoir-faire et de technologie dans les pays en voie de développement ne leur permettent pas de croire à de telles productions élevées (point négatif).

Les surfaces brutes cultivables et irrigables du monde sont estimées respectivement à plus de 3.500 millions ha et 1.100 millions ha. Cette terre dotée d'un bon savoir-faire et d'une haute technologie peut fournir d'aliments, de fibres et d'autres produits agricoles pour plus de 40 milliards de personnes, qui sont presque respectivement 10 et 6,6 fois la population actuelle et celle de l'an 2000. Mais nous savons par contre qu'en dépit du rendement obtenu grâce à une haute technologie agricole, le rendement moyen de plusieurs pays en voie de développement est faible : à comparer plus de 6 tonnes d'aliments comestibles obtenus en pratiquant une haute technologie agricole avec seulement une tonne, dans certains pays en voie de développement.

Or pour atteindre ce niveau, il faut disposer du savoir-faire, du capital et des ressources diverses. On ne saurait développer la technologie du jour au lendemain, on n'acquiert ni non plus de capital par une chance quelconque. On ne peut exploiter de vastes surfaces de terre du monde que si on ne disposait du capital, de la technologie et des divers éléments nécessaires.

Environ 20 pour cent des 13.000 ha de terre de notre planète se trouvent répartis dans des zones arides et semi-arides. L'agriculture réussie n'est possible dans ces zones qu'avec l'arrosage; bien entendu, grâce à une irrigation totale ou de l'irrigation supplémentaire, on peut espérer à de très bonnes récoltes et même des récoltes record. Le potentiel de l'agriculture irriguée est en effet très vaste.

A présent il existe approximativement 240 millions ha de l'agriculture irriguée dans le monde entier, ce qui permet d'élargir les périmètres irrigués du monde. Il existe également des possibilités pour améliorer les facilités d'irrigation actuelles. Malheureusement, seulement une partie des ressources en eau sont utilisées en agriculture dans certains pays en voie de développement. L'ICID et ses Comités Nationaux pourraient envisager un rôle actif dans ce domaine et être une source d'espoir et de guide notamment pour trouver des solutions à ces problèmes.

RAPPORT 1: **Mise en valeur des ressources hydrauliques au Canada pour faire face aux besoins de la production agricole en l'an 2000** —par le Comité National Canadien de l'ICID

Le rapport passe en revue la situation des ressources en eau et le développement agricole du Canada. La demande en eau, actuellement faible, va augmenter avec le temps. La population est de 22,5 millions et elle sera entre 26 et 32 millions en l'an 2000. L'agriculture dépend essentiellement de la précipitation. Moins d'un pour cent de la superficie totale cultivée (44 millions ha) est irrigué, dont 80 pour cent se trouvent dans les trois provinces de prairie et la Colombie Britannique. En Alberta, 20 pour cent de rendements agricoles proviennent de 4 pour cent des terres cultivées qui sont irriguées. Le drainage de surface couvre 3 pour cent de la surface cultivée.

Le rapport déclare que la mise à jour des statistiques n'a pas été possible pour identifier les rendements agricoles provoqués par les développements d'irrigation, du drainage et de maîtrise des crues. L'absence de données détaillées sur la productivité potentielle des terres a entravé l'estimation du potentiel de l'irrigation. On envisage de remédier cette situation par un système d'inventaire automatisé de terre dans les 10 prochaines années.

Le rapport traite des tendances de mise en valeur des eaux et des terres. Bien que le Canada dispose de vastes domaines de terre arable susceptibles de défrichement soit par les améliorations foncières soit par la mise en valeur par drainage, la tendance est pour encourager l'utilisation des périmètres développés avant de toucher aux terrains non développés. Ainsi pour le moment, le surcroît de population sera nourri et les besoins mondiaux en blé, orge et graine de colza seront satisfaits par l'exploitation intensive des terres agricoles actuelles.

En ce qui concerne la demande de mise en valeur et de l'utilisation des ressources hydrauliques dans le contexte d'approvisionnement alimentaire en l'an 2000, la principale contribution proviendra des cultures non irriguées. Un exploitant canadien produit à présent assez d'aliment pour 50 personnes et il lui sera possible de doubler ce rendement, avec la même surface de terre en l'an 2000, grâce à l'utilisation des entrées technologiques améliorées, à savoir, variétés à haut rendement, gestion des eaux et des substances nutritives, meilleures semences, contrôle de maladies et de pestes, etc.

On trouve normalement au Canada toutes les combinaisons de types d'irrigation et de ressources en eau. On pratique de plus en plus les systèmes mécanisés d'aspersion.

En ce qui concerne la technologie avancée d'irrigation et la recherche, le rapport déclare que les technologies mécanisées de l'agriculture et la gestion des eaux en tant que dispositifs d'économie de main-d'oeuvre, seront adoptées très rapidement par les exploitants canadiens, quand elles seront disponibles. Les besoins en recherche dans le domaine d'irrigation embrassent divers aspects tels que études sur la classification des terres, besoins en eau et aptitude des cultures sous divers régimes écologiques, contrôle efficace de perte par évaporation et méthodes de lutte contre les mauvaises herbes, conception du système d'aspersion imbouchable et amélioration de la programmation d'irrigation. Le rapport traite également des besoins en recherche pour les meilleures techniques de drainage.

Finalement le rapport discute des contraintes faisant obstacle au développement d'irrigation et de drainage et signale que la contrainte majeure est l'exploitant lui-même qui est capable d'exercer sa propre évaluation des avantages et des inconvénients de s'adapter à des technologies en voie de développement vis-à-vis son propre système conventionnel de travail qui admet divers environnements agricoles. Deuxièmement, l'infrastructure doit être intensifiée avec le futur développement de l'irrigation et l'accroissement de la population. Les autres contraintes probables comprennent manque d'eau pour le développement du potentiel d'irrigation en Alberta et Saskatchewan et absence de données de base. Les projets de drainage peuvent être exempts de contraintes si on entreprend le drainage des marais, et ceci provoquerait des soucis parmi les enthousiastes de l'environnement et de la vie sauvage.

RAPPORT 2: **Contribution probable de l'agriculture irriguée vers l'an 2000 dans la République Démocratique du Soudan**—par A.M. Ibrahim

Le rapport parle des ressources en terre et en eau du pays. Le Nil et ses affluents constituent la source principale d'eau au Soudan. Le rapport décrit les caractéristiques du débit et du limon du Nil qui influencent la conception et l'exploitation des travaux d'irrigation.

Le Soudan a une population de près de 15,7 millions, qui augmente à un taux annuel de 2,8 pour cent. Quelque 90 pour cent de la population s'occupent de l'agriculture. La priorité est accordée au développement de l'irrigation et à l'agriculture mécanisée qui dépend des pluies. Des 6,7 à 7,1 millions ha cultivés, 1,7 millions ha sont arrosés, le reste dépend des précipitations.

Le rapport discute des besoins en eau et de l'utilisation du Nil par l'Egypte et le Soudan qui ont été décidés par la Commission du Contrôle du Nil, créée en 1920 par le Gouvernement Egyptien. Le Barrage de Sennar a permis au Soudan de développer le Projet de Gezira (420.000 ha) et d'élargir les projets de pompage le long du Nil principal et de ses affluents. Le projet envisage pour le développement ultérieur de l'irrigation, la construction du barrage de Roseires sur le bleu Nil; le rehaussement du barrage de Sennar et du barrage de Jebel Aulia sur le Nil blanc pour permettre au Soudan de prélever un supplément de 200 millions m^3 d'eau.

Le rapport présente le développement qui a eu lieu après l'indépendance et les protocoles signés avec l'Egypte quant à l'usage futur des eaux, selon lesquels la part du Soudan des eaux du Nil a augmenté de 4 milliards m^3 à 18,5 milliards m^3, mesurés à Aswan. Le pays a envisagé d'augmenter le potentiel en eau du barrage de Roseires en construisant sa deuxième phase. En vue de réaliser l'autonomie dans la production alimentaire, un plan à long terme de développement de l'agriculture irriguée est en cours d'étude du Gouvernement.

Le rapport parle du développement à long terme de l'agriculture irriguée dans le pays. Le taux d'accroissement annuel de production agricole est fixé à 4,5 pour cent. Un programme de développement de six ans (1977-82) est en cours de préparation. Il envisage la mise en valeur de 28, 33 millions ha de terres qui dépendent des pluies et portant les cultures telles que coton à courtes fibres, graines oléagineuses, sorgho et les autres céréales. Le Gouvernement envisage également de mettre en valeur vers l'an 2000, 3,12 millions ha de l'agriculture irriguée pour veiller à une production stable de cultures à hauts rendements de haute valeur.

Le rapport discute l'utilisation de sa quote-part de 18,5 milliards m^3 des eaux du Nil pour ses projets existants et ceux en cours d'installation. On pense que la mise en valeur d'irrigation fournira un supplément de 1,42 millions ha, permettant de disposer d'une surface totale irriguée de 3,12 millions ha vers l'an 2000. La production future des cultures irriguées telles que le coton, le blé, l'arachide, les fruits et les légumes est anticipée à 4 fois la production actuelle et celle du sucre à 25 fois. Les besoins en eau ultimes du Soudan, à partir du Nil, seront de 30 milliards m^3. Il a besoin d'un supplément de 10 milliards m^3 pour la mise en exécution du plan à long terme de l'agriculture irriguée.

En vertu du Protocole du Nil de 1959, le Soudan et l'Egypte sont tenus de faire des efforts communs pour empêcher les pertes d'eau dans la région du Sudd, au sud du Soudan. Selon les indications des études hydrologiques il semble que la pénurie d'eau des deux pays, Soudan et Egypte, sera évitée par la mise en valeur probable de 18 milliards m^3 des marais. L'aboutissement de l'entreprise conjointe du projet de dérivation du canal de Jonglei en 1982, fournira un supplément de 4 milliards m^3 d'eau qui seront répartis également entre les deux pays pour leurs développements agricoles respectifs.

RAPPORT 3: **Impacts des fluctuations climatiques sur les écosystèmes producteurs d'aliments**—par Dr. Dexter Hinckley

Le rapport déclare qu'on ne doit pas ignorer le climat dans une planification vers l'an 2000, notamment dans les écosystèmes producteurs d'aliments. La productivité agricole dépend des périodes des conditions favorables de croissance ainsi que des techniques de gestion qui protègent les cultures contre l'impact des périodes défavorables. Les entrées vitales pour les écosystèmes producteurs d'aliments sont l'énergie solaire et l'acide carbonique, d'une part et l'eau d'irrigation, d'autre part avec une entrée supplémentaire de variation de climat, dans certaines circonstances. On peut accroître l'entrée nutritive par une application appropriée d'engrais. Les autres entrées probables sont les herbicides, pesticides, etc.

Le rapport indique qu'on a considéré l'écosystème irrigué pour la base de l'analyse d'entrée et de rendement, pour l'étude des processus de croissance des plantes pour examiner l'impact des variations climatiques, qui peuvent affecter directement ou indirectement les cultures.

De plus, les dommages des cultures dûs aux maladies et pestes peuvent également augmenter dans les conditions arides résultant des sécheresses. Ayant reconnu ces influences retardataires et nuisibles des variations climatiques sur la production agricole, il serait approprié d'installer de meilleurs écosystèmes et d'élaborer une série de stratégies protectrices basées sur le concept d'écosystème et de s'apprêter à faire face à la situation de l'an 2000.

Le rapport appuie sur l'importance de renforcer les réseaux météorologiques, les observations écologiques régulières dans les zones agricoles et l'utilisation des techniques de télédétection, à partir des avions et satellites, au contrôle au niveau terrestre. Une situation probable de grave sécheresse dans les années à venir fait appel à une réflexion et une planification pour un besoin accéléré d'irrigation, en explorant de nouvelles sources dans des bassins lointains ou des aquifères profonds, moyennant de gros investissements. De même on ne peut pas trop se fier à des techniques de variations du climat.

Le rapport suggère des voies pour l'utilisation efficace des apports d'eau rares, à savoir, concevoir l'écosystème autour des cultures tolérant la sécheresse, changement de cultures appropriées, en remplaçant les cultures qui ont besoin de grandes quantités d'eau par celles qui peuvent pousser avec moins d'eau, adoption de la technique du goutte à goutte pour réduire les pertes par évaporation, etc.

Le rapport signale plusieurs moyens alternatifs pour accélérer la croissance des plantes (en cas de manque d'eau), tels que recyclage d'eau dans les milieux où abonde l'énergie solaire, usage concentré d'engrais, usage plus efficace des éléments nutritifs, dosages accrus de l'acide carbonique pour accélérer la croissance des feuilles, etc.

RAPPORT 4 : **Contribution probable de l'agriculture irriguée vers l'an 2000. Rôle de l'ICID et de ses Comités Nationaux pour faire face à la situation**—par le Comité National Iranien de l'ICID

Le rapport établit l'importance de l'irrigation en passant en revue la contribution qu'elle a apportée à la production totale agricole qui est à présent environ 64 pour cent en termes de valeur. Des 4 millions ha irrigués, 3,7 millions ha sont arrosés pendant 1975. Environ 8 millions ha constituent la région d'aridoculture.

L'Iran dispose très peu de ressources en eau. La précipitation annuelle moyenne est de 230 mm. Les quantités d'eau de ruissellement, d'infiltration et en provenance des bassins extérieurs représentent en moyenne entre 100 et 110 milliards de m^3 par an; l'irrigation consomme 25 à 30 milliards de m^3 et les pertes dues à l'irrigation s'élèvent environ à 10 à 15 milliards de m^3. Par conséquent le potentiel hydraulique qui reste est de l'ordre de 60 à 70 milliards de m^3 par an, dont on peut espérer utiliser encore le tiers d'ici l'an 2000.

Le rapport parle de diverses contraintes et de leur influence sur l'agriculture irriguée. Ces contraintes sont le climat, les ressources en eau, le sol, les aspects démographiques et sociaux et les centres de production vis-à-vis des installations de la population.

Le rapport passe en revue le développement économique de l'agriculture irriguée et fixe l'objectif de l'irrigation à 6 millions ha et l'accroissement de la valeur nette à trois fois vers l'an 2000. Le rapport présente les actions initiées pour atteindre les objectifs du développement de l'agriculture irriguée. Ces mesures comprennent une meilleure régularisation des eaux de surface ou souterraines, réduction de l'évapotranspiration et installation de nouvelles structures.

Le rapport passe en revue la technologie avancée adoptée en Iran, dont les techniques de pluie provoquée, la réutilisation des eaux usées, la télétransmission des données hydrologiques, l'approche des systèmes, l'utilisation du dessalement des eaux occupent une place importante. Pour les complexes agro-industriels, on envisage l'agriculture sous-serre et les techniques hydroponiques, l'utilisation des eaux de basse qualité, la lutte contre la pollution, etc.

Enfin, le rapport présente le rôle du Comité National Iranien de l'ICID et la contribution qu'elle apporte à la promotion des buts de l'ICID.

RAPPORT 5: **Progrès dans la technologie d'estimation des besoins en eau. Une contribution à la gestion moderne des eaux**—par le Comité National Britannique de l'ICID.

Le rapport déclare que la plupart des zones d'irrigation traditionnelle du monde s'approchent de la limite de la mise en valeur des ressources hydrauliques dans les 25 années restantes de ce siècle. L'eau doit donc être utilisée aussi efficacement que possible vers l'an 2000. Il est essentiel d'adopter une gestion efficace des systèmes d'irrigation. Ceci exige à son tour une estimation améliorée des besoins en eau des cultures, application opportune des eaux d'irrigation et réduction des pertes en transit des eaux dans les systèmes d'irrigation.

Le rapport passe en revue les études expérimentales consacrées dans le Royaume-Uni notamment au sujet des besoins en eau des cultures tels que les travaux de Penman à la Station Expérimentale de Rothamsted, Monteith à l'Université de Nottingham et les travaux menés dans les divers centres de recherche.

Le rapport présente une courte revue historique des tendances passées constatées dans le développement des systèmes d'irrigation en Inde, Egypte, Soudan et aux Etats-Unis et précise que jusqu'à l'heure actuelle très peu a été effectué pour améliorer le contrôle des systèmes d'irrigation et l'efficacité de l'usage des eaux.

Le rapport estime au premier abord comment les méthodes anciennes et actuelles d'estimation ont aidé à fixer les gammes des besoins en eau des cultures irriguées et cultivées dans des conditions climatiques locales particulières. Le rapport passe ensuite en revue les travaux de recherche en cours qui peuvent mener au développement des méthodes d'estimation plus précises qui seront nécessaires, si on devrait utiliser l'eau d'irrigation beaucoup plus efficacement. Le rapport termine par une discussion sur la place de ces nouvelles méthodes dans une meilleure prévision des demandes d'irrigation.

RAPPORT 6: **Planification à long terme de la mise en valeur hydraulique et de l'utilisation des eaux pour l'expansion de la production agricole en Bulgarie**—par Dimiter Davidov

Le rapport décrit le rôle important de l'irrigation, du drainage et de la maîtrise des crues en Bulgarie et souligne que l'irrigation est capable de doubler la production agricole. L'examen actuel indique que de la superficie totale cultivée de 5 millions ha, 1,1 million ha sont irrigués et 0,1 million ha sont drainés. La capacité de retenue des 2047 grands et petits barrages est de 2,8 milliards de m^3, et il existe 2800 stations de pompage avec une capacitié de 500.000 kW. Les surfaces potentielles d'irrigation et de drainage sont respectivement de 3,5 millions ha et 0,2 million ha. Pour donner satisfaction au programme de développement social et économique du pays, on envisage une augmentation de la production agricole d'un taux annuel de 5 pour cent, ce qui est possible par l'expansion horizontale et verticale de l'irrigation, pour laquelle il est nécessaire de prévoir à une augmentation moyenne de 0,5 million ha par an.

A la base de l'évaluation des apports d'eau, des ressources en main-d'oeuvre et des besoins accrus de la production agricole, le rapport établit les indices numériques généralisés pour la période d'ici à l'an 2000. Ces indices sont particulièrement importants pour déterminer la quantité et le degré de reconstruction, le taux de croissance des systèmes d'irrigation et de drainage, les variétés de cultures portées par les terres bonifiées et les besoins en devises étrangères.

Le rapport passe en revue les tendances des méthodes d'irrigation. La surface irriguée par la méthode d'aspersion est à présent de 45 pour cent (1975), ce qui touchera 60 pour cent en l'an 1985 et 80 pour cent vers l'an 2000. On a mentionné, pour accroître le rendement des irrigations, quelques aspects du réseau de distribution, tels que usage du réseau de conduites à haute charge pour les débits jusqu'à 1 m^3/s, etc.

Le rapport décrit les problèmes social, économique et technique auxquels les futures activités de développement font face en vue d'augmenter la production agricole vers l'an 2000.

RAPPORT 7: **Contribution probable de l'agriculture irriguée vers l'an 2000. Rôle et activités de l'ICID et de ses Comités Nationaux pour faire face à la situation**—par le Comité National Ethiopien de l'ICID

Le rapport passe en revue la situation des ressources hydrauliques en Ethiopie qui se trouvent non utilisées pour l'agriculture scientifique irriguée, non encore introduite dans le pays. Cependant, la sécheresse continue depuis les trois dernières années et la population croissante des plateaux de l'Ethiopie ont forcé le pays à reconnaître la nécessité de développer l'agriculture irriguée et de procéder à un développement intégré des bassins. Seulement un bassin a vu un développement considérable de l'irrigation par pompes et le système de gravité.

Le Gouvernement a établi "Valleys Agricultural Development Authority" pour intensifier l'irrigation et les développements agricoles. Cette autorité est chargée d'évaluer les terres disponibles, les ressources en eau, de formuler les politiques, de lancer les études de possibilité, d'initier les projets et programmes pour le développement régional intégré, d'identifier les agro-industries et de traiter de leurs aspects socio-économiques et de l'environnement, de solliciter l'aide financière pour l'exécution des programmes de mise en valeur des ressources hydrauliques et de fournir l'assistance technique nécessaire aux exploitations agricoles de l'état, corporations rurales, etc.

Le rapport fournit sous forme de tableaux les renseignements sur les surfaces irriguées et le potentiel d'irrigation. A présent, 87.000 ha sont irrigués dans le pays. Approximativement 56.000 ha sont irrigués seulement dans la vallée d'Avash, et le potentiel de la surface irrigable est de 148.000 ha.

RAPPORT 8: **L'irrigation et le drainage: un rapport national, Etats-Unis d'Amérique**—par le US Bureau of Reclamation, Department of Interior

Le rapport passe en revue la situation nationale de la production agricole qui a toujours été excédentaire. L'agriculture américaine peut actuellement nourrir environ 50 millions de plus que la population actuelle du pays. Le Comité National Américain de l'ICID affirme leur volonté d'assister les nations en voie de développement du monde dans la mise en valeur de leurs ressources en terre et en eau envers une plus grande production d'aliments et de fibres.

En ce qui concerne le rôle de l'irrigation et du drainage, le rapport indique que 14 pour cent de la surface irriguée contribuent plus de 20 pour cent de la production totale agricole dans le pays, la population agricole a progressivement diminué de 9,4 pour cent en 1959 à 4,4 pour cent aujourd'hui, par suite de la mécanisation accrue de l'agriculture.

Le rapport parle brièvement de la tendance vers les changements dans l'utilisation des terres en indiquant que l'utilisation des terres cultivées augmentera quelque peu pour faire face à la demande mondiale et nationale, quand cela est nécessaire, et que la production s'intensifiera davantage grâce à des progrès technologiques.

En ce qui concerne la mise en valeur et l'utilisation des eaux, on rapporte que la demande en eau pour l'agriculture et les autres buts augmentera considérablement. On concentrera essentiellement les efforts vers l'utilisation économique et efficace, une mise en valeur extensive et un développement technologique simultané et distribution améliorée des eaux.

Au sujet de l'expansion verticale et horizontale de l'irrigation, le rapport déclare que la formulation d'une Politique Nationale hydraulique et agricole pourrait aider à la future planification. Le libre cours du marché y compris la dispersion de la technologie encouragent la production agricole de haut niveau.

Le rapport donne la liste des diverses nouvelles techniques de production actuellement en étude à degrés variables dans le pays. Ils sont en diverses étapes de développement et d'application. Le rapport souligne que la recherche est nécessaire pour déterminer l'avantage de ces techniques particulièrement dans les régions de haute densité de population.

Enfin, le rapport parle des contraintes économique, juridique, physique et sociale. En résumé, la considération des impacts nocifs de l'environnement à partir des activités de la production agricole s'avérerait une contrainte majeure pour le développement des ressources dans le prochain quart du siècle.

RAPPORT 9: **L'agriculture irriguée en Mexique vers l'an 2000**—par Eng. Fernando J. Gonzalez Villarreal et Eng. Manuel Contijoch (Mexique)

Le rapport décrit l'importance de l'infrastructure hydroagricole qui permet de développer la productivité des terres, la création d'emplois et une augmentation de la valeur ajoutée par la production agricole et de l'élevage du pays.

A présent, environ 5 millions ha sont dotés de l'infrastructure agricole qui représentent 30 pour cent de la surface nationale cultivée et qui fournissent 50 pour cent de la production agricole totale et une ample variété de produits de base.

Le rapport traite des objectifs nationaux d'irrigation et de drainage qui tendent à contribuer à l'augmentation de la production agro-pastorale et des éléments à l'industrie nationale, à fournir des emplois productifs pour la section rurale et à saisir l'avantage des opportunités disponibles dans le marché international, à encourager le développement rural par des ouvrages hydrauliques, et à utiliser au maximum l'infrastructure installée. Le rapport présente les buts envisagés pour l'an 2000 qui préconisent le doublement de la superficie dotée de l'infrastructure hydraulique, à savoir, de 5 millions ha à présent à 10 millions ha à la fin du siècle. Selon la stratégie régionale, 58 pour cent de nouvelles terres seront choisies dans la Zone du Golfe et du Sud-Est où, étant donné les problèmes minimes, tant sociaux qu'écologiques de tropique humide, seront installés des projets pilotes comme première étape vers les grands projets à réaliser dans cette région accompagnés de programmes spécifiques d'investigation, de formation et de diffusion qui seront réalisés par un Institut de Développement Tropical.

Le rapport indique l'investissement prévu et les résultats à réaliser vers l'an 2000. Un investissement de 266.000 millions pesos (1975) permettra d'obtenir durant les 25 prochaines années, un taux de production de 4 pour cent et un supplément de 820.000 emplois permanents d'un coût unitaire moyen de 185.000 pesos (1975).

Grâce à leur réalisation, les superficies dotées de l'infrastructure hydro-agricole, pourront en l'an 2000, contribuer jusqu'à 65 pour cent de production agricole totale. Il sera donc possible de satisfaire la demande de produits agro-pastoraux, en supposant une augmentation de la production des régions de cultures saisonnières coïncidant avec les tendances enregistrées auparavant et les politiques actuelles.

RAPPORT 10: **Effet actuel et anticipé de la mise en valeur des terres sur l'accroissement du rendement agricole en Tchécoslovaquie** —par Ing. Tasky Josef et Ing. Heldi Anton

Le rapport discute du rôle vital des améliorations foncières dans l'accroissement de la production agricole en Tchécoslovaquie. Des 7 millions ha de terres agricoles, 244.000 ha sont irrigués, 755.000 ha sont drainés et 76.000 ha sont irrigués et drainés. L'irrigation est surtout supplémentaire. La surface potentielle irrigable dans divers bassins fluviaux a été estimée à 1.366 millions ha. La production agricole des terres bonifiées a été estimée pour 1971-75 et on présente les données relatives à l'accroissement de la production annuelle des cultures essentielles cultivées dans les surfaces bonifiées. Le concept des systèmes d'irrigation grands et moyens est considéré avantageux étant donné qu'avec l'introduction de la mécanisation, les besoins en main-d'oeuvre sont nettement réduits.

Le drainage tchèque est fonction de la régulation des cours d'eau. Quelque 9.500 km de cours d'eau sont régularisés. Le rapport décrit les travaux des systèmes de drainage dans le pays.

Les renseignements démographiques de Tchécoslovaquie indiquent (1974) que parmi les 14,7 millions d'habitants, 1,06 millions sont employés dans le domaine agricole. Les tendances actuelles vers l'expansion horizontale de mise en valeur telles que prévues dans le 6ème Plan Quinquennal (1976-80) sont : le développement de drainage de 255.000 ha, l'irrigation de 64.000 ha, et la régularisation des cours d'eau de 1.600 km. Par la suite, la production accrue des plantes des surfaces bonifiées contribuera 12 pour cent de la production totale en Tchécoslovaquie.

Le potentiel de l'expansion verticale et horizontale des améliorations foncières a été estimé. Vers l'an 1990, le drainage de 86,5 pour cent de terres sera accompli et 38,4 pour cent des systèmes d'irrigation seront construits selon les besoins nationaux.

Le rapport mentionne brièvement des projets à long terme du développement agricole tchèque qui envisagent l'application accrue d'engrais, davantage de variétés plus productives et automatisme général. Une estimation des mesures de bonification intensive jusqu'à 1990 a été faite, et elle envisage l'accroissement de production (par l'expansion verticale) de 2.880 kcs/ha. Le pays pense pouvoir fournir les demandes entières en eau pour l'irrigation de 525.000 ha vers l'an 1990. La demande en eau d'irrigation en 1975 était de 268 millions m^3 et en 1990 elle est estimée à 788 millions m^3.

Le rapport présente les tendances de développement prévu par suite des technologies avancées adoptées dans la construction et l'exploitation des structures de mise en valeur. On a parlé brièvement du rendement hydraulique des irrigations, des tendances de la politique et de l'économie de la gestion des eaux, des aspects organisationnels et administratifs pour l'exécution de la politique, les besoins de la recherche et de la coopération internationale dans le domaine de la recherche et de l'application de la nouvelle connaissance.

Le rapport mentionne très brièvement des problèmes rencontrés dans la coordination des diverses activités relatives à la mise en valeur des terres. Les contraintes économiques et de l'organisation peuvent résulter des bilans inter-départementaux des matériaux et des machines de construction eu égard aux besoins de la construction des améliorations foncières.

RAPPORT 11: **Contribution probable à partir de l'irrigation, du drainage et de la maîtrise des crues, pour faire face aux besoins de la production agricole vers l'an 2000. Rôle et activité de l'ICID et des Comités Nationaux**—par le Comité National Français de l'ICID

Le rapport soumet un certain nombre de points concernant les futures activités de l'ICID et de ses pays membres, que nous énumérons ci-dessous:

(1) L'ICID doit s'efforcer d'obtenir l'adhésion de pays nouveaux, notamment en Amérique du Sud et surtout en Afrique au Sud du Sahara.

(2) Il est souhaitable que l'ICID suive de près certains grands problèmes mondiaux. L'ICID n'est pas membre du "Club des amis du Sahel" formé en 1976. Le Comité National Français est en mesure de représenter l'ICID, si cette dernière le désire, au sein du Club.

(3) Le Questionnaire relatif à la Session Spéciale doit être également envoyé aux gouvernements des pays non-membres, de façon à avoir une vue aussi complète que possible des perspectives de développement des aménagements hydro-agricoles dans le monde.

(4) L'ICID dispose d'un certain nombre de Comités ou groupes de travail permanents ou temporaires qui recouvrent une grande part des questions auxquelles devra s'intéresser la Commission dans les années qui viennent. Parmi eux, le "Comité permanent chargé d'attirer l'attention sur les nouveaux développements" et le "Comité permanent des rapports" vont devoir, à la lumière des conclusions de la Session Spéciale, proposer la mise

à l'étude d'un certain nombre de thèmes nouveaux ou renouvelés, orientés vers les évolutions d'avenir, tels que ceux qui figurent au paragraphe III du rapport. De nouveaux groupes de travail devront sans doute être créés à cet effet, mais il importe qu'ils restent peu nombreux.

(5) Les sujets qui seront choisis pour les prochains Congrès auront à tenir compte de ces orientations prévisibles. Mais outre les sujets d'ordre général, il est souhaitable que, contrairement aux habitudes acquises, certains sujets spécifiques, portant sur l'aménagement des bassins des grands fleuves mondiaux, puissent être également retenus et proposés à la réflexion de tous les pays membres, même si ces derniers n'en sont pas riverains.

(6) Des stages bilingues anglais et français, placés sous le signe de l'ICID, pourraient être organisés à raison de un chaque année, dans les pays ayant acquis de l'expérience en matière d'irrigation, de drainage et de maîtrise des crues. Le Comité National Français estime que la France peut organiser de tels stages, ouverts à trente stagiaires choisis par le Bureau Central de la Commission, tous les 6 ans à partir de 1980; il s'efforcera d'obtenir de son gouvernement une participation financière. Une aide devrait être également recherchée du côté des grandes organisations internationales.

(7) Un échange d'information sur les expériences de chaque pays en matière d'enseignement de l'irrigation, du drainage, de la maîtrise des crues et des disciplines connexes pourrait être entrepris par l'ICID en liaison avec l'UNESCO et l'OAA (FAO) concernant tous les niveaux de formation.

(8) La présente Session Spéciale et le Questionnaire qui la suivra auront été l'occasion pour les Comités Nationaux de réfléchir à l'avenir des irrigations, du drainage et du contrôle des crues à la fois dans leur propre pays et dans le monde. L'intérêt qu'aura suscité chez eux cette réflexion doit se maintenir.

Les Comités Nationaux de l'ICID sont de statuts divers, plus ou moins proches de leurs gouvernements, et disposent de plus ou moins de ressources. Il ne paraît pas utile de modifier cet état de choses, mais en résulte nécessairement un certain flou dans le rôle que peuvent jouer individuellement ces Comités Nationaux. Ce rôle doit être avant tout d'animation et de réflexion dans leur propre pays et d'information régulière à l'égard du Bureau Central.

(9) L'ICID a maintenant plus de 25 ans d'expérience et ses avis sont écoutés. Bien que n'étant pas une organisation gouvernementale, elle peut dans certains cas être amenée à faire, ce qui n'est pas actuellement dans ses habitudes, des recommandations aux gouvernements eux-mêmes, les Comités Nationaux s'employant à soutenir ces recommandations auprès de leur propre gouvernement.

RAPPORT 12: **Contribution probable à partir de l'irrigation, du drainage et de la maîtrise des crues pour faire face aux besoins de la production agricole vers l'an 2000**—par le Comité National Indien de l'ICID

Le rapport passe en revue le présent état de l'irrigation dans le pays. La surface cultivée en Inde d'environ 140 millions ha, restée stationnaire, indique qu'on est arrivé à la dernière limite du défrichement de nouvelles superficies. La population qui était de 361 millions en 1951 a atteint 547 millions en 1971 et serait d'environ 935 millions à la fin du siècle. Les demandes accrues en aliments et en fibres doivent par conséquent émaner essentiellement des rendements accrus par hectare de terre. Ceci n'est possible que grâce à la disponibilité d'irrigation à de nouvelles surfaces, l'irrigation étant une entrée de base pour la production agricole accrue.

Le rapport présente le potentiel d'irrigation et le but à atteindre avant l'an 2000. Le potentiel d'irrigation ultime du pays a été estimé à environ 110 millions ha, 70 millions ha desservis par les projets d'eau de surface et 40 millions ha par les projets d'eau souterraine. En fin mars 1974, c'est-à-dire, vers la fin du Quatrième plan quinquennal, le potentiel développé a été estimé à près de 44 millions ha, qui touchera probablement 86 millions à la fin du siècle, 53 millions ha desservis par les projets d'eau de surface et 33 millions ha par les projets d'eau souterraine. L'accroissement anticipé entre 1974 et 2000 serait donc de 42 millions ha. Le Cinquième plan quinquennal prenant fin en mars 1979 envisage la création d'un potentiel supplémentaire de 12,2 millions ha, ce qui représente une augmentation annuelle de plus de 2,4 millions ha. Gardant cette allure, il sera possible dans les plans futurs d'atteindre le but de 86 millions ha vers l'an 2000.

Le débit annuel utilisable a été estimé à 70 millions hectares mètres, desquels l'utilisation en fin du Quatrième plan quinquennal serait de 25 millions hectares mètres. Le potentiel définitif d'eau souterraine est estimé à 27 millions hectares mètres desquels 13 millions hectares mètres ont été utilisés jusqu'en 1974. La Commission Nationale de l'Agriculture a projeté une demande pour la fin du siècle aux fins d'irrigation, de 42 millions hectares mètres à partir des eaux de surface et 21 millions hectares mètres à partir des eaux souterraines. La demande pour les autres besoins industriels et l'alimentation en eau potable est estimée à 8 millions hectares mètres à partir des eaux de surface et à 4 millions hectares mètres à partir des eaux souterraines. On disposerait ainsi jusqu'en 2000 pour les activités de développement un apport suffisant de ressources en eau. Avec les progrès technologiques et la mise en valeur des ressources hydrauliques, les ressources en eau de surface et en eau souterraine qu'on peut utiliser vont probablement augmenter.

Le rapport cite quelques problèmes rencontrés et les solutions adoptées. Les années à venir verront l'exécution accélérée des travaux de préparation de terres et de provision des facilités de drainage, ce qui augmenterait la productivité des sols. Pour que les exploitants bénéficient des pratiques technologiques modernes, il faut veiller à une provision de services de vulgarisation agricole d'une manière suffisante.

On a entamé le contrôle des projets importants pour veiller à une mise en application efficace des projets et pour réaliser les programmes de construction sans aucun échec. On révise de temps en temps les besoins en fonds nécessaires pour atteindre les buts physiques et pour garnir de fonds nécessaires. Pour augmenter les ressources financières, on saisit également les facilités d'aide financières accordées par les agences internationales.

CONCLUSIONS

Les renseignements présentés dans les divers rapports varient largement en contenu et données; quelques pays se sont efforcé de fournir les renseignements et les données sollicités, tel qu'il a été prescrit dans le questionnaire aimablement mis au point par le Dr. Horning de la FAO. Les données et les renseignements soumis dans les rapports revêtent un très grand intérêt et une grande valeur. Il est encourageant de noter que même un pays nouveau (Ethiopie) ait fait un effort pour soumettre son rapport national à la Session Spéciale.

On s'aperçoit clairement des rapports les tendances positives qui permettraient de mobiliser les futurs efforts des pays membres de l'ICID pour faire face aux défis de l'an 2000 dans le domaine de l'agriculture irriguée dans le contexte du problème alimentaire mondial:

1. L'importance de l'irrigation, du drainage et de la maîtrise des crues est clairement établie comme facteur d'accroissement de la production alimentaire mondiale. La production agricole des terres irriguées est sensiblement plus élevée que celle des régions arrosées par les pluies. Avec l'introduction des intrants et de la mécanisation, le rendement unitaire augmente à la fois dans les régions irriguées et les zones de précipitations, mais la tendance de l'accroissement du rendement des terres irriguées est définitivement plus forte et fiable que celui de la zone de précipitations.

La population rurale montre généralement une tendance décroissante avec l'introduction de la mécanisation et des intrants agricoles. Dans certains pays les dimensions des exploitations augmentent étant donné les dispositifs qui épargnent la main-d'oeuvre. Il n'existe pas pour le moment de subdivision de la population agricole en ce qui concerne l'irrigation, drainage ou la maîtrise des crues.

Avec les données incomplètes que nous disposons à présent, il n'est pas possible d'estimer quantitativement la valeur individuelle de la production agricole à partir des trois facteurs, à savoir, irrigation, drainage et maîtrise des crues.

Dans certains pays qui pratiquent une haute technologie, la production agricole est accrue pour faire face à leurs ventes/exportations à l'étranger, alors que dans les autres (pays en voie de développement) la tendance est vers l'accroissement de la production en vue de réduire les importations alimentaires.

2. Il y a une tendance vers l'intensification des rendement agricoles par l'adoption de plusieurs moyens tels que mécanisation, utilisation accrue des intrants, cultures multiples, pratiques plus scientifiques et culturales élaborées à partir de la recherche et de l'expérience. Le degré d'intensification dans divers pays varie selon l'étape de développement (technique, social, économique et de l'environnement) d'un pays. L'urbanisation se multiplie pour satisfaire les aspirations de la population rurale.

La surface irriguée est en cours d'augmentation dans tous les pays, mais à une allure lente dans les pays avancés qui profitent de la recherche et de la technologie pour obtenir les rendements accrus à partir des zones déjà cultivées.

3. Les besoins en eau pour l'agriculture vont en croissant pour répondre à l'expansion horizontale et verticale. L'expansion verticale est cependant plus prépondérante dans les pays en voie de développement.

4. Dans la plupart des pays, les pouvoirs publics existent pour formuler les politiques agricoles et celles de l'usage des eaux.

Dans tous les pays, il existe d'organismes de planification de la mise en valeur des ressources hydrauliques. Les rapports n'ont pas tenté de lier divers secteurs d'eau. Les pays ont fait des tentatives pour projeter leurs besoins en eau vers l'an 2000 pour la mise en valeur et les autres emplois.

5. Parallèlement à la mise en valeur agricole, les pays prennent des démarches vers la recherche sur l'usage efficace des eaux et des terres. La valeur de la technologie avancée est bien reconnue. La recherche sur l'utilisation de la technologie avancée est nécessaire pour identifier son avantage à un pays.

6. Tous les rapports parlent des contraintes physique, sosio-economique, juridique et de l'environnement vis-à-vis de la production agricole. Les contraintes varient largement en fonction du stade de développement, des ressources disponibles, etc.

7. On envisage pour l'ICID et ses Comités Nationaux un plus grand rôle pour faire face aux besoins de la production agricole vers l'an 2000. On a souligné l'importance de la recherche, de la formation du personnel dans les pays en voie de développement et de l'organisation des réunions techniques.

REPORTS

TEHRAN SPECIAL SESSION 1977

IRANIAN NATIONAL COMMITTEE OF ICID

COMITE NATIONAL IRANIEN DE L'ICID

SESSION SPECIALE DE TEHERAN 1977

R. 1

LIKELY IRRIGATED AGRICULTURE OF 2000 A.D.

WATER DEVELOPMENT IN CANADA TO MEET AGRICULTURAL PRODUCTION REQUIREMENT FOR 2000 A.D.*

CANADIAN NATIONAL COMMITTEE—ICID

INTRODUCTION

Canada is still a young country in terms of development and the demands upon her water resources have been relatively small. However, the present population of 22·5 million is expected to grow to between 26 and 32 million by the year 2000. The major growth centers will be in the southern parts of Quebec and Ontario and on the southern coast of British Columbia. Pressures on water resources will be felt in these areas.

Most of Canada's agriculture relies on natural water supply through precipitation. There are, however, significant withdrawals for irrigation and stock watering. The Prairie Provinces (Manitoba, Saskatchewan and Alberta) lead in irrigation water withdrawals followed by British Columbia and Ontario.

I. PRESENT LAND USE AND ROLE OF IRRIGATION AND DRAINAGE

A. IRRIGATION AND DRAINAGE REGIONS

The major crop production in Canada is on rainfed soils. A relatively small proportion (less than one per cent) is irrigated. Only in the south central portion of British Columbia is irrigation essential for crop production.

The largest irrigated area of Canada is located in the province of Alberta (Tables I and II), followed by British Columbia, then by Quebec and Ontario each with about 40,000 ha. Drainage, on the other hand, has been developed primarily in Ontario and Quebec with some having been developed in British Columbia and the eastern maritime provinces.

* Mise en valeur hydraulique au Canada pour faire face aux besoins de la production agricole en l'an 2000.

TABLE I

Baseline data for land use in Canada

Region	*Total Culti-vated area*	*Fallow per cent*	*Rangeland (unimp-roved)*	*Irrigated areas*	*Drainage (subsurface)*	*Pastures and hay with irrigation*
	1,000 ha	*%*	*1,000 ha*			
1	2	3	4	5	6	7
Atlantic Provinces	561	2	857	2	11	
Quebec	2,610	1	1,761	38	86	20
Ontario	4,397	2	2,063	40	1,158	2
Manitoba	5,181	21	2,511	3		1
Saskatchewan	18,788	36	7,539	31		23
Alberta	11,518	25	8,517	217		91
British Columbia	710	10	1,646	89	4	59
Total	43,765		24,894	421	1,259	196

Moving from east to west across Canada the main regions are:

Atlantic Provinces (Newfoundland, Nova Scotia, Prince Edward Island, New Brunswick) and Quebec—These regions have a maritime climate, normally with adequate precipitation and therefore with little irrigation. Because much of the arable land is flat and nearly at sea level, drainage is necessary and frequently a problem. In some areas dyking from river and tidal flooding is necessary.

Ontario : In this province the major arable land is adjacent to lakes Ontario and Erie and in the valleys of the St. Lawrence and Ottawa Rivers. Some arable land is also to be found between the Canadian Shield and the Great Lakes of Superior and Huron. Generally the climate is continental with adequate precipitation during most of the growing period of 110 to 130 days. Supplemental irrigation is needed in the south western portion of the province where high valued crops (fruit, canning crops, tobacco) are grown.

Because of the flatness and fine texture of much of the alluvial soils (glacial lake beds) drainage is essential for efficient crop and pasture production. In some cases dyking is needed to prevent flooding from high water in both rivers and lakes.

TABLE II

Areas of irrigated crops by region (1970 Data)

(*Unit in 1,000 ha*)

Crop	Region							
	Atlantic	*Quebec*	*Ontario*	*Manitoba*	*Saskatche-wan*	*Alberta*	*British Columbia*	*Canada*
Cereals	0·2	7·8	1·0	0·9	4·8	75·3	2·3	92·3
Oilseeds		0·1		0·2	0·3	9·1		9·7
Sugar beets		0·4				15·2		15·6
Potatoes	0·7	2·0	1·8	0·4	0·8	9·1	1·5	16·3
Tobacco	0·2	2.6	25·7					28·5
Tree fruits		0·4	1·4				12·7	14·6
Small fruits	0·2	0·8	0·7				0·5	2·3
Vegetables	0·3	1·8	4·3	0·6	0·2	2·5	3·7	13·5
Tame hay	0·3	16·7	1·6	0·5	19·6	62·5	47·3	148·6
Pastures	0·1	3·4	0·6		3·7	28·5	11·5	47·8
Other		1·5	3·2	0·2	2·0	15·2	9·8	31·9
Total	2·0	37·6	40.3	3·0	31·4	217·4	89·4	421·1

Manitoba, Saskatchewan, and Alberta: These are known as the Prairie Provinces, and vary in elevation from a low of 230 m at Winnipeg, Manitoba, in the east to a high of 1,065 m at Calgary, Alberta. The climate is continental throughout the whole region, with generally low humidities, warm summers and cold winters. Precipitation is reasonably uniform during the year and sufficient (300 mm) to grow cereal and pasture crops. The growing period averages about 110 days.

The development of irrigation in Manitoba has been limited to a relatively small acreage of vegetable and canning crops because rainfall is generally sufficient. On the other hand surface drainage from frequent spring flooding is essential. Until recently, irrigation in Saskatchewan was limited to flooding schemes for hay production. However, with the completion of the Gardiner Dam on the South Saskatchewan River, development of more sophisticated systems has increased acreage of irrigated crops. These are largely cereal crops.

The major area of irrigated crops in Canada is in southern Alberta where irrigation commenced early in this century. The development of new systems and the improvement of existing systems, both delivery and farm have been steady and will continue. Linked with irrigation are some surface drainage systems. These are essential under most soil conditions where the control of salt build-up is needed. The gently rolling sandy loam to very fine sandy clay-loam chernozoic soils range from dark brown to brown. Precipitation varies from 300 to 400 mm. About 12,000 ha of solonetzic soils are irrigated.

British Columbia: The most westerly province has many different climatic zones varying from the rain forests of the coastal area to desert-like conditions in some interior valleys. Agriculture is limited to river and lake valleys and the plateaus of the central interior. Irrigation is essential in the southern interior valleys for crop production (tree fruits, grapes, vegetables and hay) while supplemental irrigation is practised in some coastal valleys and the central plateau for assured crop production.

Relative importance of regions: As will be seen from Table I the areas of cultivated and rangeland vary greatly between provinces. Likewise the areas of irrigated and/or drained land vary. As a whole, Canada irrigates less than one per cent of its cultivated land and drains only about 3 per cent.

If the area of irrigated land is used as the criteria for determining relative importance then Alberta is as important as the rest of Canada. If the area drained is considered then Ontario is most important. If cash receipts and number of farms is considered as given in Table III, Ontario leads in importance followed by Saskatchewan and Alberta. However if one judges relative importance by considering the proportion of the region's population that lives on a farm (not rural population) then Saskatchewan clearly takes the lead followed by Alberta and Manitoba.

B. CROP YIELDS

Single cropping is practised throughout Canada because of the short growing season. With some variation, if a crop is irrigated in one province then practically all of that particular crop is irrigated. For instance, the 16,000 ha of sugar beets in Alberta are all irrigated while the 12,000 ha in

TABLE III

Distribution of cash receipt, number of farms and proportion of farm to total population (1971 census) Canda

Region	Cash receipts		Number of Farms (1,000)	Farm population (percent of total)
	Total $\$ \times 10^6$	Per cultivated hectare $		
Atlantic	153	273	7·9	3.8
Quebec	692	265	40·9	5.1
Ontario	1,385	315	65·7	4.7
Manitoba	366	71	25·3	13.2
Saskatchewan	904	48	62·9	25.2
Alberta	771	67	46·5	14.5
British Columbia	220	311	8·6	3.4
Total	4,491	103	257·8	6·6

Manitoba are grown on rainfed soils. Pastures, hay and cereal crops are the only major exception to this generalization.

It is not possible to separate the production of irrigated from non-irrigated crops with Canadian data except as explained above. Table IV, therefore presents areas and yields of a few selected crops by region, regardless of cropping practice. Later in the paper yield benefit ratios for irrigation will be given.

C. COMPLEMENTARY INFORMATION

Irrigation : Nearly all combinations of types of irrigation and sources of water can be found in Canada. The use of mechanized sprinkler systems is increasing because of the reduced labour costs and the possibility of using these systems on undulating topography. Nevertheless in Alberta and Saskatchewan there are many ranchers and managers of community pastures who will continue to use surface irrigation for their hay production.

Statistics are not available for the areas irrigated by each of the several methods of water distribution. However, judgements of the principal methods used for each region are given in Table V. Only in the tree fruit district of British Columbia is there any appreciable use being made of drip irrigation. The major source of irrigation water in Canada is from river storage of spring runoff. The second source is from river diversion,

TABLE IV

Areas and yields of selected crops by Region (1975)

Crop	Region															
	Atlantic		Quebec		Ontario		Manitoba		Saskatchewan		Alberta		British Columbia		Canada	
	Kha	T/ha	Kha	T/ha	Kha	T/ha	Kha	T/ha	Kha	T/ha	Kha	T/ha	Kha	T/ha	Kha	T/ha
Cereals	113	1·7	422	2·1	1,474	3·8	2,512	1·7	8,525	1·7	4,981	2·1	128	1·9	18,155	2·0
Oilseeds					158	2·3	601	0·9	942	1·1	714	1·2	28	1·1	2,443	1·2
Sugar beets			3	43			13	28			16	28			32	29
Potatoes	42	21	20	16	18	22	13	16	1	24	7	21	4	28	105	20
Vegetables	12	4·6	49	6·8	91	11·0	1	16·2			5	5·5	7	8·9	165	9·1
Tame hay	177	5·9	1,093	4·3	1,093	5·4	506	4·5	810	3·8	1,336	3·9	253	5·7	5,268	4·5
															26,168	

TABLE V

Proportion of land irrigated, principal types of irrigation and major source of water for each region

Region	*Proportion of cultivated land irrigated per cent*	*Type of irrigation*	*Source of water*
Atlantic	0·3	sprinkler	diversion
Quebec	1·4	sprinkler	diversion
Ontario	0·9	sprinkler	diversion, ground water
Manitoba	0·1	sprinkler	diversion
Saskatchewan	0·2	flood, sprinkler	river storage, diversion
Alberta	1·9	flood. sprinkler	river storage, diversion
British Columbia	12·5	sprinkler, drip	river storage, diversion

frequently followed by storage within the irrigation system. The third source of water is the storage of surface runoff by damming water courses or constructing dugouts. This water is used both for stock watering throughout the year and frequently for flood irrigation of hay crops. Some ground water is pumped in south western Ontario and in the Lower Fraser River Valley of British Columbia.

With the exception of surface runoff in some areas of the three Prairie Provinces water for irrigation is 95 per cent to 100 per cent reliable. Since the irrigation season is no longer than the growing season (130 days maximum) there are at least 230 days when rain and snow can recharge the reservoirs. So far there has been no severe shortage of water for irrigation indeed most irrigation districts can expand their irrigated areas without increasing their storage systems.

Only rarely are irrigation systems used for frost protection, and here only in the Okanagan Valley of British Columbia and in the apple belts of the Atlantic Provinces. All cranberry bogs in coastal areas of British Columbia use sprinkler irrigation for spring frost protection. A few systems in British Columbia are used to apply fertilizer and some sewage disposal through irrigation systems are being started across Canada. Neither is widely developed in Canada as yet. Probably the most sophisticated use of irrigation by farmers occurs in the fruit growing districts of British Columbia. Here the orchards are frequently on steeply sloped bench lands that, if not properly irrigated, erode with drastic consequences. In British Columbia the systems are small in comparison with some of the large wheel move and center-pivot systems of Alberta and Saskatchewan. Alberta irrigation farmers are knowledgeable about the use of water and the culture of irrigated crops. Saskatchewan farmers are less sophisticated because irrigation is not yet being used on high value crops. In Ontario the degree of sophistication on the part of irrigation farmers is high that of the Quebec and Atlantic regions is improving.

Drainage : Statistics on drainage are not as readily available as they are given for irrigation in Table I. Drainage is essential for crop production on more than half the crop land in the cool, humid climatic regions of Canada; that is in all the farming areas except in Manitoba, Saskatchewan, Alberta and the southern interior valleys of British Columbia where a sub-humid or semi-arid climate occurs. However, it will quickly be noted from Table I that much less than half the crop land in these regions is not drained.

There are five main reasons for drainage in Canada :

(*i*) to remove precipitation excesses from agricultural lands;

(*ii*) to remove spring flood waters from low lying lands permitting early solid preparation;

(*iii*) to remove seepage water from low lying lands protected by dykes near rivers and estuaries;

(*iv*) to remove tail water from the surface irrigation systems or accidentally over-irrigated low areas on sprinkler irrigated systems; and

(*v*) to remove seepage water from the low side of unlined irrigation canals.

Open ditch drains are used for excess runoff and as outlets for subsurface drains. Quebec is cleaning old ditches or digging new ditches at the rate of about 1,300 km per year. Ontario follows with about 170 km per year while all other provinces construct lesser amounts. Subsurface field drains are being installed at the rate of about 380 km per year in the Atlantic Provinces; 11,000 km per year in Quebec; 19,000 km per year in Ontario; and 150 km per year in British Columbia. In the Prairie region drainage schemes are essential for the establishment and maintenance of productivity on low lying and usually highly fertile lands.

The possibility of reclaiming land by drainage is fraught with many problems in Canada. Migratory birds fly north in April and May to nesting grounds in the Arctic and south in September and October. Many are water species. Thus there is conflict between agriculturists who wish to drain land for food production and wildlife people who wish to maintain swamps and sloughs for waterfowl. Some reclamation by dyking and drainage of wet lands has taken place. Usually the productivity on these alluvial soils is high.

Dykes and other flood protection : The low lying areas of the Atlantic Provinces, Ontario and the lower Fraser Valley of British Columbia are generally dyked. These give protection from spring high waters in rivers and lakes, as well as from high tides on each coast. In other regions dams for storage of peak flows, river diversions, and channel improvements are used for flood protection. Such measures have been taken in Ontario on several rivers and in Manitoba and Alberta.

D. SUMMARY OF PRESENT LAND USE

Clearly irrigation, drainage and flood control have played an important role in the development of agriculture in Canada. Unfortunately it has not been possible to up-date our statistics to identify returns to Canadian agriculture from these developments. The tree fruit and grape production in the Okanagan and Kootenay Valleys of British Columbia are entirely dependent upon irrigation. In southern Alberta irrigation has converted range and dry land to an agriculture producing vegetables, sugar beets and high yields of hay and pasture. Indeed it is estimated that in Alberta, where only 4 per cent of the cropped land is irrigated produces 20 per cent of the provincial agricultural returns.

In addition to the increased agricultural production in these two areas, irrigation has brought fruit and vegetable packing plants, sugar factories and beef finishing and packing industries as well as many agricultural supply houses.

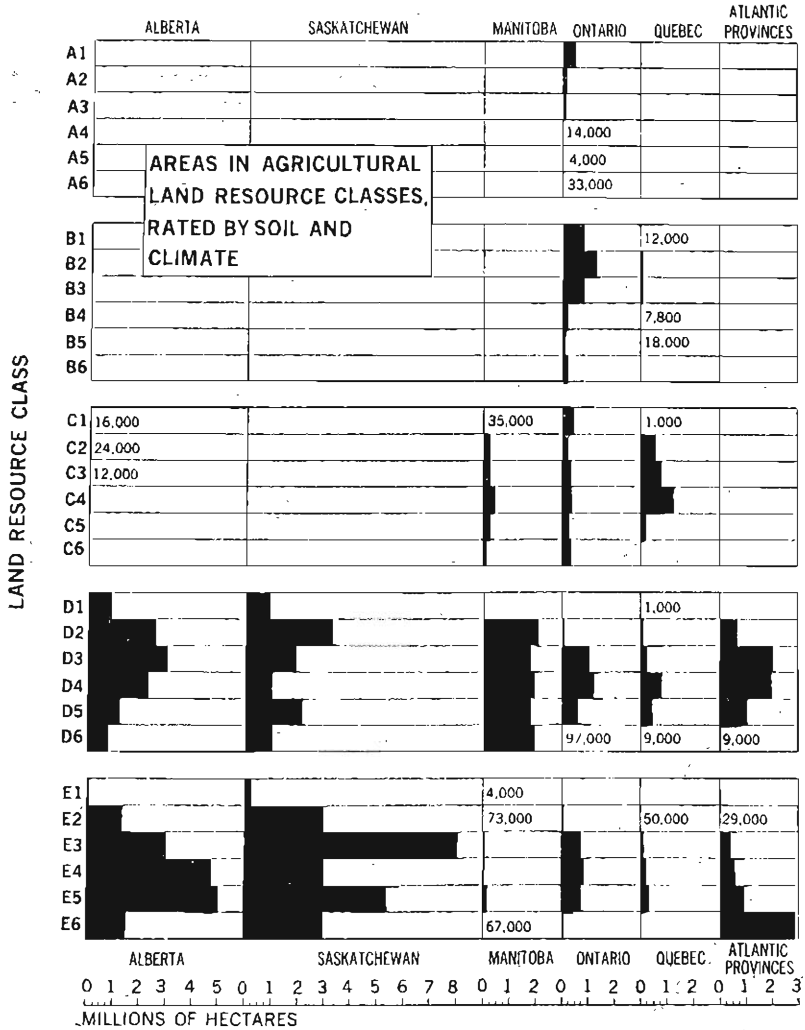
Benefits from drainage are equally dramatic to those from irrigation particularly in areas such as the Sumas Prairie in British Columbia and the Holland Marsh in Ontario. Both would produce no crop without drainage. Other areas in British Columbia, Ontario, Quebec and the Atlantic Provinces have benefited from open ditch and subsurface drainage, but much more needs to be done.

Flood protected areas are mainly those where people and buildings have been flooded or are in danger of being flooded. To give this protection requires that low lying farmlands also be protected and drained. Thus agriculture has benefited and will continue to benefit from such installations. As explained later in this paper a Canadian policy with respect to flood damage reduction is being developed.

2. TRENDS IN CANADIAN AGRICULTURE

Even though Canadian farmers rely heavily upon natural precipitation, irrigation in many instances would materially increase productivity. A recent estimate indicates that about 2 million ha of soils in eastern Canada (Ontario, Quebec and the Atlantic Provinces) are moisture deficient. The greatest problem in estimating the irrigable potential in Canada, however, is the lack of detailed land capability data. In order to correct this deficiency each provincial government, in cooperation with the federal government, is developing statistics of land capabilities. Thus within the next ten years a computerized land inventory will be available. It will identify both the capability and productivity of each parcel of land. Based on this and other information, such as economic and sociological situations, the development of rational land utilization policies will be possible (Figure 1).

Because Canada has a federal system of government, legislative powers are distributed among the national and provincial governments. Both levels have responsibilities in areas that directly or indirectly involve water management. Each province is responsible for its own natural resources and each therefore has the primary role in water management. However, where water crosses interprovincial boundaries, cooperative federal-provincial arrangements become essential. Federal jurisdiction prevails where water crosses



The five climatic zones (A to E) in order of declining quality are based on William's agroclimatic resource index ACR), which takes into account frost free season, heat accummulation and moisture deficiencies. The soil capability classes rate soils as follows.

1 No limitations for general field crops.
2 Moderate limitations that restrict range of crops or require moderate conservation practices.
3 Moderately severe limitations
4 Severe limitations suitable for only a few crops, or else the yield for a range of crops is low, or high risk of crop failure.
5 Perennial forage at best, but improvements feasible
6 Perennial forage, improvements not feasible

Data is not yet available for British Columbia- estimates for B.C. are 600.000 ha. in classes 1 and 2 1.4 million ha in class 3, and 2.6 million in class 4, in various climatic zones

Typifying areas

°CLIMATE A Essex Kent counties, Ontario only

°CLIMATE B S.W. Ontario, shores of Lake Ontario and Georgian Bay. West part of Montreal Plain

°CLIMATE C Immediate environs of Edmonton, Brandon, Morden Manitoba Plain N of Winnipeg and Portage Central Ontario, Ottawa Valley, Manitoulin, Central St. Lawrence Lowlands of Quebec

°CLIMATE D In Alta: part of Peace R., W of Edmonton to Lloydminster, Camrose, Stettler, Drumheller Calgary, Lethbridge, Medicine Hat and Cardston In Sask. Pr Albert, Melfort, Saskatoon, Wynyard, Weyburn and Estevan Most of Manitoba Plain, Interlake area Most of Eastern Ontario. Northern Clay Belt, Lac St Jean, Appalachian Valleys. Riv du Loup Southern N.B. N.S. and P.E.I.

°CLIMATE E In Alta: Rocky Mt House, Edson, Barrhead, rest of Peace R. W Sask. Meadow L., Battleford Rosetown, Maple Creek, S. Current, Moose J., Regina, Tisdale-Hudson Bay area Manitoba- Riding and Duck Mtns. Algonquin Pk in Ontario Quebec Abitibi, Laurentides Gaspe. North N.B. Highlands and Nfld

FIGURE 1

the international boundary or where navigation or fisheries are important. The planning and implementation for irrigation, drainage, and flood control works may involve both federal and provincial as well as local government agencies.

The Prairie Provinces Water Board is an example of inter-provincial and provincial-federal government co-operation. This board has the responsibility for advising governments upon the quantity and quality of water passing across provincial boundaries, that is, west to east from Alberta to Saskatchewan and from Saskatchewan to Manitoba in accordance with the 1969 Master Agreement on Apportionment of these waters. Within each province various policies and programs are available to farmers for allocating government owned land for irrigation farming and for assisting farmers in establishing irrigation systems. Alberta, for instance, has survey, design, and estimate services both for irrigation districts and for irrigation farmers to help in maintaining and up-grading existing systems or to establish new systems. Saskatchewan has a similar policy plus a grant to individual farmers of up to 33 per cent of their costs of development. In addition irrigation farmers may obtain low interest loans to help finance the other 66 per cent of their irrigation development costs.

Similar programs are available with respect to drainage schemes. In northern Ontario there are still several million ha of class 4 land that, if drained, would produce a narrow range of food and fodder crops. Thus this province has an advisory service and a grant or low cost loan policy to encourage the adoption of technology to increase crop production. The Prairie Provinces, on the other hand, do not have any technical or financial assistance to help in draining the half million ha of swamp areas because these waters are used by migrating waterfowl. They do however have technical and some financial assistance for other types of drainage.

A. ANTICIPATED POPULATION GROWTH

On a national basis, the dominant component of population growth in Canada since 1851 has been natural increase. This trend is likely to continue with only a modest contribution from migration. The most realistic projection available taking into consideration changes in mortality, fertility and migration is that the population will increase from 22·5-million in 1975 to 31 million in 2000. Even though the current fertility rate of 2·19 births is close to the replacement level of 2·13 births under present mortality conditions, it will not be until well into the 21st century that Canada reaches a zero population growth. This estimate assumes an annual population growth of between 1·4 per cent and 1·2 per cent reducing to 1·0 per cent by 2000.

The population increase will not be uniform across the country. As previously mentioned the major growth centers are, and probably will continue to be, southern Quebec and Ontario and south western British Columbia. Past and current trends indicate that the Atlantic Provinces will increase slowly; Quebec's annual rate of increase, having recently dropped dramatically from 2·8 per cent in 1951-61 to 0·8 per cent in 1966-71, will probably level out at under 0·8 per cent; Ontario, Alberta and British Columbia are holding their annual rates of increase at between 2 and 3 per cent while Manitoba and Saskatchewan are increasing at about the same rate as the Atlantic Provinces (under 1 per cent).

Farm and urban populations are diverging. In Table III it will be noted that the farm population was 6·6 per cent of the Canadian population at the time of the 1971 census. Actually 24 per cent of the Canadian population is rural but 75 per cent of the rural population is not farming.* In the ten-year period (1961 to 1971) the farm population dropped from 11·4 per cent to 6·6 per cent of the total population. The decline accelerated between 1966 and 1971. It seems unlikely that the rate of decline will continue. A further severe decline in the absolute size of the farming population is unlikely although the proportion of farming population to total population will continue to decline. The best estimate available is that the farm population will level out at about 4 per cent of the national population. Thus if Canada's population is 32 million in 2000 the farm population will be about 1·3 million—the same as it is today.

Statistics on the numbers of people employed in rainfed agriculture are not readily available. The trend however is that they will reduce at a greater rate than the total farming population, because the irrigated and more intensive agricultural enterprises will require greater manpower per unit area than the extensive enterprises. As a consequence the urban population employed in agricultural enterprises associated with irrigation will increase.

B. POLICIES ON POPULATION AND REGIONAL GROWTH

Both the federal and provincial governments have policies aimed at developing urban and rural areas in a uniform manner. The federal government, for instance, has established a Department of Regional Economic Expansion (DREE). This department has as its objective to assist business enterprises establish in the less developed and usually less populated areas of Canada. The assistance is given in the form of grants to processing industries and some through provincial governments in the form of grants to farmers. Most provincial governments have programs that encourage particular developments within their provinces. The enterprises which are assisted are all types of manufacturing industries (large and small) as well as natural resource based industries including agribusiness. Farming enterprises are assisted through a number of special programs financed through DREE (such as the Agricultural and Rural Development Act) and the Department of Agriculture (Crop Insurance Plans, New Crops Development Program, Farm Credit, etc.).

The federal Department of Industry, Trade and Commerce fosters the export of agricultural products (as well as other natural and manufactured products). Of particular concern is its interest in the international trade in cereal and oil seeds. It cooperates closely with the Department of Agriculture in assuring that suitable quantities of the desirable grades of cereals are available for Canada's overseas customers and in advising of changes in demands not only for current products but for potential new products.

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* For census purposes in Canada, the farm population consists of those people living on one acre (0·4 ha) or more with sales of agricultural products amounting to $50 or more the previous year. Thus the definition of the farm population is generous. The rural population consists of those living in villages of less than 1,000 people or areas of less than 1,000 people per mile^2 (less than 385 per km^2).

C. RESOURCE ALLOCATIONS

It is not possible without a great deal of research to determine the present resources allocated to achieve the policies outlined in the previous section or to estimate the anticipated increases. As will have been noted these policies not only are administered by both federal and provincial governments but frequently there are significant inputs from municipal (local) governments through land tax incentives for the establishment of new industries. For this reason, then no attempt has been made to estimate the total resources assigned.

Some indication as to the size of these resources may be of interest. They should not be summed. British Columbia will continue to spend $ 500,000 per year on its Land Commission (see powers under 2.D). In addition $ 4 million per year will be spent on land development and, aided by the federal program, about $ 6 million per year for community pasture development. In the next ten years Alberta will spend $ 200 million to rehabilitate and expand its irrigation systems. Saskatchewan has Land Bank, Farm Start and Crop Insurance programs costing $ 12 million per year for administration and grants and $ 45 million per year for recoverable low interest loans.

The impact of the Agricultural and Rural Development Act (ARDA) programs funded by the federal Department of Regional Economic Expansion (DREE) during the period 1972 to 1976 in British Columbia, the Prairie Provinces and Ontario is apparent from the following:

—35,000 farmers acquired 130,000 ha of land;

—60,000 ha were improved through drainage;

—65,000 ha of community pastures were improved; and

—46 irrigation and water supply projects were given assistance.

In Quebec and the Atlantic Provinces direct funding invested in agricultural development was 30 per cent of the national rural development ARDA budget.

More recently, agreements between DREE and provincial governments affording specific opportunities for agricultural development are:

—a three-year agreement with Quebec to provide $ 8 million annually for the reclamation of the Montreal Plain including subsurface drainage; and

—a five-year agreement with Nova Scotia to provide $ 18 million for land clearing and improvement of 20,000 ha of farm land.

D. TRENDS IN LAND USE

The trends in agricultural land use and development in Canada are toward a more intensified production rather than towards the development of more land. The policy of most provincial governments is to encourage farmers to make better use of those lands already developed. The reason for this policy is to minimize the need to develop additional infrastructure such as communications, schools, and hospitals. Thus there is a general trend to increase the use of irrigation, to make the present use of water more efficient, and to increase the extent and efficiency of drainage schemes. With respect to flood control, however, the policy is to restrict development on those lands which are subject to flooding in a manner such that damage from floods is minimized over the long term rather than to increase the protection from flooding.

Several provinces are seriously contemplating means of restricting the use of good agricultural land to agricultural use. Ontario has a strategy for the use of its farmland that commits the government to:

(*i*) ensure that within any area, the better land is kept for agricultural purposes,

(*ii*) initiate programs that will make it economically feasible to use these lands for agricultural production.

British Columbia has already established a Land Commission whose responsibility it is to administer the lands which have been permanently reserved for food production. However, until soil productivity data are available for all potentially arable land in each province, planned use of this resource will not be possible on any large scale.

Ontario estimates an increase in population of 4 million people (from 8 to 12) by the year 2000 which will require 120,000 ha for housing and infrastructure. Should the total population of Canada increase by 10 million (from 22·5 to 32·5) by the year 2000 then 300,000 ha will be needed for housing. Even assuming all this land will come from cultivated areas, the proportion of cultivated land used in Ontario will be 2·7 per cent and in Canada 0·7 per cent. Thus Canada visualized no great shift in land use from agriculture to urbanization by the year 2000 except for urban fringes. But we cannot be complacent. British Columbia estimates an increase in population from 2·5 million to 4·5 million by the year 2000. If the assumptions used for Ontario are applied in calculating the land required for housing in British Columbia then 8·4 per cent of its cultivated land would be needed. It is for this reason that British Columbia has had to establish stringent land use policies.

Energy inputs into food production have increased as agriculture has become mechanized. Some output-input ratios for products at the farm gate (excluding human labour and solar energy) recently calculated for Canadian conditions are: wheat 4·0:1, oats 5·5:1, barley 5·0:1, maize 4·0:1, rapeseed 5·0:1, alfalfa hay 15·0:1, mixed hay 6·7:1, potatoes 2·2:1 and apples 2·0:1. Because of present concerns for the preservation of energy sources and the environment these ratios will improve. On the whole Canadian agriculture is efficient in its production of agricultural products when judged by its energy output-input balance. Protection of the environment by properly utilizing the input of fertilizers and other agricultural chemicals (pesticides) will tend to improve this relationship. The energy used to produce food at the farm gate, however, is only 20 per cent of that energy required to put the food on the table. Thus transportation and processing energy consumption is where the big gains can be made.

Generally there is no tendency to abandon cultivated land in Canada at the present time. There was such tendency particularly in the third decade of this century. Now, however, the pressure is to consolidate and intensify. There are a few minor exceptions. In the Atlantic Provinces the area of cultivated land is falling at about the rate of the declining farm population.

In the three Prairie Provinces, and particularly Alberta and Saskatchewan, there are small areas going out of production because of salinization on both rainfed and irrigated lands.

All levels of government are attempting to reverse these trends. The Atlantic Provinces and British Columbia land abandonments are subject to the various policies as outlined under 2.B. The salinization problem is of current concern to various agriculture research organizations who are searching for economical and lasting solutions to both prevent further salt movement and reclaim land already abandoned.

E. SUMMARY OF TRENDS

Although Canada has large areas of arable land that could be developed either by clearing and breaking or reclaiming through drainage the trend is to encourage the use of presently developed areas before moving in to undeveloped areas. Thus, for the present, the population increase will be fed and the world demand for Canadian wheat, barley and rapeseed will be met by intensive use of current agricultural lands.

The trends are toward :

—a reduction of the proportion of people actually farming;

—an increase in the number of people servicing the agricultural industry;

—a consolidation of land holdings;

—an increase in the control of the use of good agricultural land for non-agricultural use;

—an intensification of production;

—a reduction in the rate of increase of energy inputs including fertilizers; and

—a continued assistance on the part of governments to bring about these changes.

3. DEMAND FOR WATER DEVELOPMENT AND USE

When considering the contribution that Canada can make to the world food supply in the year 2000 it must be realized that:

(*a*) the major contribution will come from non-irrigated crops grown upon land that requires little or no drainage and probably no flood control;

(*b*) in 1946 each Canadian farmer produced enough food to feed himself and 12 other people. Today, 30 years later, each Canadian farmer produces enough food to feed himself and 50 other people (a four-fold increase);

(*c*) with the same land and farm labour base a conservative estimate is that production will double by the year 2000 through the use of improved technology but without the use of irrigation.

The land resources of Canada are shown in Table I. It will be noted that of the 44 million ha under cultivation, 25 per cent is in fallow and only one per cent has irrigation facilities. Thus, even with a doubling of irrigation, the proportional increase in total crop produced would be small in comparison with other means of increasing production. If, for instance, ways could be found of reducing the amount of fallow to half of that used today without reducing the per hectare yield, increased production would be in the order of 10 per cent.

A. HORIZONTAL EXPANSION OF IRRIGATION AND DRAINAGE

The area of irrigation will continue to expand in Alberta and Saskatchewan and additional wet soils will be drained in Ontario and to the east and in British Columbia. Potential increases with our present restricted knowledge of soil capabilities are given in Table VI. Some provinces are much more active than others in promoting irrigation and drainage.

TABLE VI

Potential horizontal expansion

(*Unit 1,000 ha*)

Region	*Irrigation*		*Drainage*	
	by year 2000	*Potential*	*by year 2000*	*Potential*
Atlantic			22	113
Quebec	25	150	480	1,214
Ontario	40	200	805	1,618
Manitoba	5	100		680
Saskatchewan	180	265	240	800
Alberta	607	2,064		800
British Columbia	5	10	24	300

In irrigation, Alberta has been and will be successful in bringing additional cultivated land under irrigation because irrigated farming is now in the second to third generation, the benefits from irrigation are substantial and the infrastructure is in place to handle irrigated crops. In Saskatchewan, on the other hand, farmers are used to dry land (rainfed) agriculture, the benefits from irrigation are not as great as in the neighbouring province of Alberta. In Saskatchewan there are few facilities for handling the produce from specially cropping.

In drainage, there are also large discrepancies between regions. The Atlantic Provinces, while requiring drainage for a considerable portion of its cultivated land do not have the machinery to make rapid advances. Quebec and Ontario, on the other hand, are equipped to subsurface drain between 25 and 40 thousand ha per year. Furthermore these provinces have a number of assistance programs to help farmers design and finance drainage schemes.

The increase in productivity from irrigation and drainage is so variable between regions and between crops within regions that a detailed discussion is not possible. Estimates from British Columbia give yields for irrigated crops over non-irrigated crops as 1·5 times for maize silage, 2·5 times for tame hay, and 2·6 times for improved pasture. In Alberta the value of irrigated crops over non-irrigated crops from the same area of land varies from 1.4 times to 12·2 times depending upon the area.

B. VERTICAL EXPANSION OF IRRIGATION AND DRAINAGE

An increase in production is expected to result from improved technological inputs such as improved plant varieties, more knowledgeable use of water and plant nutrients, better weed, disease and insect control, and a shift from staple food crops to vegetables and other high value crops. Of those crops presently irrigated only fruits and vegetables for processing are expected to find a place in the export markets. Cereal grains will continue to be used in the crop rotation and farmers will continue to take advantage of world market conditions.

The improvement of irrigation distribution systems is taking place quickly in both Alberta and British Columbia. This activity will continue for at least the next 10 years. Thus, with no increase in the amount of water diverted, there will be a significant increase in the number of hectares irrigated as a result of reduced water loss from runoff, seepage and greater storage capacities within the systems.

C. OTHER RECLAMATION MEASURES

As pointed out under Complementary Information in para 1, Canada has changed its policy from protecting flood prone lands to discouraging their use for capital intensive agriculture or permanent structures. Thus the expectation of any expansion in this direction is limited and the demand comes from very few self-interest groups. This policy and lack of demand will probably continue until all non-flood prone lands are fully developed. Certainly until well after the year 2000.

In a similar manner the draining of slough and marshy areas is discouraged because of their use by migratory waterfowl. Some marshes have been reclaimed and are highly productive. Future reclamation however will probably be limited to small areas within present cultivated farms.

D. SUMMARY OF DEMAND FOR WATER DEVELOPMENT

As an indication of the demand by farmers to develop their farming operation and hence their irrigation and drainage schemes, an examination of the Farm Improvement Loans and Farm Credit Mortgages on a yearly basis may be of help. Annually both schemes loan about $ 200 million each. These funds are not used solely for irrigation and drainage but they are used for farm improvement and indicate the extent of demand. Alberta, Saskatchewan and Manitoba are the heaviest users in both number and value. In addition to these Federal programs many of the provinces are intensively involved in development financing.

The demand for irrigation expansion and improvement comes first from Alberta, followed by British Columbia, Saskatchewan and Ontario. For drainage the demand probably is in the order of Ontario, Quebec followed by British Columbia and the Atlantic Provinces. Both policy and demand come from a desire on the part of the farmer to expand vertically rather than horizontally because the infrastructure is already in place and the operational knowledge is available.

Notwithstanding the advantages on an area basis for improving crop yields through irrigation, the possibility of improving total crop production through improved technology on rainfed soils (dryland farming) must not be ignored.

4. ASSESSMENT OF POTENTIAL FOR EXPANSION

There are two types of potential expansion. One is a consideration of expanding irrigation and drainage regardless of cost, the other considers expanding on the basis of economic reality. If, for instance, the cost of energy was inconsequential, then pumping to all elevations where crops would grow, or moving water from humid regions to dry regions could be included in an assessment of potential expansion. However, since Canadian farmers operate in response to market demands, agricultural production and expansion is geared to meet these demands. On the other hand Canada is attempting to organize its production toward helping meet the needs of an increasing global population. These two demands for expansion need to be met in a way such that the living standards of the farmer will be maintained, that regional disparities can be resolved and that export earnings will continue to balance import requirements.

A. EXPANSION OF IRRIGATION

The assessment made here attempts to take a middle view of the above problem. From Table VI, it will be noted that the increase in area or horizontal expansion of irrigation is to be found in the western provinces. The potential for development is large. In Alberta the irrigated area could be increased by a factor of 10, and in Saskatchewan by a factor of 8·5 over presently irrigated areas. However water is somewhat limited. In eastern Canada it is difficult to estimate the potential unless the assumption is made that all cultivated areas could benefit from supplemental irrigation in dry years. Taking this view the increases would be in the same order as in Alberta. However, such is economically unrealistic and therefore a factor of about 5 has been used, which may still be high.

An outstanding example of planning for future irrigation development is to be found in Alberta where the Irrigation Division of its Department of Agriculture and the Engineering Division of its Department of Environment has established a large scale water conservation and development program. This program embodies major water diversion and storage projects as well as the renovation and extension of existing projects.

B. EXPANSION OF DRAINAGE

As with the potential and expected expansion of irrigation, Table VI gives information for drainage in Canada. Unlike irrigation, expansion will take place primarily in Ontario and Quebec both as to potential and that expected by 2000. The decision to drain rests primarily with the individual farmer. Thus the costs in relation to the expected returns from drainage play the major part in this decision-making process. No generalization can be formulated because each decision is dependent upon the class of land, the nature of the farming enterprise, the markets available and the personal assessment of each farmer with respect to the possibility of an investment in drainage making a reasonable return.

C. THE CAPACITY TO EXPAND

Canada has great potential for both horizontal and vertical expansion in irrigation and drainage. However, as explained under para 3, Demand for Water Development and Use, doubling of irrigation would increase food production very little in comparison with improvements in technology of rainfed agriculture.

Long term projections for water use by agriculture cannot be made in isolation from projections for all other uses. The major sectors to be considered are agriculture (both irrigation and stock watering), municipal, industrial, power generation, fish and wildlife, recreation, and pollution abatement. Clearly a regional growth study to provide the socio-economic base data is a fundamental component of each investigation. In Canada the the major policy objectives with respect to those projections involving agricultural use of water are :

(*i*) providing food for a growing national population;

(*ii*) earning foreign exchange, and

(*iii*) improving regional development.

Because of the structure of Canadian agriculture, irrigation per se rarely increases the per capita income of individual farmers.

Changes in water use in Canada are currently being studied but detailed predictions have not yet been made. This situation is due to a poor understanding of the current pattern of water use, limited data availability and a tendency to generalize from individual cases. It is clear however that Canada faces an emerging scarcity problem of water quantity in the southern Prairies and a water quality problem where industrial withdrawal and in-channel recreational uses increasingly conflict. Currently there is a little conflict between these two uses and withdrawals for agricultural purposes.

The estimates of areas that can be increased by the year 2000 for both irrigation and drainage are probably optimistic. In British Columbia and southern Alberta irrigation on a commercial scale was started early in the 20th century. In the rest of Canada it was started about 1945 with the introduction of movable aluminum pipe. Thus in 40 years Canada has developed more than 400,000 ha of irrigation. Can 800,000 ha be developed in the next 25 years? Yes it can. The probability of it happening, however, is about 50 per cent given the present economic situation.

There is no question that the construction capability for both the major works and distribution systems exists. The funds could be made available provided there was sufficient political pressure and the economic advantages were seen favourable. Neither of these situations is likely to prevail, however, and thus the expansion may be a potential rather than a reality.

Drainage has increased in ten years from 825,000 ha to 1,259,000 ha, a 50 per cent increase. In this period it has accelerated from 30 to 60 thousand ha per year. Therefore if it remains only at 60,000 new ha per year the next 25 years should see an additional 1,500,000 ha drained. The estimates in Table VI seem to be reasonable.

5. TECHNOLOGICAL ADVANCES

The major technological advances will come from the application of labour saving devices in water control at the farm level, from greater accuracy in the long prediction of local weather patterns and from the improvements in plant varieties and cultural techniques such as pest control and fertilizer use. In general Canadian farmers are quick to utilize new technology as it becomes available. Indeed it is sometimes necessary to exercise security on current research programs in order to prevent their use by farmers before the details of application have been formulated.

In irrigation, more efficient use of water will probably not occur until pressure on the available water supply become more acute. Today very few irrigation systems meter water delivery at the farm gate. With the exception of a few small areas, irrigators can and do use all the water they wish. When metering becomes necessary, then more sophisticated application techniques will be used in order to reduce the payments demanded for the metered water. This day is approaching in many irrigation districts.

Research needs for irrigation include:

—land classification studies to more closely defined water requirements and crop suitability under varying ecological regimes;

—greater detail on consumptive use by crops on specific soil types;

—the development of effective evaporation loss control methods of storage reservoirs;

—effective non-polluting methods of controlling aquatic weeds in reservoirs and canals;

—the design of drip systems not subject to clogging by silt or salts;

—the improvement of irrigation scheduling; and

—a better knowledge of application rates under varying soil, crop and climatic conditions.

In the area of drainage there are a number of research needs including:

—effective filters for drain tubes intended for use on fine sandy loam soils;

—the development of more economical drain tiles or tubing;

—effective methods of open drain weed control, maintenance, and bank stabilization;

—the refinement of techniques to ascertain the optimum depth and spacing of drains that provide adequate drainage;

—the determination of the effects of various agricultural land use activities on the quality of drainage waters;

—the determination of the extent of sealing and clogging of drains with iron oxide deposits and the development of remedial measures; and

—the investigation of new types of economical control structures for open drains.

6. CONSTRAINTS AND PROBLEMS

Probably the major constraint to the development of irrigation and drainage schemes in Canada is the way in which the individual farmer assesses the advantages and disadvantages of the various systems. His considerations will include the cost of planning, construction and maintenance, a possible loss of productivity during the installation period, the cost of changing farm machinery to handle a different cropping array, the need to learn methods of crop and water management different from his rainfed methods, the fear of making new business contacts for purchase of inputs and the sale of outputs, and the concern of obtaining hired labour to handle a more intensive form of production. Therefore active rather than passive agricultural extension services are necessary for increasing the areas of irrigated and drained lands.

Since there are no potentially irrigable lands in Canada that are not now being cultivated, the problem of lack of infrastructure is not acute. With irrigation, however, the population density increases and therefore the infrastructure must be intensified as the system develops.

Lack of water may well be a constraint to the full development of the irrigation potential in Alberta and Saskatchewan. Until more detailed land capability data are available this question cannot be fully answered. Thus the lack of base data on land and water presents a constraint to full development.

When considering drainage schemes, in addition to and part of the attitude of the individual farmer is the matter of capital for installation. Otherwise there are few constraints unless the scheme includes the drainage of swamps. When this is proposed the environmental and wildlife enthusiasts become concerned, and frequently the scheme is delayed indefinitely.

N.B.—This paper has been prepared with the assistance of several provincial departments of agriculture, by reference to various district, provincial and regional water studies, and with data supplied by Statistics Canada. It does not present the official views of the Government of Canada or those of any single department of government. It is believed however to be an accurate assessment of the present Canadian situation.

T.H. Anstey,
Chairman,
Canadian National Committee,
ICID.

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R. 2

LIKELY IRRIGATED AGRICULTURE OF 2000 A.D.

LIKELY IRRIGATED AGRICULTURE OF 2000 A.D. IN THE DEMOCRATIC REPUBLIC OF SUDAN

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1. GENERAL

The Sudan is the largest country in Africa covering a total area of 2·5 million km^2. It is situated between latitudes 3° and 23°N and longitudes 21° 45′ and 38° 30′ E.

The physiography of the country displays an extensive plain traversed throughout its length of 2,000 km from north to south by the River Nile and its tributaries. On the eastern side, it is bound by the Red Sea hills rising up to altitude 2,100 m. On the western side lies the Jebel Marra massif with its crest altitude reaching 3,089 m.

The Nile River and its tributaries display the most permanent physical feature of the country. The origin of the White Nile is from the Equatorial Lakes on the Lake Plateau. On entering into the Sudan, it flows through rocky rapids extending for a length of 170 km and thereafter it flows through the swampy Sudd region where huge losses are experienced. After it emerges from the swamps, it is joined by Bahr EL Ghazal on the west and by the Sobat on the east. At Khartoum, the White Nile joins the Blue Nile which originates from the Ethiopian Plateau. The Main Nile which flows from Khartoum down to the High Aswan Dam Reservoir is joined on its way by the Atbara River.

The fertile Central clay plains of the Sudan are enclosed by the Main Nile, the White Nile, the Atbara River and the Blue Nile.

* Perspective de l'agriculture irriguée en l'an 2000 dans la République Démocratique du Soudan.

In the Jebel Marra area and in the central plains of the Sudan, there is a number of seasonal flashy streams originating from the Ethiopian Plateau, among these are the Gash and Baraka Rivers. In the central region plains, considerable runoff in the form of sheet flow and stream flow finds its way to the main courses of Bahr EL Jebel, Bahr EL Ghazal, the Sobat and the Machar marches.

With regard to the climatic zones, the Sudan has predominantly a tropical continental climate with a maritime climate along the Red Sea coast

The south westerly monsoons, laden with moisture, flowing from the Atlantic Ocean are the source of rainfall in the Sudan. The extent of their inland penetration determines the annual volume and distribution of rainfall in the country.

The northern third of the Sudan is almost a desert with an annual average rainfall of about 20 mm. The rainfall increases steadily from north to south until it reaches isohyets 400 mm to 800 mm in the fertile central clay plains of the Sudan, and in the extreme south of the country, the rainfall varies from 1,200 mm to 1,500 mm.

The population is approximately 15·7 million, increasing at an annual rate of 2·8 per cent. The annual per capita income is of an order of 120 US Dollars. The country depends on agricultural and livestock production as the back-bone of its economy. More than 90 per cent of population are engaged in the agricultural sector which forms almost all the Sudan's exports. The main cash crops are cotton (about 60 per cent of the country's exports) followed by gum Arabic (about 10 per cent of the exports) followed by sesame (about 8 per cent of the exports) and then comes the livestock products (7 per cent of the exports) and ground nuts (6 per cent of the exports).

Dura or sorghum being the staple food in the Sudan is cultivated in more than one third of the cropped area in the whole country. The productive forests cover an area of about 7 million feddans* producing mainly gum Arabic.

At the beginning of the five years national development plan 1970–1975, a total sum of 280 million US Dollars was earmarked for agricultural development in the public sector. Investment in the irrigation development has been given top priority followed by mechanized rain-fed agriculture, livestock development and agricultural services. The considerable investment in irrigation development helps to utilize the Sudan's share of the Nile waters, the available manpower, the available machinery and the existing water resources in the existing reservoirs.

Pastures cover 80 million feddans, and the available livestock comprises 12 million cattle, 10 million sheep, 8 million goats and 2·5 million camels.

The cultivated land ranges from 16 to 17 million feddans of which about 4·1 million feddans are irrigated and the remainder are rainfed.

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* One feddan = 0·42 ha

2. HYDROLOGY OF THE NILE

The Nile is one of the most remarkable and the second longest river in the world. The length of its course from the most remote source near Lake Tanganyika to the sea is about 4,000 miles (6.440 km). Its rival in length is the Mississipi-Missouri River which is about 4,200 miles (6,760 km) long.

With regard to volume of flow, it is exceeded by many rivers. The Amazon in Latin America has an annual flow of 2,500 milliard* m^3 and the Congo has an annual flow of 1,250 milliard m^3 as compared with the Nile having an average annual flow of 48 milliard m^3, measured at Aswan. This flow constitutes only 6 per cent of the total amount of rain falling in the Nile Basin. The Nile is known for its marked seasonal and annual variations. The variation in discharge is illustrated by the fact that more than 80 per cent of its annual flow occurs from August to October and only 20 per cent occurs during the remaining nine months. It is also interesting to note that the annual discharge of the Nile for the year 1913-1914 was 41 milliard m^3 as compared to 151 milliard m^3 in 1878–1879 while the average annual flow for this century is 84 milliard m^3. The percentage contribution of the main tributaries of the Nile is as follows:

Blue Nile	59 per cent
Sobat	14 per cent
River Atbara	13 per cent
Bahr EL Jebel	14 per cent

Or in other words 85 per cent of the flow of the Nile comes from the Ethiopian Plateau and only 15 per cent comes from East Africa. During flood time the percentage contribution of the tributaries is as follows :

Blue Nile	68 per cent
River Atbara	22 per cent
Sobat	5 per cent
Bahr EL Jebel	5 per cent

Or in other words during flood 95 per cent of the water comes from the Ethiopian highlands and only 5 per cent comes from East Africa.

During the low period 60 per cent of the water comes from Ethiopia and 40 per cent from East Africa.

The low contribution of the White Nile to the Main Nile is attributed to the great amount of water which is wasted by evaporation in the swamps while the Ethiopian Plateau acts efficiently for draining the water to the Nile.

These figures are very important when we come to consider the conservation and control works of the Nile.

The White Nile is characterised by its relatively uniform flow as compared to the Blue Nile and the Atbara River. Its average seasonal variation at Malakal for the period 1912–1962 ranges from 525 m^3/s to 1,215 m^3/s as compared to the average variation of the Blue Nile at Roseires for the same period which ranges from 125 m^3/s to 6,200 m^3/s.

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* One milliard = 1,000 million or 10^9.

These seasonal variations are important from an irrigation point of view, as the marked difference of flows in the Blue Nile between the flood period and the low period necessitates storage; while the rather uniform flow of the White Nile makes annual storage for irrigation unnecessary.

The silt carried annually by the Nile is about 110 million tons as measured in Egypt. This silt content is much less than that carried by other rivers, i.e., the Mississipi (150 million tons), the Colorado (260 million tons) and the Yellow River (2,000 million tons). The average suspended matter of the Nile during flood is 1,600 ppm and the maximum is about 5,400 ppm.

The rivers flowing from the Ethiopian Plateau, especially the Blue Nile and the Atbara River, are the main source of silt in the Nile. The White Nile carries relatively less silt. This is due to the fact that most of its silt is deposited, on its way, at the lakes, swamps and marshes through which the White Nile flows.

The estimated annually suspended matter of the Blue Nile is 140 million tons. Silt measurements of the Blue Nile in 1955 had shown that during the flood the silt load varied from 7,000 ppm to 4,000 ppm. Its mechanical analysis had indicated that sand constitutes about 45 per cent, silt about 15 per cent and clay about 40 per cent.

The annual sediment load of the Atbara River is about 8 million tons. The grain size analysis of the sediment samples from the Atbara River indicated that sand is 52 per cent, silt is 15 per cent and clay is 18 per cent, rather similar to the Blue Nile.

Silt has influenced considerably the designs and operation of dams built on the Nile as well as irrigation canals.

3. CONTROL OF THE NILE

Before the present century irrigation in the Sudan was confined to the inundated basins in the northern Province and to the patchy areas which were irrigated by *Sagia* (Water wheels) and *Shaduf*. Irrigation by pumps was introduced in the country in the early years of this century.

By 1919, areas irrigated by pumps were only 38,500 feddans. Perennial irrigation was introduced earlier in Egypt. By 1890, the area under perennial irrigation in Egypt was 2,900,000 feddans which consumed the whole of the natural flow of the Nile during the low period from January to July. The basin areas at that time were 2 (two) million feddans. In order to meet further expansion in irrigation development in Egypt and Sudan it was necessary to construct annual storage dams which would be filled by the flood water to be released during the period of shortage. Aswan dam was built in 1904 with an initial storage of one milliard m^3 and was further heightened in 1912 and 1938 to provide five milliard m^3 of stored water.

Jebel Aulia dam was also built by Egypt in 1937 on the White Nile south of Khartoum with a net storage capacity of 2·5 milliard m^3 of water. These works enabled Egypt to proceed with its agricultural development without difficulty.

In 1920, the Egyptian Government appointed the Nile Control Commission to advise on the ultimate needs of Egypt and the Sudan and to propose the projects which would make available irrigation water to meet the agricultural expansion in the two countries. The Nile Control Commission recommended, among other things, the construction of Sennar Dam across the Blue Nile in the Sudan to irrigate the Gezira Plains. The initial idea was to construct only a barrage to a level that would command 100,000 acres (40,470 ha). But with the incidence of an extremely low flood in 1914 and with the introduction of long staple cotton for agriculture which needs water up to April, the idea of the barrage was changed to a proper dam with ample storage. The dam was built in 1925. Its regulation was governed by the Nile Water Agreement which was concluded in the form of exchange of notes between Egypt and Britain. According to that Agreement the natural flow of the Nile during the restricted period (January–July) was reserved to the use of Egypt. During this period Sudan was allowed to draw from the Sennar storage.

Sennar dam enabled Sudan to develop the Gezira scheme (1 million feddans) and to expand the pump scheme along the Main Nile and its tributaries. The developed area in 1963 was 1·4 million feddans with a onsumption of 4 milliard m^3 of water.

By 1961 the Sudan started to realize the need for more irrigation development and was faced with the imposed restriction on the use of the Nile waters.

Studies for the possibility of constructing a dam on the Blue Nile at Roseires started. In 1952 Egypt was contacted for the approval of raising Sennar dam by one metre and Jebel Aulia dam on the White Nile by 10 cm, to enable the Sudan to draw an extra 200 million m^3 of water during the restricted period to meet its agricultural expansion.

After independence Sudan embarked on the development of Managil Project, an extension to the Gezira scheme of approximately 800,000 feddans. As the Sudan was not allowed to draw from the natural flow of the Nile after January and as the storage available at Sennar reservoir was already utilized for other areas, Egypt agreed to allow the Sudan to store 850 million m^3 at Jebel Aulia reservoir temporarily, as a virtual storage to enable Sudan to withdraw from the Blue Nile the same amount during the restricted period provided the same amount was released from Jebel Aulia reservoir.

This arrangement was the only way left for the Sudan to enable it to go ahead with its agricultural development without impairing the rights to Egypt established by 1929 Agreement.

This adverse situation of restricting the Sudan from having a free hand in the use of water was resolved by the establishment of the over-year storage of High Aswan Dam and by the conclusion of the 1929 Nile Water Agreement between Egypt and the Sudan. According to the Agreement the Sudan share of Nile waters increased from 4 milliard m^3 to 18·5 milliard m^3 as measured at Aswan, out of an annual average flow of 84 milliard m^3, Sudan was allowed to construct storage works on the Nile which it considers essential for the utilization of its share. The construction of Khashm EL Girba dam on the Atbara River, with a storage capacity of 1·3 milliard m^3

which started in 1960, was completed in 1966. The dam is at present irrigating 450,000 acres (182,110 ha) of land. At the same time Roseires dam on the Blue Nile was built in 1960 and completed in 1966.

The dam has an initial storage of 3 milliard m^3 and an ultimate capacity of 7·6 milliard m^3 which can be made available by raising the dam an extra 10 m. The dam will enable the Sudan to utilize the share of the Nile waters. Plans are being drawn at present to get the maximum use out of Roseires Dam and to study the possibility of constructing the second phase of the Roseires Dam.

4. LONG-TERM DEVELOPMENT OF IRRIGATED AGRICULTURE

Agriculture is the back-bone of the economy of the country accounting for 40 per cent of the gross domestic production and almost all export earnings. The traditional agricultural sector, which is primarily subsistence oriented, consists mainly of farming and pastoral activities which depend upon rainfall for growth of crops and forage. Rain-fed agriculture constitutes 75 per cent of the 17 million acres (6·88 million ha) annually cropped but account for only 30 per cent of the agricultural production, while the pastures produce an additional 20 per cent. Cash-crops farming (irrigated-agriculture), which now amounts to about 4 million acres (1·6 million ha) or about 25 per cent of the yearly cropland, produces about 50 per cent of the total production.

The growth rate of agricultural production is estimated at the rate of 4·5 per cent annually. During the 1962–1974 period, irrigated area increased at an average rate of 100,000 acres (40,470 ha) per year while rain-fed area increased at a rate of 350,000 acres (141,640 ha) per year.

The Government is at present preparing a six-year development plan from 1977 to 1982. The proposed allocation for the agricultural sector amounts to 780 million Pounds out of a total of 2,600 million Pounds.

The Government is also considering the long-term plan for agricultural development in the country up to 2000 A.D. The main objective of the plan is to attain self-sufficiency in food production, increase foreign exchange earning and export the surplus to the outside world with special consideration to the Arab countries. According to this long-term plan it is envisaged to develop 70 million acres (28·33 million ha) of rain-fed land cropped with short-staple cotton, oil seeds, millet and other cereals.

The development of this area is expected to yield 18 million tons of millet, 4 million tons of sesame, 6 million tons of groundnuts, 150 thousand tons of coffee and tea and 30 million tons of green forage.

As the production of rain-fed agriculture is comparatively low and varies from year to year because of the annual and seasonal variations in rainfall, the Government is also planning to develop by 2000 A.D. some 8 million acres (3·23 million ha) of irrigated agriculture to ensure a stable production of high value, high-yielding crops.

At present the Sudan is committed to the utilization of about 18 milliard m^3 of its share of the Nile waters for the irrigation of the established irrigation schemes and for the irrigation projects currently under construction as shown below:

	Area million acres (ha)	*Water consumption milliard m^3*
Area along the Blue Nile	2·96 (1·20)	11·98
Area along the White Nile	0·62 (0·25)	2·86
Area along the Main Nile	0·42 (0·17)	1·60
Area along the Atbara River	0·50 (0·20)	1·86
	4·5 (1·82)	18·3

By 2000 A.D. it is anticipated to develop an additional area of 3·5 million acres (1·42 million ha), bringing the total irrigated area to 8 million acres (3·24 million ha). The development of this additional area requires about 12 million m^3 as detailed below:

	Area million acres (ha)	*Water consumption milliard m^3*
Upper Atbara Project	0·600 (0·24)	2·200
Rahad Project 2nd phase	0·520 (0·21)	2·000
Kenana Gravity project	0·800 (0·32)	2·600
Jonglei project	0·200 (0·08)	0·300
Pengko project	0·500 (0·20)	0·750
Renk-Jelhak sugar project	0·200 (0·08)	1·000
Kenana sugar project	0·080 (0·03)	0·800
Extensions to existing schemes	0·600 (0·24)	2·050
Total =	3·500 (1·40)	11·700

The anticipated irrigated crops by 2000 A.D. will be as shown below:

	Area million acres (ha)	*Production million tons*
Cotton	2·6 (1·05)	2·6
Wheat	1·6 (0·65)	1·6
Groundnuts	1·8 (0·73)	2·2
Sugar	0·6 (0·24)	2·7
Fruit and vegetables	0·7 (0·28)	5·0
Forage	0·5 (0·20)	5·0
Other crops	0·2 (0·08)	—

The future production of irrigated cotton, wheat, groundnuts, fruits and vegetables is expected to be four times the present production while that of sugar will be twenty-five times.

It is evident that the Sudan's ultimate annual water requirement from the Nile for irrigation will be about 30 milliard m^3.

Therefore it is becoming necessary to make available about 10 milliard m^3 of additional water to enable Sudan to implement the long-term plan of irrigated agriculture.

In the 1959 Nile Waters Agreement it was stipulated that Sudan and Egypt should make a joint effort to prevent underlosses which take place in the Sudd region in the southern Sudan.

Preliminary hydrological studies conducted by the P.J.T.C. indicate that it is possible to reclaim economically 18 milliard m^3 from the swamps. This reclamation will make good the shortage of water needed for irrigation development in the two countries.

At present the two countries are undertaking the execution of the first phase of these reclamation projects (Jonglei canal diversion project) by digging a canal having a capacity of 20 million m^3 per day, taking off from the Atem River, a tributary of the Behr EL Jebel, circumventing the swamps and flowing into the Sobat River. By completing this diversion in 1982, 4 milliard m^3 of additional water will be made available to be shared equally by the two countries for their agricultural development.

The other swamps reclamation projects are linked with the future over-year storage of the Equatorial Lakes (Victoria, Kyoga, and Albert.

At present the Sudan is participating with the East African countries and Egypt in the Hydrometeoroligical survey project of the catchments of the Equatorial Lakes. The main objective of the project is the collection and analysis of the hydrological and meteorological data which will assist in the control, storage and regulation of the Lakes for the beneficial use of all the participating countries.

TEHRAN SPECIAL SESSION 1977

IRANIAN NATIONAL COMMITTEE OF ICID

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SESSION SPECIALE DE TEHERAN 1977

R. 3

LIKELY IRRIGATED AGRICULTURE OF 2000 A.D.

IMPACTS OF CLIMATIC FLUCTUATIONS ON FOOD-PRODUCING ECOSYSTEMS*

DR. A. DEXTER HINCKLEY**

ABSTRACT

Climate has inherent variability which must be considered in planning ahead to 2000 A.D. The impacts of climatic fluctuation are especially important when they modify inputs, outputs or internal processes of food-producing ecosystems. If droughts become more prolonged and widespread, the crop species in such ecosystems will be directly stressed. Certain forms of disease and pest damage may also increase under arid conditions. Meteorological and ecological changes must be well monitored throughout food-producing regions with remote sensing and ground-level observations. Irrigation can counter some of the effects of drought but it may prove increasingly expensive to bring water from distant watersheds or deep aquifers. Nor can weather modification be relied upon to provide much relief. It may be best to design ecosystems around drought-tolerant species and to use water as conservatively as possible. Perhaps the ultimate ecosystem for an arid environment would use recycled water and nutrients in a closed hydroponic system powered by solar energy.

RESUME

Le climat a une variabilité inhérente qui doit être considérée dans la planification pour l'année 2000. Les effets de la variation climatique sont particulèrement importants quand ils modifient les entrées, les rendements ou les processus internes des écosystèmes producteurs d'aliments. Si les sécheresses sont prolongées ou répandues, les diverses cultures appartenant à ces écosystèmes auront un effet direct. Certaines formes de dommages

* Effets des variations climatiques sur les écosystèmes producteurs d'aliments.

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causés par les maladies et la peste peuvent également augmenter dans des conditions arides. Les changements météorologiques et écologiques doivent être bien contrôlés dans toutes les régions productrices d'aliment par télédétection et les observations au niveau du terrain. L'irrigation peut agir contre certains effets de la sécheresse mais elle serait de plus en plus chère d'emmener de l'eau des bassins distants ou des aquifères profonds. On ne peut ni s'attendre à des changements de climat pour un soulagement quelconque. Il conviendrait mieux de concevoir les écosystèmes autour des espèces qui tolèrent la sécheresse et d'utiliser l'eau aussi conservativement que possible. Peut-être l'écosystème ultime pour un environnement aride utiliserait-il des eaux usées et des éléments nutritifs dans un système hydroponique fermé actionné par l'énergie solaire.

INTRODUCTION

Most definitions of climate emphasize "long-term", "average" or "general" atmospheric conditions, in contrast to the short-term variations of temperature, precipitation and wind that characterize weather. This convenient distinction can be misleading. Climate is not merely the sum and average of daily weather. Climate, like all natural phenomena, has inherent variability. Therefore, a true and complete picture of climate should include not only the average conditions but the full range of variability observed in the past and probable in the future.

Many planners have found it convenient to ignore the inherent variability of climate. When planning investment, settlements or agricultural development, their tasks are complex enough. Yet equations that treat climate as a constant may lead to disastrous miscalculations. Economic growth is possible only within limits set by resource availability. In that context, agricultural productivity can be considered dependent on periods of favorable growing conditions combined with management techniques that protect crops from the impact of unfavorable periods.

Gunnar Myrdal(1) recognizes that such climatic constraints have often been ignored in plans for development. He calls for "much more intensive and systematic research" that "would entail co-operative efforts of geographers and meteorologists, biologists and other natural and medical scientists, engineers, foresters and agricultural experts, and economists". The Institute of Ecology (TIE), an international network of researchers and environmentalists, strongly endorses Myrdal's plea. Under the sponsorship of the Charles F. Kettering Foundation, TIE recently produced a study report analyzing the "Impact of Climatic Fluctuation on Major North American Food Crops" and we are seeking support for a multi-national study on the ecological and economic consequences of climatic impacts in major crop areas.

Other recent studies in North America have also emphasized the importance of climatic variation. In particular, we would like to call attention to two publications: "Living with Climatic Change" Proceedings, Toronto

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(1) G. Myrdal, "Asian Drama—An Inquiry into the Poverty of Nations", Pantheon, N.Y. 1968, Vol. III, Appendix 10, p. 2138.

Conference Workshop, November 17-22, 1975, published by the Science Council of Canada in March 1976; and "Climate and Food" published by the National Academy of Sciences in October 1976. Similar reports in the appropriate languages would be well received in many parts of the world.

Before we describe some impacts of climatic fluctuation, We would like to share with you some ecological views of agriculture.

FOOD-PRODUCING ECOSYSTEMS

A holistic view is ecology's major contribution to agriculture. From an ecological viewpoint, crops are not grown in fields but in systems with complex, interacting physical-chemical-biological processes—in short, ecosystems. This is quite different from a traditional agronomic orientation focused on the crop species. Too narrow a focus can fail to see actual or potential problems associated with agronomic management practices. However, the ecological perception permits management of the environmental factors preventing pest outbreaks, salt build-up and other problems.

Like other systems, food-producing ecosystems are better understood through input-output analysis. Solar energy and carbon dioxide are two vital inputs generally beyond human control. However, water can be augmented through irrigation and, under certain circumstances, weather modification. Similarly, nutrient input can be increased by appropriate applications of fertilizers. Other possible inputs include herbicides to reduce competition between crops and weeds as well as pesticides to kill animals attacking the crops. Unfortunately, many of these agricultural chemicals also become part of the output. Fertilizers may contaminate drinking water and biocides can be transported in water, on wind-blown dust or on the harvested portions of the crops.

An irrigated ecosystem is especially suitable for such input-output analysis. The quantities of water going in are usually measured and it is also possible to measure the concentrations of silt and dissolved compounds in the water. Out-flow through seepage, runoff and evapotranspiration can also be measured or, at least, estimated. Ideally water flow through an irrigated ecosystem is carefully controlled to provide not only enough for optimum crop growth but also enough to flush out salts before they reach phytotoxic concentrations.

Input-output analysis, however, is only one aspect of the ecosystem approach to agriculture. Looking within an irrigated ecosystem, an ecologist will see many species interacting with the crop species and with the physical-chemical environment established for the benefit of the crop. These organisms include those beneficial from our viewpoint (earthworms, pollinators, enemies of pests), those which are harmful to the crop (weeds, plant pests and pathogens) and those which are economically neutral. The irrigated ecosystem may also contain species that are of great importance in the area of public health. These include the immature stages of mosquitos that, as adults, transmit pathogenic protozoa, filaria or viruses. Then, of course, there are the snails that serve as reservoirs for schistosomal parasites and the free-swimming stages of the schistosomes themselves. An irrigated ecosystem can become a menace to public health if infested snails are common and human contacts frequent.

There are many other components and processes that may be important in a food-producing ecosystem. However, those already mentioned should serve as a foundation for the following discussion of climatic impacts.

IMPACTS OF CLIMATIC FLUCTUATION

Recognizing that a "normal" climate is inherently variable and food-producing ecosystems are more than "crops planted in well-watered soil", it should be possible to predict some important impacts and describe their ecological consequences. Much of this is more common sense than science since we do not have statistics to support the examples. Yet the problems may be solved by management techniques based on the ecosystem concept.

Climatic fluctuations can affect a crop species directly and indirectly. During a drought, transpiration rates can exceed uptake rates and the plants wilt, with consequent reduction in photosynthetic fixation of solar energy in carbohydrates. Other effects are more indirect. Evaporation and transpiration will both leave soil or standing water with increasing salinity, imposing osmatic stress on the plants' root systems. Certain pest species, especially grasshoppers, may be favored by arid conditions. Grasshopper populations may increase in crop areas or migrate into those areas from even more arid natural ecosystems. Some pathogens may be able to penetrate the defenses of crop plants weakened by the combined stress of direct and indirect climatic effects. At the beginning of a drought period, areas of standing water will be reduced and chances of schistosomiasis infection will increase. However, a prolonged drought can greatly reduce the hazard by decimating the snail populations. Many more examples of drought related effects can be found in agronomic, entomological, parasitological, and phytopathological literature.

Excess precipitation, even in an arid region, can also cause many problems in a food-producing ecosystem. Fungal pathogens may increase as the humidity within the crop microhabitat rises. Accelerated erosion can, in varying combinations, silt in irrigation ditches or damage water channelling systems. Waterlogging can increase with deleterious effects on the crop root systems and nutrient up-take. Water is an essential input for every food-producing ecosystem, yet it can be "too much of a good thing".

We have used precipitation extremes as the main example. Obviously, similar examples can be based on variations in temperature, wind-speed or any other atmospheric characteristic. Generally speaking the long-term change of greatest interest to this special session would be an increased prevalence of drought. Even if we had a crystal ball, we could not tell if monsoon failures will increase in decades to come. Climatologists suggest that a warming trend augmented by increased CO_2 concentration from combustion of fossil fuels would lead to prolonged droughts. Other experts emphasize the importance of particulates from volcanos, industry and cultivated fields in reducing solar energy penetration at high altitudes, although particulates, like CO_2 and water vapor, can also increase atmospheric entrappment of solar energy (the so-called "greenhouse effect"). Despite the diversity of opinion, climatologists do agree that fluctuations have always occurred and that their amplitude may even increase. Therefore, global cooling or warming trends may be less relevant than increasingly extreme climatic variation affecting large areas of food producing ecosystems.

BUILDING BETTER ECOSYSTEMS

Recognizing that all food-producing ecosystems will be buffetted by climatic fluctuations—perhaps increasing in their extremes—we should be developing an array of protective strategies based on the ecosystem concept. Such plans are especially appropriate for a meeting that is looking ahead to 2000 A.D.

First, we want to emphasize the importance of monitoring changes in climate and in food-producing ecosystems. There are large areas of the world where meteorological stations are few and far between. Gaps in this network should be filled with automatic recording and transmitting stations if trained observers are not available. There is also great need for regular ecological observations in agricultural areas, especially those being brought into production. Early detection of pests and diseases affecting man, livestock and crops can permit corrective measures of relatively modest expense. Remote sensing from aircraft and satellites is a very useful adjunct to ground-level monitoring. Imagery from such "flying carpets" can provide large-scale assessments of cloud cover, soil moisture and crop condition. However, there is no way in which remote sensing can replace all ground-level observations. You cannot tell from five miles up if snails are harboring blood flukes !

Assuming droughts become more widespread and prolonged, irrigation and drainage will become increasingly important in food production. Paradoxically, the flow of water through conventional irrigation systems may have to increase as precipitation decreases. This means tapping new sources in more remote watersheds or deeper aquifers. Either approach will involve great capital expense and higher operating costs. Deep wells, mining fossil water, must be examined very carefully in areas where rising fuel costs have already inhibited the use of pumps. Even in those situations where water from deep aquifers is reasonably free from dissolved solids, there is good reason to evaluate exploitation potential very carefully. It would be tragic to develop a large agricultural settlement supported by water from deep wells only to have fuel and drilling costs strangle the settlement decades hence.

Similarly, weather modification has definite limitations in coping with drought. Even the most optimistic rain maker would not promise to wring precipitation out of a clear sky. The best he could do is augment rain or snow through cloud-seeding over a watershed which then might provide more water for irrigation. This orographic augmentation has been well demonstrated in the Rocky Mountains of the U.S. However, weather modification is not accepted as a reliable technique for increased food production in the American grain belts. Either increased rain or reduced hail would certainly lead to higher yields but cloud seeding procedures must be improved before they can produce guaranteed results.

If increased supplies of water will be hard to obtain during a drought, what else can be done to maintain food production ? *Making do with less* ! There are many ways in which scarce water supplies can be used more efficiently. Building your ecosystem around drought-tolerant crops is one. Sorghum can be substituted for maize, or upland rice can replace the wetland varieties. You can even shift all the way to plants pre-adapted to desert conditions. Unfortunately, cactus cannot readily replace rice or wheat in the human diet.

For orchards and vineyards, trickle irrigation (delivering the water through plastic piping directly to the roots) will greatly reduce evaporative losses. This technique is, however, too expensive for most food crops. Hydroponic greenhouses are also luxurious at present but we would like to see much more experimentation on their use. In environments where solar energy is abundant and water scarce, it makes ecologic sense to recycle water rather than losing it to the air and the soil. With a closed system, it is also possible to make very efficient use of nutrients, essentially replacing only those removed through harvest. The nutrient input can be provided by sanitized sewage or other specially processed waste. You can even accelerate leaf growth by increasing the concentration of CO_2. Furthermore, careful selection of planting material greatly reduces losses to pests and pathogens. At present, the pumps used to circulate nutrient solutions are powered by fossil fuels and face some of the same limits imposed on well pumps. Perhaps the ultimate answer to drought is a closed, hydroponic ecosystem powered by solar energy.

In conclusion, we would like to emphasize that The Institute of Ecology's multi-national study of climatic impacts on major food crops is open to additional participation and support. We need help in collecting data series on climate, yields and prices, and would welcome support for meetings to analyze and present results. Although we expect to identify data gaps that can be filled by additional research, we feel that existing information has not been fully utilized.

We hope that our findings will be of value to engineers, economists and all others creating plans to 2000 A.D. and beyond.

TEHRAN SPECIAL SESSION 1977

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SESSION SPECIALE DE TEHERAN 1977

R. 4

LIKELY IRRIGATED AGRICULTURE OF 2000 A.D.

PERSPECTIVE DE L'AGRICULTURE IRRIGUEE EN L'AN 2000 ROLE DE L'ICID ET DE SES COMITES NATIONAUX POUR FAIRE FACE A LA SITUATION*

COMITE NATIONAL IRANIEN DE L'ICID

RESUME

L'Iran est situé dans une zone aride du globe. La moyenne annuelle des précipitations sur l'ensemble du territoire est de l'ordre de 230 mm soit 3 fois plus faible que la moyenne annuelle mondiale.

Cette valeur moyenne ne représente d'ailleurs qu'imparfaitement la réalité, car la variabilité des précipitations est particulièrement forte que l'on se place au niveau interannuel ou au niveau inter régional.

Les ressources en eau de l'Iran sont limitées. Les quantités d'eau ruisselées, infiltrées ou provenant de bassins extérieurs représentent en moyenne entre 100 et 110 milliards de m^3 par an. Environ la moitié de ces ressources sont actuellement mobilisées grâce à des ouvrages traditionnels ou à des ouvrages modernes. Les quantités définitivement consommées principalement par la production agricole représentent 25 à 30 milliards de m^3 par an. Les pertes définitives dues à l'irrigation s'élèvent à environ 10 à 15 milliards de m^3 par an. Donc le potentiel hydraulique encore disponible est de l'ordre de 60 à 70 milliards de m^3 par an dont on peut espérer utiliser encore le tiers d'ici l'an 2000.

Etant donné que la surface consacrée à l'agriculture irriguée en 1975 s'élevait à environ 3,7 millions d'hectares, il semble que l'on puisse fixer comme objectif à l'horizon 2000 une superficie irriguée totale d'environ 6 millions d'hectares, avec des cultures plus intensives qu'aujourd'hui.

* Perspective of irrigated agriculture in 2000 A.D. Role of ICID and its National Committees to face the situation.

Dans ce cas, on estime que la valeur ajoutée nette de la production agricole, qui a été de 180 milliards de Rials en 1975, atteindrait environ 3 fois ce niveau en l'an 2000.

SUMMARY

Iran is situated in an arid part of the world. Annual average precipitation over the whole of the country amounts approximately 230 mm or a third as much as the annual world average.

This average figure gives only a very imperfect indication of the real situation, as precipitation levels vary greatly not only from one season to the other but also from one region to the other.

Iran's water resources are limited. On an average approximately 100 to 110 billion m^3 of water is collected annually by runoff, percolation into the water table or from extra-territorial drainage basins. At the moment almost half of these resources are mobilized either by traditional or modern means. The amount of water actually consumed, largely by agriculture, totals 25-30 billion m^3 per year. Actual losses due to irrigation amount to approximately 10-15 billion m^3 a year. Thus the remaining water potential is in the order of 60-70 billion m^3 a year, of which it is hoped a third can be harnessed between now and the year 2000.

Given that in 1975 the total area devoted to irrigated culture was approximately 3·7 million hectares, it would seem reasonable to set 6 million hectares as the target for the year 2000 assuming more intensive farming methods than at present.

If this were the case, net value added by agricultural production, which totalled Rials 180 billion in 1975, would almost triple by the year 2000.

INTRODUCTION

L'Iran est pour l'essentiel un haut plateau situé au Sud-Ouest de l'ASIE, entre 44 et 63.15 degré de longitude et 25.4 et 39.45 degré de latitude Nord.

Par sa situation et son relief particulier, l'Iran est un pays aride ou semi. aride (120 millions d'hectares subissent un climat désertique, 40 millions un climat tempéré, et 4 millions un climat froid montagneux).

Aussi tout au long de son histoire, le problème de l'eau a-t-il été la grande préoccupation de ce pays dont les habitants ont su très tôt élaborer et mettre en oeuvre des techniques efficaces de mobilisation de l'eau d'irrigation.

Il y a plus de 9000 ans, naissaient sur les pentes de Zagros[1] les premières civilisations agricoles et pastorales, qui très tôt ont su développer et utiliser des techniques d'irrigation efficace (barrage poids—canaux—ghanat) dont on retrouve des vestiges datant de plus de 2000 ans.

(1) Selon Norman E. Borlaug, The green revolution.

Préoccupation de toujours, le problème de l'eau se pose avec une nouvelle et particulière acuité à l'orée de ce dernier quart de siècle.

Il se pose en effet à l'Iran une fois encore le délicat problème de tirer le meilleur parti de ses ressources en eau dans la perspective d'un quasi doublement de sa population et de l'utilisation maximale de son potentiel agricole.

1. PLACE DE L'AGRICULTURE IRRIGUEE DANS LA PRODUCTION AGRICOLE

1.1 AU NIVEAU NATIONAL

En dehors des zones de parcours, on estime que la superficie exploitée à l'heure actuelle, couvre entre 12 et 13 millions d'hectares. Ceci représente un peu moins de 10 pour cent du territoire de l'Iran.

La surface exploitée par la culture en sec (principalement la céréaliculture) s'étend sur environ 8 millions d'hectares, jachères comprises. Le reste, soit 4 millions d'hectares, représente les surfaces équipées pour l'irrigation. Ces 4 millions d'hectares peuvent être répartis en:

—2,5 millions d'hectares implantés sur des sols de bonne qualité sans contraintes particulières. La surface totale de telles zones représente environ 3,7 millions d'hectares pour l'ensemble de l'Iran.

—1,5 millions d'hectares implantés sur des sols présentant des contraintes importantes de salure, de pentes et (ou) de drainage.

Sur ces 4 millions d'hectares équipés, la superficie cultivée, en 1974, s'élevait à environ 3,4 millions d'hectares, et à environ 3,7 millions d'hectares en 1975.

Les parcours, quant à eux, comprennent toutes les terres non cultivées et non occupées soit environ 125 millions d'hectares, forêts et déserts inclus. Les ressources pastorales fournies par les parcours représentent en année moyenne environ 8,5 milliards d'unités fourragères (l'unité fourragère équivaut à 1 kg d'orge), et fournissent environ 65 pour cent de la consommation de l'élevage extensif.

Une part non négligeable des superficies irriguées sert, par ailleurs, à l'alimentation des troupeaux. C'est ainsi que l'on estime la superficie couverte par l'orge irriguée à environ 350.000 hectares (alimentation du bétail en stabulation pendant l'hiver), et celle cultivée en fourrages à quelques 270.000 hectares (élevage bovin laitier principalement).

Les cultures irriguées représentent actuellement environ 64 pour cent de la production agricole en valeur, les cultures, en sec 12 pour cent et les parcours environ 24 pour cent. Si l'on rapproche en estimation des surfaces cultivées on conçoit tout l'intérêt que représente l'irrigation et en particulier la maîtrise de l'eau.

1.2 AU NIVEAU REGIONAL

Un découpage de l'Iran en 33 régions agricoles a été utilisé (voir Figure 1) pour déterminer la répartition par zone et par système de production des surfaces cultivées (voir Tableau I).

TABLEAU 1

Répartition des surfaces cultivées par système de production en 1974

Grands types de régions	Régions agricoles	Surface totale exploitée 1.000 ha	Surface totale cultivée 1.000 ha	Poles et grands périmètres de plaines 1.000 ha	Petite hydraulique		Total irrigué 1.000 ha	%	Culture en sec 1.000 ha	%
					Plaines irriguées 1.000 ha	Vallées de montagne piémont et oasis 1.000 ha				
Zones de nouvelle mise en valeur	Khouzestan	709	407	320	—	4	324	9,7	83	2,1
	Sistan	100	45	45	—	—	45	1,4	—	—
	Moghan	27	23	20	3	—	23	0,7	—	—
		836	475	385	3	4	392	11,8	83	2,1
Régions intensives	Teheran	552	405	159	139	19	317	9,5	88	2,2
	Esfahan	344	239	69	64	18	151	4,5	88	2,2
	Mazandaran	775	537	105	152	5	262	7,9	275	6,9
	Gilan	300	241	160	24	4	188	5,6	53	1,3
	Rezaiyeh	825	500	75	129	32	236	7,1	264	6,6
	Nord Knorassan	1.518	855	8	282	10	300	9,0	555	13.9
		4.314	2.777	576	790	88	1.454	43.6	1·323	33,1
Territoire du nord Zagros	Hamadan	800	420	—	100	20	120	3,6	300	7,5
	Kermanshah	560	340	—	80	10	90	2,7	250	6,3
	Ilam	140	75	—	—	15	15	0,5	60	1,5
	Lorestan	490	299	—	46	24	70	2,1	209	5,2
	Arak	305	185	—	77	3	80	2,4	105	2,6
		2.295	1.319	—	303	72	375	11,3	924	23,1

Zones céréalières du nord ouest	Tabriz	1.250	660	—	54	29	83	2,4	577	14,5
	Zanjan	450	232	—	—	16	16	0,5	216	5,4
	Kurdistan	640	360	—	—	60	60	1,8	300	7,5
		2.340	1.252	—	54	105	159	4,7	1.093	27,4
Territoires dispersés du Zagros et du centre Khorasan	Shiraz	262	183	40	78	30	148	4,4	35	0,9
	Jahrom	202	128	—	76	42	118	3,5	10	0,2
	Bakhtlari	110	72	—	27	13	40	1,2	32	0,8
	Kobkilouyeh	57	33	—	—	14	14	0,4	19	0,5
	Central Khorasan	1.060	630	—	186	64	250	7,5	380	9,5
		1.691	1.046	40	367	163	570	17,0	476	11,9
Territoires marginaux	Saveh	60	48	20	26	2	48	1,4	—	—
	Semnan	55	34	—	21	3	24	0,7	10	0,2
	Ardestan	15	11	—	11	—	11	0,3	—	—
	Yazd	47	40	—	33	7	40	1,2	—	—
	Kerman	119	85	—	55	25	80	2,4	5	0,1
	Jiroft	46	30	10	5	10	25	0,8	5	0,1
	Bam	29	23	—	19	5	24	0,7	—	—
	Baluchistan	20	11	2	6	3	11	0,3	—	—
	Sud Khorasan	202	130	—	37	18	55	1,7	75	2,0
	Bushehr	38	23	—	8	15	23	0,7	—	—
	Bandar Abbas	60	45	10	20	15	45	1,4	—	—
		691	480	42	241	103	336	11,6	95	2,4
Iran		12.167	7.330	1.043	1.758	535	3.336	100	3.994	100

SOURCE = SCETIRAN

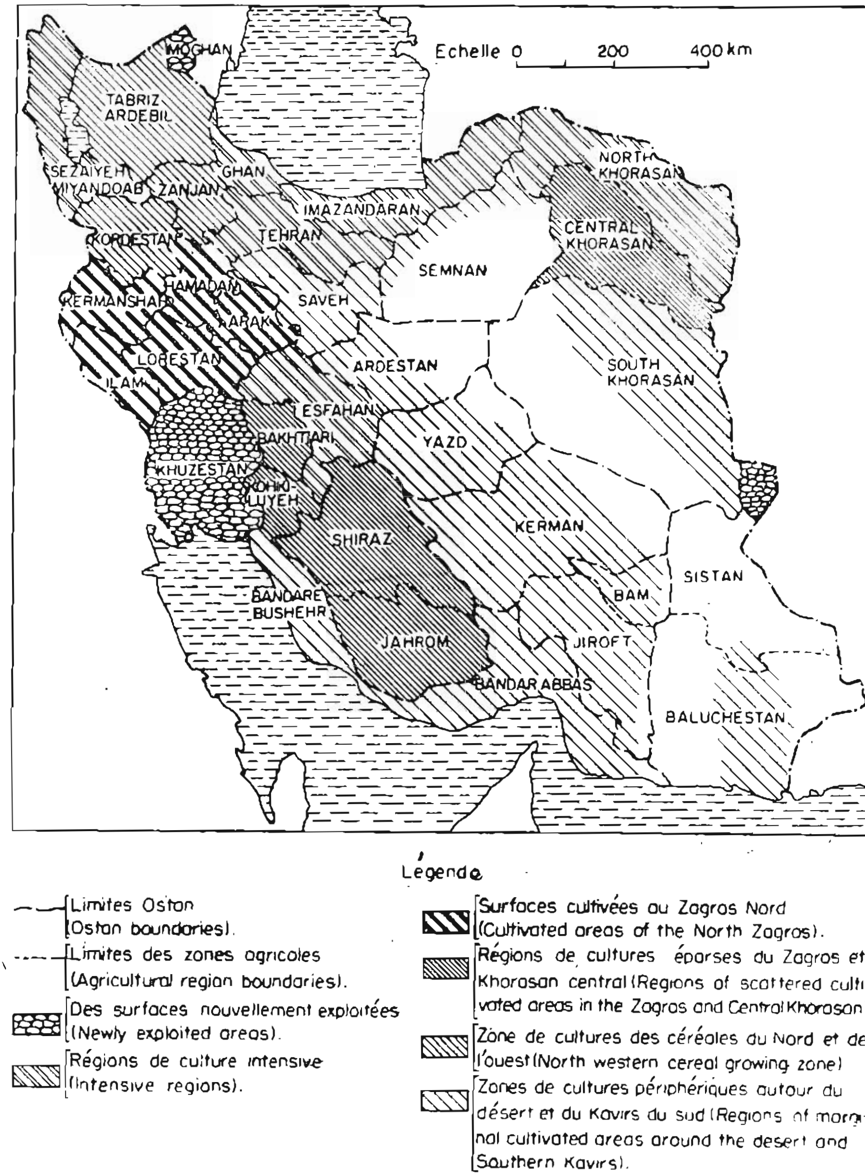

FIGURE 1 : Types de régions agricoles (Types of agricultural regions)

On peut regrouper ces 33 régions en six ensembles présentant malgré des différences notables des traits communs.

(*a*) *Zones de nouvelle mise en valeur:* Ce sont celles du Khouzestan, du Zabol (Sistan) et du Moghan. Le trait commun à ces régions, par ailleurs fort dissemblables réside en ce que la maîtrise des ressources en eau qui est en train de s'accomplir au travers de la construction de grands barrages réservoirs provoque dès maintenant et provoquera plus dans le futur une restructuration de l'espace rurale.

De grands périmètres modernes sont déjà installés ou se mettent en place à l'aval des barrages exécutés. On peut en particulier citer les périmètres:

—du Dez (Khouzestan) alimenté par le barrage de Mohamad Réza Chah Pahlavi (93.000 hectares)

—du Chavour alimenté par un barrage de dérivation sur la rivière Chavour (Khouzestan) (10.000 hectares)

—du Karkeh (Khouzestan) alimenté par un barrage de dérivation construit sur la rivière du même nom (11.200 hectares)

—de Haft Tapeh (Khouzestan) alimenté par le Dez (11.000 hectares)

—de Moghan alimenté à partir du barrage construit conjointement par l'Iran et l'URSS sur le fleuve frontalier Arax (90.000 hectares)

—de Zabol (Sistan) alimenté par un barrage de dérivation construit sur la rivière Sistan (67.000 hectares).

En général l'exécution des réseaux de drainage se fait, lorsque cela s'avère nécessaire, parallèlement à l'exécution des réseaux d'irrigation. En certaines zones, par exemple dans la partie bonne du Khouzestan, un effort reste toutefois à accomplir en ce sens pour lutter contre les phénomènes de salure des sols liés à la remontée des niveaux piézométriques.

Les zones de nouvelle mise en valeur sont caractérisées par la part importante que tient l'irrigation dans la valeur ajoutée agricole régionale: près de 80 pour cent, le reste de la V.A.N. provenant des parcours.

La contribution actuelle de ces zones à la V. A. N. agricole nationale n'est encore que de l'ordre de 10 pour cent, mais ce pourcentage est appelé à croître fortement et rapidement.

(*b*) Les régions de Téhéran, du Gilan, du Mazandaran, d'Esfahan, du Nord Khorassan et le Rezaiyeh-Miandoab peuvent être regroupées sous le terme d'intensives. L'agriculture irriguée avec maîtrise de l'eau y est prépondérante. Ces régions, où les grandes plaines dominent, occupent une place majeure dans l'économie agricole actuelle : près de 50 pour cent de la valeur ajoutée agricole, 44 pour cent des surfaces irriguées, 33 pour cent des cultures en sec de l'ensemble de l'Iran.

Cette maîtrise de l'eau se fait d'une part grâce à la construction de barrage :

—réseau d'irrigation du Sefid Rud (Gilan), alimenté par la retenue du barrage Chahbanou Farah (240.000 hectares)

—réseau d'irrigation du Gorgan alimenté par la retenue du barrage Vochmguir sur le Gorgan Rud (25.000 hectares)

—réseau d'irrigation d' Esfahan alimenté par la retenue du barrage Chah Abbas Kabir construit sur le Zayandeh Rud (95.000 hectares)

—réseau d'irrigation de Ghazvine (Téhéran) alimenté par deux barrages de dérivation édifiés sur la rivière Chah Rud (58.000 hectares)

—réseau d'irrigation du Zarrineh Rud (Miandoab) alimenté par le barrage de Kourosh Kabir (50.000 hectares)

—réseau d'irrigation de Mahabad (Rezaiyeh) alimenté par le barrage Chapour ler (21.000 hectares)

mais aussi grâce à l'exploitation intensive des ressources en eaux souterraines. par l'intermédiaire de forages profonds remplaçant l'ancienne exploitation par ganâts (plaine de Mashhad dans le Nord Khorassan par exemple), et quelque fois grâce à la réutilisation des eaux usées urbaines (extension des périmètres de Varamin-Garmsar à partir des eaux de la nappe de Téhéran alimentée par les effluents de la ville).

Les superficies totales irriguées dans ces régions intensives correspondent à environ 1.500.000 hectares, soit environ 52 pour cent de la surface totale cultivée régionale et fournissent plus de 80 pour cent de la V. A. N agricole de l'ensemble de la zone.

(*c*) La région du Nord Zagros a par contre une productivité générale faible. Les surfaces irriguées sont réduites (375.000 hectares soit 28 pour cent du total régional des terres cultivées) malgré l'importance des ressources en eau qui restent difficilement maîtrisables. Il n'existe encore de ce fait que peu de périmètres modernes, l'essentiel de l'irrigation étant réalisé à partir d'ouvrages de petite hydraulique (épandages d'eaux de crues, captages de sources, ganâts, forages).

(*d*) La zone céréalière du Nord Ouest où la culture en sec et l'élevage extensif dominent. On y trouve toutefois les plaines extensives de Tabriz et d'Ardebil dans lesquelles la production des périmètres irrigués est importante. En total les zones irriguées ne couvrent qu'environ 160.000 hectares sur un total régional cultivé de l'ordre de 1.250.000 hectares.

(*e*) Les zones agricoles disposées du Fars, du Bakhtiari, du Kohkiluyeh et du centre Khorassan sont généralement caractérisées par l'élevage extensif, une agriculture en sec marginale et l'isolement relatif des plaines irriguées parfois de façon extensive, généralement de taille moyenne (2.000 à 10.000 hectares). Dans les régions de Shiraz, de Jahrom et du centre Khorassan, la culture irriguée est prépondérante dans la production agricole ce qui montre bien l'intérêt et l'importance de la maîtrise de l'eau en ces zones peu favorisées soit par le relief, soit par le climat. Certaines de ces régions telles celles du Bakhtiari et de Kohkiluyeh présentent des ressources en eau importantes, peu utilisables sur place du fait des contraintes du relief, aussi le transfert d'une part importante de leurs ressources vers des zones voisines (celles d'Esfahan par exemple) est-il non seulement envisagé mais déjà réalisé en partie (captage et tunnel de diversion de Kuhrang qui accroît les disponibilités en eau et la régularisation du barrage de Zayandeh Rud).

(*f*) Enfin les terroirs marginaux rassemblent les régions périphériques du désert central et des Kavirs ainsi que les zones côtières du Sud. Dans l'ensemble de ces zones se posent pratiquement toujours de graves problèmes de surexploitation des ressources en eaux souterraines et très souvent des contraintes importantes de salinité des eaux et du sol. Localement d'importants travaux hydrauliques ont permis la régularisation des faibles ressources en eau de surface existantes. On peut citer:

—le périmètre de Jiroft qui sera alimenté à partir d'un barrage en construction sur la rivière Hallil Rud (235 millions de m^3 régularisés)

—le périmètre de Minab qui sera alimenté par le barrage en cours de construction sur la rivière du même nom (240 millions de m^3 régularisés)

—le réseau d'irrigation de Bampur (Balutchestan) alimenté par un barrage de dérivation sur la rivière Bampur (2.700 hectares)

—le barrage de Pichine et le réseau d'irrigation associé (12.000 hectares) en cours de construction dans le Balutchestan.

Malgré la faiblesse de leurs ressources en eau, ces zones marginales représentent 10,5 pour cent de la valeur ajoutée agricole nette de l'ensemble de l'IRAN, la part prise par les productions provenant des zones irriguées étant de l'ordre de 6 pour cent de cette même V.A.N. agricole national.

2. LES CONTRAINTES AUXQUELLES SE TROUVE CONFRONTE LE DEVELOPPEMENT DE L'AGRICULTURE IRRIGUEE

2.1 LE CLIMAT

L'Iran est situé dans une zone aride du globe. La moyenne annuelle des précipitations sur l'ensemble du territoire est de l'ordre de 230 mm soit 3 à 4 fois plus faible que la moyenne annuelle mondiale.

Cette valeur moyenne ne représente d'ailleurs qu'imparfaitement la réalité car la variabilité des précipitations est particulièrement forte que l'on se place au niveau interannuel ou au niveau interregional. (Par exemple la zone comprise entre la chaîne de l'Alborz et la Caspienne reçoit presque partout plus de 600 mm de pluie, souvent plus de 1.000 mm alors qu'une grande partie de la région centrale reçoit moins de 100 mm).

La faible humidité de l'air et les températures élevées qui règnent sur la grande partie du territoire conditionnent l'importance de l'évapotranspiration potentielle et des besoins en eau des cultures.

2.2 LES RESSOURCES EN EAU

Les ressources en eau de l'Iran sont limitées, les quantités d'eau ruisselées, infiltrées ou provenant de bassins extérieurs au territoire (fleuves frontaliers) représentent en moyenne entre 100 et 110 milliards de m^3 par an. Environ la moitié de ces ressources sont actuellement mobilisées au travers soit d'ouvrages traditionnels et quelque fois plusieurs fois millenaires (ganats, ouvrages de dérivation et d'épandage...), soit d'ouvrages modernes (barrages, forages, prises en rivière, stations de pompage...). Les quantités définitivement consommées, principalement par la production agricole, ne représentent toutefois que 25 à 30 milliards de m^3 par an. Actuellement, les pertes définitivies non productives dues à l'irrigation (évaporation, évapotranspiration de la végétation parasite...), à la gestion des ouvrages hydrauliques (évaporation sur lacs de barrage par exemple) s'élèveraient à environ 10 à 15 milliards de m^3 par an.

Dans l'avenir ces pertes pourront être réduites, mais ne pourront pas disparaître totalement. En admettant que l'on puisse les réduire de 50 pour cent, le potentiel hydraulique encore disponible serait de l'ordre de 60 à 70 milliards de m^3. Cette valeur peut paraître importante, notamment si on la compare aux consommations actuelles, il convient, toutefois de rappeler que les travaux déjà exécutés ont concerné:

—les sites les plus facilement accessibles ou constructibles

—les ouvrages ayant le meilleur taux de régularisation

de ce fait, les ouvrages futurs seront tous à la fois moins productifs et plus onéreux.

Compte tenu de cette remarque, il semble que l'on puisse fixer comme objectif, à l'horizon de l'an 2000, la régularisation et donc la maîtrise d'environ 1/3 de la ressource encore disponible soit environ 20 milliards de m^3.

La marge de progrès est donc importante mais elle n'est pas illimitée.

D'autre part les ressources en eau sont très inégalement réparties non seulement dans le temps, ce qui est la règle pour toutes les régions à forte aridité, mais également dans l'espace iranien. Certaines régions sont comparativement extrêmement favorisées. C'est ainsi que les fleuves qui traversent le Khouzestan (Karkeh, Dez, Karun, Marun, Zoreh) représentent à eux seuls un volume annuel moyen écoulé de l'ordre de 5 à 30 milliards de m^3 par an. Si on y ajoute les ressources en eaux souterraines, cette région représente le 1/3 des potentialités hydrauliques de l'Iran et beaucoup plus du 1/3 des ressources restant à utiliser.

A l'opposé de ceci se trouvent la plupart de ce que l'on a appelé les zones marginales, mais également des régions intensivement exploitées telles que le Nord Khorassan, Téhéran, etc.... Dans ces régions les ressources en eau et notamment les nappes aquifères sont intensivement exploitées voire surexploitées, de ce fait l'extension des zones irriguées pourra provenir non pas de l'accroissement de l'exploitation de la ressource mais d'une meilleure gestion de celle-ci. Le maintien d'un taux élevé de régularisation des ressources dans toutes les zones naturellement défavorisées impose, non seulement de conserver mais dans toute la mesure du possible d'améliorer les structures hydrauliques traditionnelles. Ceci ne peut se faire qu'au travers d'un effort difficile et de tous les jours, effort peu visible mais indispensable dès lors que l'on veut lutter contre la dégradation de la production, contre la désertification d'une partie du pays par l'exode rural.

En outre, dans de nombreuses régions, les ressources en eau sont de mauvaise qualité, qu'il s'agisse des effets provoqués par l'évaporation ou de ceux à attribuer à la présence de terrains géologiquement salifères (diapirs, formations gypseuses...).

2.3 LES SOLS

Bien que l'eau puisse être considérée comme le facteur naturel principal de limitation de l'agriculture irriguée, les sols également constituent une contrainte.

On estime, en effet, que la surface totale des sols de bonne qualité sur lesquels l'irrigation n'est soumise à aucune contrainte est de l'ordre de 3,7 milliards d'hectares, desquels 2,5 millions sont déjà équipés. Au delà de cette limite l'irrigation devra se faire, comme elle se fait déjà sur environ 1,5 millions d'hectares, sur des sols présentant des contraintes importantes de pentes, de drainage, de salure.

La surface actuellement exploitée par la céréaliculture en sec s'étend sur 8 millions d'hectares, jachères incluses, alors que le potentiel utilisable sans risque d'érosion irréversible est estimé à environ 5 millions d'hectares.

2.4 ASPECTS DEMOGRAPHIQUES ET SOCIAUX

Le recensement de 1956 indiquait une population rurale (population vivant dans des localités de moins de 5.000 habitants) de 15.000.000 habitants, soit 62 pour cent de la population totale. D'après l'enquête 1974 exécutée par le Centre Iranien des Statistiques ces valeurs seraient respectivement de 18.800.000 et 58 pour cent. On assiste donc à la fois à un accroissement de la population rurale en valeur absolue, et à une diminution de cette même population en valeur relative. L'exode rural existe donc dès maintenant, le taux de croissance de la population rurale (2 pour cent) étant inférieur au taux de croissance naturelle (2,4 pour cent).

Les zones prioritaires de migration rurale semblent être d'une part celles situées à proximité des grandes villes (Téhéran, Esfahan, Mashhad, Tabriz) et d'autre part les zones les plus déshéritées (les bordures des déserts centraux, les ostans du Sud).

Cet exode rural peut être expliqué par l'attrait qu'exercent les grandes villes où le niveau de vie est nettement supérieur, par le peu d'emplois qu'offrent en milieu rural les secteurs secondaire et tertiaire, par un niveau d'équipements et de services encore insuffisant malgré le grand effort entrepris depuis plusieurs années.

2.5 STRUCTURES DE PRODUCTION

Une des contraintes principales auxquelles a à faire face l'agriculture iranienne provient du caractère marginal d'une grande partie de sa production. La marginalité pouvant résulter soit de l'isolement géographique de certaines zones irriguées (cet isolement étant lié à l'existence des ressources en eau), soit de conditions physiques défavorables (sols salés, eaux de mauvaise qualité...). Les productions de ces zones marginales sont toutefois, extrêmement importantes puisqu'elles participent actuellement pour environ 1/3 à la production agricole, et qu'elles permettent un déploiement optimum de la population sur l'ensemble du pays. La politique du gouvernement iranien consiste à tout mettre en oeuvre pour tirer le meilleur parti de ce potentiel de production en améliorant les conditions de production et d'environnement du secteur paysanal concerné.

3. LE DEVELOPPEMENT POTENTIEL DE L'AGRICULTURE IRRIGUEE

3.1 AU NIVEAU NATIONAL

L'important accroissement de la population et du niveau de vie entre 1976 et l'an 2000 entraînera une très forte augmentation des besoins en produits agricoles.

Compte tenu de ses potentialités, limitées en eau comme en sol de qualité, l'auto-suffisance de l'Iran sera très difficile voire impossible à atteindre.

Le problème sera de limiter au maximum la dépendance de l'Iran vis-à-vis de l'extérieur. Dans ces conditions l'accroissement rapide des surfaces irriguées est dès à présent une impérieuse nécessité. Toutefois cet accroissement ne doit pas se faire au détriment du secteur paysannal traditionnel car à terme cela conduirait à une réduction du potentiel et du niveau de production par abandon de toutes les zones marginales qui représentent comme on l'a vu un potentiel non négligeable.

De ce fait le schéma de croissance retenu réalise un compromis entre la création de nouveaux périmètres et la rénovation des périmètres traditionnels.

C'est ainsi que sur les 3,7 millions d'hectares actuellement irrigués, on estime au maximum à 1,3 million d'hectares les surfaces où la maîtrise de l'eau est satisfaisante (700.000 hectares irrigué par puits et forages, 600.000 hectares en périmètres de plaine disposant d'eaux de surface).

Compte tenu de ce fait, il est prévu pour la période 1976-2000 d'équiper ou de rénover 4,7 millions d'hectares pour atteindre un objectif de 60 millions d'hectares où la maîtrise de l'eau sera optimisée compte tenu des contraintes particulières liées à la nature de la ressource. Le rythme annuel d'équipement devrait donc atteindre plus de 180.000 hectares sur des périmètres souvent petits où les travaux devront aller jusqu'à l'aménagement terminal des parcelles (tant en ce qui concerne l'irrigation que le drainage).

Cet accroissement des superficies irriguées devra s'accompagner d'un accroissement général de la productivité. La valeur ajoutée par hectare devra croître d'environ 3 pour cent par an jusqu'à 1990, les rendements moyens devront doubler. Par la suite c'est-à-dire jusqu'en 2000 on estime que l'amélioration de la productivité se poursuivra à un rythme de l'ordre de 2 pour cent par an.

Par contre dans le domaine de l'agriculture en sec, on assistera à une diminution des surfaces effectivement ensemencées, du fait d'une part de sa productivité faible et d'autre part des efforts qui seronts faits pour la limiter sur les terrains érodables. C'est ainsi que les superficies effectivement ensemencées passeront de 4.000.000 hectares en 1975 à environ 3.000.000 en 2000.

Au total on estime que la valeur ajoutée nette de la production agricole, qui a été de quelques 180 milliards de Rials en 1976, atteindra environ 3 fois ce niveau en l'an 2000.

3.2 AU NIVEAU REGIONAL

Dans les zones de mise en valeur nouvelle, la croissance très rapide de la V.A.N. est due à la très forte extension des surfaces irriguées modernes. On prévoit qu'en 1990 plus de 860.000 hectares seront irrigués dont 650.000 au Khouzestan (dont le potentiel maximum, utilisé à l'horizon 2000/2010, est évalué à 850.000 hectares) et 90.000 à Moghan (dont la croissance très rapide se poursuivra après 1990 pour atteindre en place finale 200.000 hectares).

Dans les régions intensives, la croissance de la V.A.N. proviendra essentiellement de l'intensification et de l'extension de l'irrigation moderne dans les grandes plaines proches des grandes villes. Dans certaines zones d'agriculture péri-urbaine, il se posera, toutefois, des problèmes difficiles de concurrence pour l'utilisation du sol (par exemple à Rezaiyeh, Qazvin, Esfahan) et pour l'utilisation de l'eau (par exemple Mashhad) ainsi qu'avec le tourisme (par exemple en bordure de la Caspienne).

Le progrès sera plus lent dans la zone céréalière du Nord Ouest où les plaines peuvent être irriguées ne représentent qu'un faible pourcentage de la superficie.

La culture en sec restera également très importante autour des plaines du Nord Zagros, mais les progrès rapides qui sont escomptés proviendront essentiellement de l'irrigation des plaines cultivées souvent de façon extensive actuellement.

Dans les autres régions, et notamment dans l'ensemble des zones marginales, les progrès peuvent être importants, bien que les superficies irriguées ne soient pas appelées à développer. Ce progrès proviendra essentiellement d'une meilleure productivité, d'une amélioration du niveau technique des paysans, et surtout d'une meilleure adaptation des systèmes de production (spécialisation dans des cultures à haute valeur ajoutée: arboriculture, maraichage...).

4. ACTIONS ENTREPRISES OU A ENTREPRENDRE POUR ATTEINDRE LES OBJECTIFS DE DEVELOPPEMENT DE L'AGRICULTURE IRRIGUEE

Le développement de l'agriculture irriguée se fera au travers une meilleure régularisation des eaux qu'elles soient souterraines ou de surface. Dans ces domaines, les actions entreprises sonts nombreuses. On peut en particulier citer:

—la poursuite de la politique de création de barrages réservoirs, et de barrage de dérivation, les tableaux 2 et 3 ci-joints donnent les principales spécifications des barrages existants, en cours de construction et projetés à court terme.

— La poursuite de la politique d'exécution de réseaux modernes d'irrigation et de drainage, le tableau 4 fournit les principales spécifications des canaux principaux construits, en cours de construction et projetés.

—L'accentuation de la politique de remplacement des ganâts par des forages, toutes les fois que cela est utile en s'assurant, cependant, grâce

TABLEAU II

Caractéristiques des barrages de retenue en Iran

BARRAGES ACHEVES

N°	Nom du barrage	Nom de la rivière	Province	Type (l)	Hauteur (m)	Longueur de crête (m)	Capacité d'évacuation m^3/s	Capacité totale du réservoir $10^8 m^3$	Eau régularisée annuelle $10^3 m^3$	Surface irriguée (ha)	Capacité du générateur d'électricité (KW)	Année d'achèvement
1.	Mohamad Reza Shah Pahlavi	Dez	Khuzestan	VA	203	212	6.000	3.340	6.938	104.500	52.000	1963
2.	Shahbanou Farah	Sefidrud	Guilan	CB	106	425	6.000	1.800	2.000	240.000	87.500	1962
3.	Amir Kabir	Karaj	Teheran	VA	180	390	1.450	205	400	21.000	90.000	1962
4.	Chahnaz Pahlavi	Abchineh	Hamedan	PG	53	286	500	8	17	200	—	1964
5.	Shah Esmaïl	Golpayegan	Golpayegan	TE	56	360	2.000	445	80	5.500	—	1971
6.	Farahnaz Pahlavi	Jajrud	Teheran	CB	107	450	1.750	95	245	30.000	22.000	1966
7.	Shah Abbas Kabir	Zayandeh Rud	Esfahan	MV	100	450	1 880	1.450	1.200	95.000	55.000	1977
8.	Shahpour Aval	Mahabad	Azarbayejan	ER	465	700	1.850	230	195	21.000	5.760	1971
9.	Kourosh-E-Kabir	Zarineh Rud	Azarbayejan	TE	50	720	4.300	650	535	85.000	10.000	1971
10.	Aras	Aras	Azarbayejan	TE	38	945	2.760	1.350	1.400	90 000	22.000	1971
11.	Vochmguir	Gorgan	Gorgan	TE	19	430	1.400	79	100	25.000	—	1971
12.	Daryush Kabir	Kor	Fars	TE	60	700	3.100	993	433	41.000	—	1972
13.	Reza Shah Kabir	Karun	Khuzestan	VA	200	380	16 200	2.900	9.259	48.000	1.000 000	1976

BARRAGES EN COURS DE CONSTRUCTION

14.	Jiroft	Harir Rud	Kerman	VA	133	250	6.900	430	235	10.500	30 000	1980
15.	Minab	Minab	Ostan Saheli	CB	60	450	12.000	350	240	14 000	—	1978
16.	Lar	Lar	Teheran	TE	105	1.500	1.700	960	450	65.000	100.000	1979
17.	Ghechlagh	Ghechlagh	Kordestan	TE	80	300	2.600	225	105	7.000	4.000	1977
18.	Pichine	Sarbaz	Baluchestan	TE	60	400	18.000	230	90	9.000	—	1979
19.	Tchah Nimeh	Sistan	Sistan	TE	17	200	50	700	350	45.000	—	1979

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20.	Nader Shah	Marun	Khuzestan	TE	165	220	10.700	1.284	888	55.500	—	1981
21.	Saveh	Vafraghan	Teheran	VA	88	262	275	290	328	20.000	9.500	1981
22.	Khoda Afarin	Aras	Azarbayejan	TE	60	380	3.500	1.620	1.500	60.000	100.000	1981
23.	Taleghan	Taleghan	Teheran	TE	125	1.200	1.600	721	467	35.000	1.000.000	1982
24.	Bahou	Bahou	Baluchestan	TE	25	1.150	12.800	140	30	3.000	—	1981

(1) *Type* : (TE) terre; (PG) poids; (CB) contreforts; (VA) voûte; (MV) voûtes multiples.

TABLEAU III

Caractéristiques des barrages de dérivation en Iran

N°	Nom du barrage	Nom de la rivière	Province	Longueur en crête m	Hauteur m	Débit de prise d'eau m^3/s	Date d'achèvement
1.	Chabankareh	Shahpur	Bushehr	55,5	3,5	5	1941
2.	Chavour	Chavour	Khuzestan	21	6,5	6	1946
3.	Kheyrabad	Chavour	Khuzestan	26	9	8	1940
4.	Tchaghalvandi	Kassian	Lorestan	40	5	3,2	1951
5.	Seyghalan	Seyghalan	Gilan	36	7	1	1949
6.	Karkheh	Karkheh	Khuzestan	192	4,7	61	1956
7.	Kouhrang	Cheykh alikhan	Esfahan	70	10	20	1953
8.	Abvand	Abvand	Kermanshah	32	4,8	4	1949
9.	Bampour	Bampour	Baluchestan	60	6,5	2,5	1956
10.	Abchar	Zayandehrud	Esfahan	64	6,9	30	1971
11.	Nekouabad	Zayandehrud	Esfahan	64	6,5	65	1972
12.	Passikhan	Sefidrud	Gilan	498	5	4	1959
13.	Tarik	Sefidrud	Gilan	40	5	3,2	1959
14.	Sangar	Sefidrud	Gilan	231	18	181	1955
15.	Chakazr	Sefidrud	Gilan	190	4	2	1959
16.	Sangueban	Shahrud	Téhéran	183	10,5	30	1973
17.	Ziaran	Ziaran	Téhéran	184	25,5	30	1973
18.	Zehak	Sistan	Sistan	52.2	8,3	45	1963
19.	Kahak	Sistan	Sistan	68,2	6,3	22	1965
20.	Kutecheri	Golpayegan	Golpayegan	172	3,5	3,5	1965
21.	Gonjantcham	Gonjantcham	Ilam	205	2,4	5	1966
22.	Milo-Moghan	Aras	Azarbayejan	135	8,5	80	1969
23.	Barimavand	Abvand	Kermanshah	30	3	4,5	1972
24.	Shahpur-aval	Mahaba	Azarbayejan	443	4,5	17	1970
25.	Novrouzlou	Zarinehrud	Azarbayeján	510	6	60	1970
26.	Hechmatrud	Dissam	Gilan	30	5	25	1953
27.	Dez	Dez	Khuzestan	314	4	250	1969
28.	Gotvand	Karun	Khuzestan	720	22	101	1977
29.	Varamin	Jajrud	Téhéran	610	4	32	1977
30.	Garmsar	Hablehrud	Téhéran	120	3	12	1977
31.	Sistan	Sistan	Sistan	158	11	60	1978

TABLEAU IV

TABLEAU IV

Caractéristiques des réseaux d'irrigation et du drainage en Iran

Location	*Longueur des canaux principaux Km*		*Longueur des canaux principaux secondaires*		*Longueur des drains Km*		*Surface irriguée ha*	*Année d'achèvement*
	complet	*réalisé*	*complet*	*réalisé*	*complet*	*réalisé*		
Dez Pilote	1,8	1,8	183	183	151	151	22.000	1966
Grand Dez	120,5	117	436,5	381	397	339	82.500	1977
Chavour	20,2	20,2	85,8	85,8	80,1	80,1	10.000	1971
Behbahan	4	4	60	60	—	—	2.500	1947
Karkheh	45	45	100	100	30	30	11.200	1958
Gotvand	62	5	217	—	841	—	28.000	1978
Chabankareh	6	6	45	45	60	60	6.000	1941
Marvdasht	22	22	141	141	140	140	47.000	1979
Esfahan	164	164	129	129	235	235	95.000	1978
Karaj	0,5	0,5	52	52	—	—	21.000	1966
Golpaygan	5	5	63	63	26	26	5.500	1965
Qazvin	97	20	217	4	57	—	80.000	1976
Gilan	227,7	171	621	470	650	597	240.000	1982
Gorgan	65	30	325	220	916	450	25.000	1977
Moghan	209	209	360	360	417	404	90 000	1977
Mahabad	34	31	290	256	976	487	21.000	1978
Zarrineh-Rud	24	24	216	164	134	105	85.000	1977
Bampour	20,9	20	60,1	29	49,2	21	2.645	1976
Myankangui	24,7	20	66,7	64	564	380	22.000	1977
Sistan	80,8	—	111	—	235,5	—	45.000	1980
Sumar	11,5	11,5	53	—	78,6	—	1.200	1976
Dachtzahab	16,7	16,7	22	22	78	39	3.000	1976
Dachtmehran	3,1	3,1	41,7	41,7	120	120	5.000	1974
Varamin	18	—	292	—	100	—	50.000	1979
Garmsar	23,5	—	88	—	60	—	18.000	1979
Minab	45	2	11	5	124	60	14.000	1980

aux réseaux de contrôle des nappes mis en place dans la plupart des grandes plaines, qu'il n'y a pas une surexploitation de la ressource irréversible dans ses conséquences.

—L'effort constant entrepris en vue d'une meilleure utilisation des réserves souterraines, en leur faisant jouer leur vrai rôle de réserve régulatrice. C'est ainsi que les bilans de nappes sont actuellement établis dans un sens dynamique c'est-à-dire en étudiant l'effet d'une surexploitation limitée sur le nouvel équilibre hydrodynamique (accroissement des infiltrations, diminution des pertes par évaporation dans les zones basses...). Cette manière de gérer les nappes s'accompagne d'un effort accru dans le domaine de la suralimentation soit par bassins d'infiltration, soit par forages, soit enfin par mise en place de réseaux d'épandage de crues sur les cônes d'éboulis, fortement perméables, dont l'extension constitue un trait majeur de la géomorphologie de l'Iran. La construction de barrages ecrêteurs de crues, dont le pertuis ouvert est calculé de façon à ce que le débit évacué soit compatible avec les possibilités d'infiltration des alluvions situées à l'aval, est une solution intéressante pour l'Iran pour accroître les ressources disponibles et combattre les dommages causés par les crues.

—L'intensification de la politique de transferts entre zones voisines, à potentialités ou à besoins différents: c'est ainsi, par exemple, que la région de Téhéran (et en particulier la ville elle-même) est en partie alimentée par des eaux qui s'écouleraient normalement vers la Caspienne, que le barrage sur le Zayandeh Rud (Esfahan) reçoit des apports provenant du haut bassin du Karun etc...

—Cet ensemble de mesures se traduit par l'établissement de plans directeurs d'utilisation des eaux au niveau des grands bassins. Dans ces plans directeurs, on étudie l'adéquation des ressources aux besoins actuels et potentiels dans le temps et dans l'espace. Les schémas hydrauliques retenus doivent en particulier non seulement permettre à un instant donné cette adéquation mais en outre ne pas empêcher ou limiter le développement futur. Ils doivent donc s'inscrire dans un processus continu de développement, d'équipement. A l'occasion de l'établissement de ces plans directeurs sont particulièrement soulignées l'interaction entre eaux de surface et eaux souterraines, les possibilités d'organiser des recyclages de l'eau de l'amont vers l'aval, et à l'aval des villes importantes (Téhéran par exemple), les possibilités d'améliorer la qualité chimique de certaines rivières par dérivation d'eaux provenant de rivières plus douces etc...

Parallèlement à ces réalisations qui portent sur la mobilisation de la ressource, l'Iran a entrepris une série d'actions qui portent sur son utilisation. On peut notamment citer:

—les travaux de modernisation de la petite hydraulique (périmètres de montagne, petits périmètres de plaine).

—la recherche d'une diminution des consommations unitaires en eau des plantes par une meilleure adaptation des doses fournies au calendrier des besoins, par l'utilisation des nouveaux systèmes d'irrigation (par aspersion notamment).

—les travaux de lutte contre l'envasement des réservoirs de barrage, en particulier par la recherche d'une meilleure utilisation des parcours (régénération, mise en défense) ce qui permet de réduire le surpâturage et par voie de conséquence l'érosion.

Depuis environ 10 ans, l'Iran s'est doté, pour faire face aux problèmes posés par le développement, notamment dans le domaine agricole, d'une législation moderne et de nouvelles structures.

La loi sur l'eau de 1968 portant sur la nationalisation de toutes les ressources en eau est un instrument fondamental dans la recherche d'une meilleure utilisation de ce bien précieux. Les anciens droits d'eau sont progressivement transformés en permis d'utilisation délivrés par le Ministère de l'Energie, spécifiant les quantités pouvant être prélevées et l'utilisation qui doit en être faite. Dans le domaide agricole, ces permis sont rattachés à la parcelle que l'eau concédée permet d'irriguer et ne peuvent être transférés sans qu'il en soit de même pour la parcelle. En tous les cas il n'existe plus d'autre propriétaire de l'eau que l'Etat Iranien. La transformation des anciens droits d'eau en permis d'utilisation est l'occasion de procéder à un bilan hydrologique précis d'une région ce qui permet de faire avancer la connaissance des réalités hydrologiques de l'Iran, et d'adapter au mieux les ressources aux besoins. Cela débouche donc sur de véritables plans directeurs d'utilisation des eaux.

Dans le domaine des structures administratives relatives à l'eau, le Ministère de l'Energie occupe une place prépondérante. Il est, en particulier, chargé de la préparation et de l'exécution des plans et projets destinés à mobiliser et distribuer l'eau de la supervision de l'utilisation de toutes les ressources en eau, de l'étude et de l'éxécution de tous les systèmes d'alimentation en eau potable, de la supervision, de la construction de tous les grands projets hydrauliques que ceux-ci soient destinés à un seul ou à plusieurs buts.

En vue d'assurer une utilisation efficace par l'agriculture des travaux hydrauliques entrepris sur les grands périmètres, le Gouvernement de l'Iran les a organisés par la plupart en pôles de développement. Un pôle a pour objectif de concevoir et de mettre en oeuvre des programmes d'aménagement de détail des terres et de développement de l'agriculture à partir des infrastructures mises en service.

En pratique peuvent adhérer à l'organisation des pôles :

—les privés (Agrobusiness et fermes commerciales de plus de 50 hectares)

—les petits et moyens exploitants sous réserve de regroupement de leurs exploitations en unités coopératives s'étendant sur au moins 20 hectares

—les sociétés anonymes agricoles

—les coopératives agricoles de production.

En outre les zones situées hors des pôles de développement dont les limites ont été fixées par la loi, peuvent bénéficier des dispositions de cette loi sous réserve que les propriétaires de 50 pour cent des terres en expriment la volonté et que la région dispose des potentialités jugées suffisantes par le Ministère de l'Agriculture.

La création de ces pôles repose sur l'élaboration par le Ministère de l'Agriculture d'un projet de développement prévoyant toutes les actions nécessaires à l'aménagement hydro-agricole de la région (lotissements, remembrements nécessaires pour créer des mailles hydrauliques viables...).

En outre le Ministère de l'Agriculture a fait porter une grande part de son effort sur le développement des cultures industrielles (betterave à sucre, canne, coton, déogineux...).

5. L'IMPACT DE LA TECHNOLOGIE AVANCEE SUR LE DEVELOPPEMENT HYDRO-AGRICOLE DE L'IRAN

Un certain nombre d'actions relevant de la technologie avancée sont déjà entreprises en Iran. On peut, en particulier citer:

—les techniques de pluie provoquée, utilisées depuis plusieurs années près de Téhéran avec ensemencement des nuages soit par avion soit par générateurs situés au sol. Les résultats en sont toutefois pas encore très probants, ce qui paraît être un cas général dans le monde.

—l'utilisation de radars pour suivre les formations majeures, prévoir les modifications de temps et contribuer ainsi à la prévision et à l'annonce des crues.

—la réutilisation des eaux usées des principales villes. Des plans d'utilisation de ces rejets sont établis pour Téhéran et Esfahan, d'autres suivront dans le futur. Il y a là un champ de recherches très important, conditionnant dans une certaine mesure l'extension des irrigations periurbaines.

—la télétransmission des données hydrologiques, commencée en Iran il y a plus de 10 ans, s'amplifie notablement dans le domaine quantitatif, elle est à l'étude pour le domaine qualitatif.

—l'utilisation systématique de modèles mathématiques ou analogiques de simulation des écoulements superficiels ou souterrains est maintenant de règle en Iran. Les modèles d'optimisation de gestion des eaux sont eux aussi d'un usage qui rend à se généraliser.

—l'utilisation des photographies aériennes et des photos-satellite est constante en Iran depuis de nombreuses années. En particulier les images ERTS sont utilisées depuis 1972 pour les cartographies, les études de sol, pour la recherche hydrologique, les implantations de routes, la délimitation des zones inondables, etc....

—l'utilisation du dessalement des eaux marines et saumâtres devrait s'amplifier considérablement à court et moyen termes. C'est ainsi qu'il sera fait appel dans une large mesure au dessalement des eaux marines pour alimenter en eau les installations industrielles et portuaires échelonnées le long de la côte du Golfe Persique, au dessalement des eaux saumâtres pour lutter contre la mauvaise qualité des ressources d'une grande partie du pays. Il est en particulier envisagé la création de grands complexes agro-industriels à proximité de grosses usines de dessalement. En ce cas la notion d'usines mixtes s'impose pour avoir un prix plus bas de l'eau; il en résulte une très forte disponibilité en énergie électrique qui permettra d'implanter à proximité des industries grosses consommatrices d'énergie, et en particulier les fabriques d'engrais et d'insecticides nécessaires à l'agriculture.

Du point de vue des quantités en jeu, ces usines peuvent paraître marginales mais elles ont l'avantage de permettre la création non seulement de périmètres agricoles dans des zones où il est actuellement impossible de les réaliser mais également la création de villes, de centres industriels, de ports. En ce sens elles perdent tout caractère de marginalité et deviennent un élément important de toute politique de développement et d'aménagement du territoire.

—Pour ces complexes agro-industriels il est envisagé une agriculture différente, effectuée sous serre et avec des techniques d'irrigation consommant la quantité minimale d'eau (aspersion goutte à goutte, serre, culture sans sol...) (L'Iran fait d'ailleurs appel depuis plus de 15 ans aux techniques de l'irrigation par aspersion).

—La lutte contre la mauvaise qualité des eaux naturelles de certaines régions de l'Iran sera également entreprise avec d'autres moyens que le dessalement. Il s'agira de contrôler les sources de salinisation, de rectifier le tracé de certains cours d'eau pour éviter les affleurements salifères, d'interconnecter des réseaux hydrauliques (amélioration de la qualité des eaux du Marun et du Zoreh par des eaux douces provenant du Karun par exemple).

—La lutte contre les pollutions commence également à devenir une réalité en Iran, c'est ainsi qu'en 1974 a été promulguée la "loi sur la protection de la nature", loi qui sera précisée et renforcée dans un proche avenir.

Cet ensemble de nouvelles technologies utilisé concurremment avec les techniques classiques permettra une utilisation optimum de l'eau au travers des plans d'aménagement intégrés de l'ensemble des ressources.

Cet effort technologique s'accompagne d'un développement accéléré de la recherche et de la formation dans tous les domaines touchant à l'utilisation optimale des eaux et des sols:

—Institut de l'eau

—Institut des sols

—Nouvelles facultés d'agronomie, etc.

6. ROLE DU COMITE NATIONAL DES IRRIGATIONS ET DU DRAINAGE DE L'IRAN

Pour bien comprendre le rôle du Comité National des irrigations et du drainage de l'Iran dans le problème des ressources en eau du pays, il est nécessaire d'en connaître les tâches définies par le gouvernement et qui sont les suivantes:

—Collaborer et échanger les informations avec l'ICID ainsi qu'avec les divers comités nationaux d'irrigation et de drainage.

—Encourager les recherches relatives à l'irrigation, au drainage, au contrôle des crues, à l'érosion des sols et autres afin de promouvoir le développement de l'irrigation.

—Organiser des séminaires et symposia d'irrigation et de drainage, inviter les experts iraniens et étrangers dans le but d'utiliser leurs informations.

—Etudier les problèmes d'irrigation et de drainage de l'Iran et si nécessaire proposer ces problèmes à l'ICID.

—Choisir les représentants du comité national, pour participer aux réunions de l'assemblée générale, congrès, réunions de consulation et d'exécution de l'ICID d'après les statuts de cette commission; choix des experts invités à participer aux séminaires et symposia du comité national de l'ICID des autres pays du monde. Collecter d'informations relatives à l'irrigation et au drainage du pays, ainsi qu'aux résultats des recherches obtenues par divers organismes en Iran et dans les autres pays du monde.

—Etudier et approuver les articles qui doivent être proposés par les représentants du comité national aux réunions de l'ICID.

—Editer les articles scientifiques relatifs à l'irrigation et au drainage écrits ou traduits par des experts iraniens, distribuer les bulletins de l'ICID, acheter des livres et revues. Prévoir les crédits qui doivent figurer dans le budget annuel du Ministère de l'Energie.

—Présenter et recommander à l'Organisation du Plan les crédits nécessaires à l'exécution des travaux de recherche en irrigation et drainage.

Parmi les tâches du COMITE NATIONAL d'irrigation et du drainage d'Iran, celui-ci a organisé 4 séminaires, et a produit 16 publications scientifiques et techniques, dont le dictionnaire technique des irrigations et du drainage.

A l'avenir les seminaires auront lieu systématiquement tous les 2 ans.

De même les experts iraniens ont été invités à participer dans une large mesure aux CONGRES, SYMPOSIA et réunions de l'ICID; des livres et publications de l'ICID leur ont été distribués, ce qui est la meilleure manière de faire connaître à ces experts les technologies modernes en irrigation et drainage.

Les tâches ci-dessus décrites donnent bien l'importance du rôle du Comité National des irrigations et du drainage de l'Iran ainsi que le rôle de l'ICID elle-même.

TEHRAN SPECIAL SESSION 1977

IRANIAN NATIONAL COMMITTEE OF ICID

COMITE NATIONAL IRANIEN DE L'ICID

SESSION SPECIALE DE TEHERAN 1977

R. 5

LIKELY IRRIGATED AGRICULTURE OF 2000 A.D.

ADVANCES IN THE TECHNOLOGY OF ESTIMATING CROP WATER REQUIREMENTS—AN AID TO IMPROVED WATER MANAGEMENT*

British National Committee—ICID

SUMMARY

In many of the traditional irrigated areas of the world, water resources are at present near to full development, and it is essential that water should be used more efficiently by the year 2000. Improvements will be needed both in estimating water requirements of crops and in reducing water conveyance losses.

Considerable research resources have been devoted in Great Britain to studying the relationship between plants and water both in the soil and the atmosphere, of particular importance being the work of Penman at the Rothamsted Experimental Station and Monteith at the University of Nottingham. The paper reviews these research studies and how they may be used to develop new and more accurate methods for estimating the water requirements of irrigated crops.

RESUME

Dans plusieurs des régions irriguées traditionnelles du globe, les ressources hydrauliques sont déjà presque totalement développées et, d'ici l'an 2000, il sera indispensable d'en faire un emploi plus efficace. Il sera nécessaire d'afiner les méthodes d'évaluation des besoins en eaux des cultures et de réduire les pertes au cours de l'adduction.

En Grande Bretagne des ressources importantes ont été consacrées à des travaux de recherche pour étudier les rapports qui existent entre les cultures

* Progrès réalisés dans le domaine de la technologie de l'évaluation des besoins en eau des cultures afin de rendre plus efficace la gestion des aménagements hydrauliques.

et la teneur en humidité et du sol et de l'atmosphère; les travaux réalisés par Penman au Experimental Station, Rothamsted et par Monteith à l'Université de Nottingham sont d'un intérêt particulier dans ce domaine.

Le présent article passe en revue les travaux de recherche réalisés et examine comment ceux-ci peuvent être appliqués au développement de méthodes nouvelles et plus précises d'évaluation des besoins en eau des cultures irriguées.

PAST TRENDS IN DEVELOPMENT OF IRRIGATION SYSTEMS

By the year 2000 "systematic" irrigation as we know it today will have passed through a history of about one and a half centuries of major development. It dates from the time when controlled canal schemes were introduced on an extensive scale to replace the former flood and basin irrigation. These systematic schemes were mainly dependent on the diversion of the natural river flow, without means of water storage, and with few exceptions this form of development continued until about the middle of this century.

In the Indian sub-continent the system of water delivery was based essentially on constant flow through the canals down as far as the head of the watercourses, except at times of seasonal shortage when rotational rationing is introduced in the distributary canals. Normally there is a constant discharge in the watercourses and the farmers share the discharge among themselves by taking the full flow in turns for a given period of time. It is thus left to the farmer to maximise his crop production from a given rate of flow for specific periods of time. Despite its obvious inefficiency, the "constant flow" method of delivery is simple, it suited the regime flow principles which were used in canal design and was developed at a time when it was thought to be advantageous to segregate from irrigation engineering the complex domestic details of water distribution at farm level.

In Egypt the system of water delivery is more variable. Despite the construction of some storage reservoirs (in the period before the construction of the High Aswan dam) larger flows were passed through the canals in times of High Nile than in the summer when the river is low. In many areas the water levels in the canals were allowed to fall below command levels so that the farmer became constrained to some economy by the need to lift his supplies on to the field (a form of control that still survives).

In the Sudan irrigation water supplies are adjusted periodically to crop needs by a system of control which is more flexible than many others.

In the U.S.A. and Europe attention has for some time been given to the development of irrigation control systems. For the most part, however, the prevailing conditions are very different from those in the vast irrigated regions in the developing countries.

Towards the middle of this century things were beginning to change. The natural flow, or run-of-river schemes were proving inadequate in certain areas and large storage dams were being constructed to extend and intensified crop production. In certain areas, notably in the Indo-Gangetic plains, more attention was being given to the ground-water aquifer as a means of supplementing irrigation supplies.

Up to the present time little has been done to improve the control of irrigation systems and the efficiency of water use. In fact the need and pressures to do so have not arisen except in a limited number of cases. The inefficiencies of the old systems have been accepted and indeed new irrigation developments are still being built based on traditional systems, with insufficient regard for the high value that must in future be attached to water. Even where waterlogging has occurred as the result of over-application, remedy has been sought in drainage measures with inadequate attention to improved control and management.

Now, in the last quarter of this century, many of the traditional irrigated regions are approaching the limit of water resource development. With few exceptions (such as the Brahmaputra) little further water remains to be abstracted from river basins and in some cases the available discharge has even been over-exploited in terms of reservoir storage capacity. These limits on water resources make it essential that water for irrigation is used as efficiently as possible.

Efficient water management demands that the water requirements of the crop are correctly estimated so that the right quantity is delivered to the crop at the right time and that water losses in the supply system are reduced to a minimum.

To achieve these aims there must be, firstly, better methods of preparing estimates of crop water requirements and translating these into water indents at farm level. Secondly, there is a need for a vast improvement in the control of water deliveries through land consolidation, reconstruction of parts of canal systems and the introduction of more control structures. This paper deals with the first of these two factors and attempts to identify the trends in research and development that may lead to new practical methods of estimating crop water requirements more precisely. The subject has been selected by the British National Committee because considerable research resources have been devoted to this topic in Great Britain, such as the work of Penman at Rothamsted Experimental Station, Monteith at the University of Nottingham, and work at other research centres including the Institute of Hydrology of the Natural Environment Research Council.

WATER CONTROL IN IRRIGATION SCHEMES

In presenting this subject, the British National Committee is most conscious of the difficulties that arise in the adoption of a system of water delivery that is capable of flexibility in operation and adjustments in amount of flow—both prerequisites to the application of the principles discussed here. Existing canal systems, such as those described above, are now well established and the farmers have become accustomed to the pattern of water delivery however inefficient this may be.

In some areas, where good ground-water aquifers underlie the irrigated areas, variations in the total amount of water supplied from surface and tubewell sources can be achieved to some extent by varying the ground-water abstraction. In most areas major modifications will be required to the whole canal system and in particular to the downstream stages of it.

Setting aside the question of comparative losses between open-channel and piped methods of water conveyance, it might be argued that the most efficient form of water management is the "on-demand" system (used particularly in America and Europe), provided that the farmer is required to pay the economic cost of his water and at the same time is able to determine accurately the crop water needs. The "on-demand" system though appropriate to developed countries, is far removed from many of the existing major irrigation systems of the world. Ultimately, as water approaches a degree of scarcity comparable perhaps with what can now be seen in the oil and energy sectors, complex methods of water control may well be adopted almost throughout the world, but initially compromise solutions such as remodelling of the canals and installation of additional control structures will have to be found for many irrigated regions. Examples of such developments have already been described in a number of papers produced for ICID.

This paper considers first how past and present methods of estimation have helped in setting ranges for the water requirements of irrigated crops grown under particular local climatic conditions. The paper continues with a review of current research work which may lead to the development of the more accurate estimation methods which will be needed if irrigation water is to be used more effectively. It concludes with a discussion of the place of these new methods in the better forecasting of irrigation demand.

THE CONCEPT OF LIMITS OF CROP WATER REQUIREMENTS

Climatic conditions provide the principal driving force for the loss of water from crops into the atmosphere, and thus set the pattern of variation of crop water use over a growing season. Simple relationships do not exist, however, between water loss and individual climatic parameters and water loss is also a function of soil moisture status and of the responses of the plants themselves to the availability of water. To satisfy the practical demands of irrigation agronomists and engineers attempts were made to define the approximate range of the water requirements of irrigated crops on a day to day basis to assist water demand forecasting, as well as to estimate seasonal water needs.

A useful concept which allows considerable simplification was the use of an upper limit of the range of water requirement, occurring when the crop was freely transpiring with its roots adequately supplied with water. This is generally known as the potential evaporation from the crop. Under these conditions the loss of water to the atmosphere could be related to evaporation from open water surfaces. There is little benefit in attempting to define in similar general terms a lower limit of crop water requirement, for not only do the relationships between climatic and soil conditions and crop yield vary for each irrigated area, but so also do economic factors such as local costs of irrigation water.

Economy in water use is more logically related to an optimum level of water requirement, defined in terms of the particular conditions of each irrigated zone, and the latter part of this paper discusses how experimental work on the relations between soil, plant and water may be used to assist in establishing such optimum levels of requirement.

The complex processes of moisture exchange within soils and plants, as well as those of water vapour movement from plants into the surrounding atmosphere are beginning to be studied and quantified. Despite the apparent complexity of some of the methods of estimation which are emerging, it is confidently forecast that the continually increasing real or social price of irrigation water throughout the world will make the use of many of them economically necessary. Methods initially introduced at the district experimental farms should affect management techniques at production level well before the year 2000 A.D.

TRENDS IN ESTIMATION OF UPPER LIMITS OF WATER REQUIREMENT

Simple methods which aim to estimate an upper limit of evaporative loss (or some more general value for "crop water use") such as those based on evaporation pans or on the measurement of single climatic parameters, have been of great practical benefit in replacing guesswork as a guide to application of irrigation water. However, the complexity of the relationships between the plant and water in the soil and the atmosphere has led to a wide variety of more sophisticated approaches, some empirical and some more soundly based in physics.

The need for accuracy has led to the increasing use of combination formulae of the Penman type, despite early objections that the number of climatic variables (air temperature, humidity, wind run and solar radiation or sunshine), were too many to be measured as part of practical irrigation management, or that records containing all these variables were not available for most irrigated areas. In the period of nearly 30 years since Penman originally published his approach to evaporation (Penman 1948), the international coverage of climatological stations collecting data suitable for use in Penman type equations has greatly increased, due mainly to the activities of the World Meteorological Organisation and the International Hydrological Decade Programme. Furthermore it has become clear that a great deal of the most urgent improvement work needs to take place on existing irrigated areas where suitable data are often already available.

The Penman equation was originally developed to estimate potential evaporation from short grass. Later modifications have extended its range of application to a variety of crops, and work in this field is continuing. A future trend of particular importance to the irrigation manager will be the increasing development of tabular versions of these formulae. These will enable field staff to make estimates quickly, without performing all the calculations required to solve the full equation. [McCulloch 1965([2]); Smith 1967([7]); Woodhead 1968([10, 11])].

TRENDS TOWARDS THE ESTIMATION OF OPTIMUM WATER REQUIREMENT

The concept of potential evaporation was useful in defining an upper limit to crop water use. In the future, however, the irrigation engineer must try to apply only sufficient water to satisfy the optimum water requirements and to assess these it is first necessary to measure or estimate the actual evaporation from the crop.

Three alternative methods can be identified:

(1) water balance models on a regional scale,

(2) local plot or lysimeter studies, and

(3) detailed studies of the processes involved in the interaction of meteorological factors and water in both plants and soil.

Water balance models usually aim to predict soil moisture deficit. In the U.K. maps of estimated deficit are prepared on a routine basis using data from some 200 climatological stations throughout the country(9). When conditions for potential evaporation are not met, the semi-empirical model developed by Penman (1949) is used on a regional scale to relate deficit values and estimates of actual transpiration(1).

This regional approach contains several inherent problems: runoff and deep percolation to ground-water require an elaborate model supported by direct measurements which are rarely available; the value of the results is much reduced at the local level due to variation in soil and vegetation. Indeed for irrigation schemes in an arid environment, where these local variations are perhaps compounded by different irrigation practices, this method is of only marginal value. Water balance models are used primarily in temperate latitudes where only supplementary irrigation is necessary and here the methods are being continually refined.

The second method is a modification of the water balance approach on a micro-scale, using an isolated block of soil in a lysimeter. Of the many designs of lysimeter that have been developed, only weighing lysimeters have been of use in understanding crop water requirements. At one time they were the only method available for accurately measuring actual evaporation and changes in soil moisture over short periods, i.e., a day or less. However, lysimeters have a number of fundamental disadvantages, due to the difficulty of making conditions for crop growth within the tank sufficiently similar to those of crops grown extensively on a field scale, which make the extrapolation of their results to larger areas of very doubtful value. With the advent of newer methods, such as micrometeorological techniques to measure actual evaporation and neutron moisture meters to measure changes in soil moisture content, these inherent disadvantages of lysimeters imply that their general use in future is very unlikely.

The third and most promising approach for the future is the study of the processes controlling the disposition of water in the soil, and in the plant and its immediate environment. These studies can be usefully described under a number of headings since no one experimental study embraces all components of the system.

WATER IN THE SOIL

Given the problem of the local variability of soil and crop, the advantages of taking direct measurements of the two principal parameters relating soil and water, the moisture content and the matric suction, are readily apparent. Simple measurement methods are well established in field irrigation use. Gravimetric sampling, which requires field collection and laboratory weighing and drying of samples, is used to measure moisture content and tensiometers or electrical resistance blocks to measure matric suction.

The great advantage of these methods is that, once again, they have helped to take guesswork out of irrigation water management, but the benefits of simple equipment and straightforward techniques have to be balanced against a lack of accuracy in measurement. Current experimental work is aimed at developing more accurate methods of measuring and estimating soil moisture status.

The portable neutron meter is a major advance over gravimetric sampling in that soil moisture can now be measured quickly and accurately throughout the soil profile with minimum disturbance of the soil. It can be used both to measure the variation of soil water content and to establish in situ measurements of fundamental soil constants such as 'field capacity' and 'available water capacity' and any defined lower limits of water storage related to crop yield. In conditions where field capacity is an acceptable concept, the soil moisture depletion rate can provide a direct measurement of crop water use. The potential of the neutron meter is as yet not fully appreciated by practising irrigation engineers and its use will undoubtedly increase now that stable and reliable instruments are available.

The tensiometer provides a direct measurement of the matric potential of the soil water which, in practical terms, represents the force which has to be overcome by the plant to abstract water from the soil. Tensiometers are already widely used to schedule the timing of irrigation applications so as to prevent unacceptable stress to the plant which could result in reduced yields. More sophisticated experimental schemes incorporate tensiometers as part of automatic control systems.

Multiple banks of tensiometers installed vertically in the soil profile are used to indicate the potential gradient controlling the direction of water movement. Thus the onset of drainage from an irrigated profile, or of the reverse process, the upward flux of water from ground water, can be identified. Both these processes are particularly important in saline soil. Undoubtedly, there will be a trend towards increased use of these techniques as new and more effective types of tensiometres are developed.

In addition to the advantages gained from the separate use of neutron meters and banks of tensiometers a promising new research technique is at present being developed based on their combined use. Not only can the directions of soil water flow be identified, but the fluxes can also be quantified. Furthermore, important information can be obtained on unsaturated conductivity characteristics and soil moisture retention curves.

PLANT RESPONSES TO WATER

Monteith (1976)([4]) has stressed that a major trend in applied plant physiology is the increasing interest in how little water may be required to grow successful crops, following the earlier work of Penman and others in estimating the upper limits of water requirement.

Work which relates the growth of crops to their use of water is currently in progress at a number of British research centres including the National Vegetable Research Station at Wellesbourne, Rothamsted Experimental Station, the fruit research centres at East Malling and Long Ashton, and the Universities of Nottingham and Reading. In addition, trials are in progress at various experimental centres of the Ministry of Agriculture.

Areas of study include crop responses to water at different stages of growth, the influence of plant spacing on irrigation water need, growth in relation to water stress, and the use of water misting above crops to relieve plant stress on hot dry days and possibly also to reduce overall water from the soil. An interesting additional possibility of saving water which would otherwise be lost to the atmosphere through crop is the use of anti-transpirant chemicals sprayed on the leaves; evaluation work on this topic is proceeding at the University of Lancaster.

Although this work is concerned most directly with important British crops such as wheat, barley, sugar beet and potatoes, as well as temperate fruits and vegetables, studies of plant physiology which lead to a clearer understanding of the water relations of plants can provide useful guidelines to agronomists and crop breeders working under tropical conditions. The application of research findings to practical irrigation conditions overseas is greatly assisted by the continuing British involvement in tropical agriculture, both in Commonwealth countries and the developing network of international agricultural research centres (e.g., ICRISAT, at Hyderabad in India).

WATER MOVEMENT FROM PLANT TO ATMOSPHERE

The rate of flow of water vapour from the crop to the atmosphere is not only related to the solar energy available to cause evaporation and the ability of the air to absorb water vapour, but is also controlled by conditions at the leaf surface.

Transpiration, the flow of water through the leaf, is controlled by the opening of stomatal pores set into the leaf surface. When less water is available to the plant roots than would satisfy conditions for potential transpiration, or when certain physiological controls within the plant operate, the stomata will be partially closed, thus restricting the transpiration rate.

Using the common analogy between the movement of fluids and that of electricity, restrictions to the flow of water vapour from the plant into the atmosphere may be considered as resistance, and two resistance values are of particular importance in evaporation physics. The Stomatal Resistance of a single leaf is controlled by the degree of stomatal closure which is related to the availability of water from the soil and climatic conditions. Extrapolated to an extensive canopy of crop foliage this is known as the Surface Resistance. The Aerodynamic Resistance is a measure of how difficult it is for water vapour to be transferred from within the crop canopy into the free atmosphere above. This resistance becomes smaller, (i.e., vapour transfers more readily) as the wind speed increases and as the height, and therefore the aerodynamic roughness of the crop, increases.

By developing Penman's approach to incorporate separate values for the surface and aerodynamic resistances instead of incorporating these values into semi-empirical terms, Monteith (1965)[3] developed a new formula which provides a rigorous physical basis for the estimation of actual, not potential, evaporation from vegetation. At present the Monteith-Penman formula is a research tool since there are very real difficulties in estimating the appropriate values of the two resistances. In particular, there has as yet been very little research into the relationships between stomatal or surface resistance and soil moisture deficit.

However, the derivation of the formula is an important advance towards the estimation of evaporation when the crop roots are not fully supplied with water due to unavoidable shortage or when moisture deficits in the soil are known to be acceptable at certain stages of the growth of a crop without affecting final yield.

Of similar importance is recent work at Edinburgh University and the Institute of Hydrology [Thom and Oliver 1977([8])] on the modification of the Penman potential tranpiration equation to evaluate evaporation totals that take account of the surface roughness, wetness, and resistance of various crops by the use of empirical constants derived from previous research work.

Besides estimation of actual evaporation from climatological variables using the Monteith-Penman formula, another approach is the direct measurement of actual evaporation using micrometeorological techniques. That most commonly used is the Energy Budget approach, although this can never be expected to be used other than at a research level due to complexities of the tehnique and restrictive experimental site requirements. Another technique is the Eddy Correlation method, which uses special fast response sensors to detect upward and downward movements of water vapour directly above vegetation. This approach is also at present at the research stage, but the development of sensors and the associated computing equipment for practical field use is forecast within the foreseeable future.

Although transpiration is the major process by which water is lost from crops to the atmosphere, it is not the only one. During early stages of crop growth irrigation water and rainfall are evaporated directly from the soil surface and, although this loss reduces as crop cover increases, the crop foliage intercepts water from rainfall and overhead irrigation to an increasing extent as it develops. This water also is evaporated back into the atmosphere. Work is currently in progress to improve the evaluation of these losses. Interception studies make use of the differences in rainfall measurements above and below the crop canopy. The Monteith-Penman equation is also used in these studies, the surface resistance being reduced to zero due to the wetness of the leaf surfaces.

Once again, by no means all the work discussed in this section is directly oriented to the practical problems of irrigated agriculture, but in a similar way to the studies of water relations of soils and plants discussed earlier, some of the techniques reviewed will provide the basis for new practical methods of estimating crop water requirements as the economic need for efficient water use becomes more important.

APPLICATION OF CROP WATER ESTIMATES TO SYSTEM OPERATION

Once the estimation of crop water requirements, in relation to plant growth, have been substantially improved it is necessary to examine whether the application of these quantities is efficient in terms of the return to water. The yield of a crop may not be greatly affected by reducing the water supplied or by changing the timing of application within certain limits. The highest production may therefore be achieved by spreading the available water to a limited extent. Intelligent management will involve the increasing use of this principle in the future as water supplies become scarcer.

Such techniques only provide a partial solution to the problems of efficient water management. Solutions have to be found to other difficulties such as the attitudes and traditions of the farmers and the physical problems of accurate water control. Stricter control in water management will arise out of water scarcity which in effect means that water will take on a high opportunity value. The human problem will be to get the farmer to recognise value in a different way to what he has done hitherto. Because supplies are not metered the farmer has tended to regard water as a free commodity which is to be acquired and applied to the land whenever it is available to him (except at times of heavy rainfall). In some areas of the world the advent of the private tubewell within the traditional irrigated regions has done something to adjust this outlook. Here the farmer, being faced with substantial energy costs, regulates ground-water abstraction to supplement surface supplies in accordance with his judgement of crop water requirements. Erroneous though this judgement may be at times, the farmer is at least using water more efficiently than in many of the traditional gravity irrigation systems.

In the "on-demand" system used on some schemes in Europe, America and to a lesser extent in some other parts of the world there is much more scope to apply advanced techniques in the measurement of crop water demand. The system conveyance networks can be designed on a probability basis to function much in the same way as conventional metered urban and industrial water supply. The farmer may use any available method to estimate when his crops need irrigating. Such methods depend, as stated earlier, primarily on a monitoring of the water status of the soil or on evaporation measurements.

In most parts of the world the "on demand" system is not feasible for extensive surface water irrigated areas. Its application by the year 2000, though perhaps large in absolute area, will only cover a small proportion of the irrigated areas of the world. An obvious alternative for the traditional areas lies in improving the existing indent procedures but, of course, with compatible improvements in the system of water control.

Starting from the crop, techniques must be developed to provide engineers and agriculturalists with a more accurate and dynamic accounts of the soil moisture balance sheet. In areas of smallholding agriculture the responsibility must rest with well trained and competent staff who should be motivated towards water economy. They need to be well equipped with measuring devices to monitor climatic and soil moisture conditions and also the inflow of water. In areas of tubewell pumping they must also be able to monitor the ground-water levels. In short, they will need to be equipped to collect within their irrigation districts all the data which are required to provide a comprehensive and continuous record of the various components which comprise the water balance sheet.

The more fundamental measurements should be:

(a) **Soil moisture**

Measurements using neutron meters and tensiometers on experimental trial plots and at selected sites throughout this production area.

(*b*) Evaporation

From climatic data adjusted to give optimum crop water requirements.

These data will then be used in the preparation of forecasts of the rate of soil moisture depletion.

Any continuous method of forecasting crop water requirements should be based on the principle of departures from the estimate of normal crop water requirements traditionally adopted for irrigation system planning. It will be a matter for decision on the part of an irrigation engineer or agronomist responsible for water management of a given area as to whether a departure should be made from the normalised demand and by how much. Such a decision implies either (*i*) the absence of bias on his part or (*ii*) the provision of incentives to make economies in water use and penalties against extravagence. The latter approach will perhaps be the only effective way because of the need to have the co-operation of the farmers. Incentives may take the form of a financial benefit to farmers such as rebate or loading on water rates. Alternatively it would be possible to develop a water credit system to allow groups of farmers to transfer supplies from one part of the season to another to fit better the cropping patterns and seasonal levels of soil moisture deficits.

In any case the engineers responsible for water management should be given the instrumentation and the incentives to prepare sound and economical indents of water demand at regular intervals throughout the irrigation season and the benefits of water savings should whenever possible accrue to those farmers who make them.

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R. 6

LIKELY IRRIGATED AGRICULTURE OF 2000 A.D.

LONG TERM PLANNING OF WATER DEVELOPMENT AND WATER USE FOR THE EXPANSION OF AGRICULTURAL PRODUCTION IN BULGARIA*

DIMITER DAVIDO**

Irrigation, drainage and flood control activities in Bulgaria take place in accordance with the overall programme for social and economic development of the country. The programme is designed so as to be consistent with the national objectives for satisfaction of society's increasing needs in all aspects—food, clothes, housing, work, culture, entertainment, etc. On the other hand, the overall reclamation development is planned on the basis of the National Water Economy Plan, in which, on a territorial and chronological basis, the optimal possibilities for total and complex regulation, conveyance and use of national water resources are clarified and presented in the form of general schemes and technical indices for the purposes of irrigation, drainage, flood control, power generation, water supply, etc.

The direct and indirect objectives of irrigation, drainage and flood control are to increase the amount of the agricultural production and net income.

The increase in the amount of agricultural production is obtained, in case of drainage, as a result of the increase in the arable lands: in irrigation—as a result of the increase in crop yields per unit of land; and in flood control—due to the reduced losses of crop production.

The effect of flood control measures is realized almost automatically after the completion of the relevant structures, without the necessity to use additional technological labour. To realize the effect of drainage, besides the initial investments, additional amount of labour must be used every

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year, which labour does not differ in its nature from the conventional agricultural labour, but it is organized on a new territory. In irrigation, the realization of the effect substantially depends on the amount of the additional labour used, which by its nature represents a new type of agricultural labour. Therefore, it is most simple to realize the effect of flood control measures, and most difficult in irrigation, since in this case, besides the engineering structures needed for water delivery of a given area, it is necessary to introduce and organize on the same area a new agricultural activity, which, besides additional qualification and culture, requires also additional production of irrigation equipment. Nevertheless, irrigation in Bulgaria has a predominant development, due to the greater possibilities which it creates for an absolute increase in the country's agricultural production.

If the possibility to increase the amount of the agricultural production by flood protection measures is not more than 5 per cent, by drainage—about 10 per cent, then by means of irrigation, agricultural production of the whole country can at least be doubled. It is for this reason that irrigation in Bulgaria has a development priority. This development has been particularly intensive after the 1944 Revolution, as a result of which the possibilities of the State for increasing the investments in agriculture augmented and large agro-industrial complexes have been created for the most efficient use of the lands, which enables to realize optimal technical solutions in operation.

By the end of 1975, the total cultivated land of the country was about 5 million hectares, of which about 0·1 million hectare are drained and 1·1 million hectares are irrigated. About 2,300 km of river length has been regulated and about 4,000 km of levees have been constructed, which permit the protection of about 0·2 million hectare of agricultural lands. For the regulation of national water resources and their use for irrigation, about 2,047 dams have been constructed, of which 115 large dams with a total storage capacity of 2·2 milliard* m^3 and 1,932 small dams with a total storage capacity of 0·6 milliard m^3, as well as 2,800 pumping stations with a total power capacity of about 500,000 kW. The total costs of the reclamation funds amount to about one milliard levs.

The potential possibilities of the country permit the total irrigated area to be increased up to 3·5 million hectares and the total drained lands—up to 0·2 million hectare.

Initially the irrigation in the country has developed mainly in horizontal direction—increasing of the irrigated area and more efficient use of the available manpower in agriculture. The predominant part of the irrigated lands is supplied by open canals and the irrigation is accomplished chiefly by furrows with additional temporary network of irrigation ditches. The experience shows that these types of irrigation systems and the irrigation practice require great amount of labour and water and they are effective only in case of low cost of labour and water.

As a result of the rapid industrial development in Bulgaria, especially after 1956, the amount of water used for industrial and domestic supply

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* One milliard = 10^9

increased, but on the other hand the number of workers occupied in agriculture diminished abruptly. These two trends though to a less extent will hold also for the future period up to the year 2000. The two factors—water and labour deficits in agriculture determine the need for vertical development of irrigation, which is reflected by the introduction of some measure in the irrigated lands in order to reduce the unproductive losses of water and using new technologies and irrigation methods with a view to increasing labour productivity in irrigation in accordance with the available labour resources.

The programme for social and economic development of the country requires an yearly increase in agricultural production of 5 per cent. This increase under the natural conditions of our country is not possible without irrigation, a fact which imposes that irrigation should be developed both in horizontal and vertical directions. This determines an average increase in the irrigation lands of 0·5 million hectare per year.

On the basis of these three factors—water, labour resources and necessity for an increase in agricultural production, the basic concept for the development of irrigation in Bulgaria during the period up to the year 2000 can be expressed by the following three generalized numerical indices :

(*a*) Labour productivity in irrigation or the unit area served by one man should not be less than 50 hactares;

(*b*) Minimum unproductive losses of water in irrigation, corresponding to an irrigation efficiency of not less than 0·85;

(*c*) Continuous stable rate of increase in the agricultural production of not less than 5 per cent per year.

These three generalized numerical indices are both a goal and a starting point for the development of the tangible programmes concerning water development and particularly irrigation in the following aspects:

—amount and degree of reconstruction and updating of the existing reclamation funds;

—rate of increase in the newly constructed irrigation and drainage systems and flood control facilities;

—structure and varieties of crops on the reclaimed lands;

—need for foreign currency and construction of plants for production of irrigation equipment, pipes, fertilisers, etc.

The effect of irrigation, as it was mentioned above, depends mainly on the irrigation equipment.

While before 1960, the basic method of irrigation in Bulgaria was furrow irrigation with temporary irrigation canals and ditches, after this year an extensive use of irrigation by sprinkling has begun as a more efficient method of irrigation. By the end of 1975 the use of the different methods of irrigation in per cent of the total irrigated area of the country is as follows:

Furrow irrigation (conventional)	50 per cent
Furrow irrigation (improved techniques)	5 per cent
Sprinkler irrigation with portable equipment and taking water from open canals by means of portable pump units	23 per cent
Sprinkler irrigation—semifixed systems with movable sprinkler equipment and taking water from buried pipelines under pressure	21·5 per cent
Sprinkler irrigation—fixed systems	0·5 per cent
Total	100·0 per cent

The total amount of sprinkler irrigated lands is 45 per cent. It is expected that by 1985 this figure would increase up to 60 per cent by the year 2000 up to 80 per cent. During the next 10 years the fixed sprinkler irrigation systems will have a limited use, because of their high cost and the insufficient technical solutions of some constructive elements.

In order to increase the irrigation efficiency the following concept of distribution network is accepted: for all water discharges up to 1 m^3/s, a high-pressure pipe network will be used. For greater discharges, open canals with concentrated accumulation basins will be used, which will enable the automatic water distribution with minimum unproductive losses of water.

Water resources development, especially irrigation, in accordance with the generalized numerical indices mentioned above, leads to the corresponding industrial development of the country for production of irrigation equipment, pipes, fittings, regulators for automatic water distribution, fertilizers, varieties of crops, etc., in quantities needed to achieve the outlined objectives.

The indicated numerical indices represent also generalized criteria and standards for water resources development in Bulgaria. Within the framework of these criteria, for determining the ratio between the different measures and the efficiency of the structures, as a basic criterion, the minimum annual costs, or the maximum net return are used.

In principle, according to the type of water development—irrigation, drainage or flood protection—no alternative economic comparisons are made. Irrigation is accepted as a basic activity, the problem of drainage and flood protection in a given area or region being solved in its framework.

The basic social, economic and technical problems, the solution of which is indeed for the development corresponding to the increase in agricultural production up to the year 2000 are as follows:

(1) Production of high-productive irrigation equipment.

(2) Production of pipes and fittings.

(3) Use of high-productive crop varieties and the corresponding quantity of fertilizers, in order to use the potential capacity of soil fertility and irrigation and drainage systems.

(4) Improvement of method and labour organization used in agricultural production on the reclaimed lands so as to realize an optimum soil water supply and stable high yields.

For the solution of these problems, several complex co-ordinated programmes at national level have been developed which clarify research activities, designing, construction and implementation of the projects, as well as the time limits for all the institutions involved in their realization.

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R. 7

LIKELY IRRIGATED AGRICULTURE OF 2000 A.D.

LIKELY IRRIGATED AGRICULTURE OF 2000 A.D.—ROLE AND ACTIVITIES OF ICID AND ITS NATIONAL COMMITTEES TO MEET THE CHALLENGE*

VALLEYS AGRICULTURAL DEVELOPMENT AUTHORITY—ETHIOPIA

Ethiopia—the water reservoir of Africa—has not as yet utilized its water resources to the benefit of its people through scientific irrigated agriculture. However, due to the last three years continuous drought and overpopulation in the highlands of Ethiopia, special emphasis is now being given to develop irrigated agriculture in the major Ethiopian river valleys. It is planned that through irrigated agriculture, Ethiopia will intensify integrated agricultural development to satisfy the domestic supply, to produce for the world market and raise the standard of living of the rural population. Integrated development of the valleys of Ethiopia is, therefore, the major objective of economic development of Ethiopia. Integrated development is to be taken as a comprehensive approach to rural development, based on a suitable agricultural use of available land, making use of irrigation in general but not exclusively so. It includes land allocation and settlement patterns, the definition of crops (including animal production and forestry) and of cultivation methods, irrigation systems, as well as related farming inputs and agriculture services including marketing, storage and/or processing of agricultural products and distribution of agricultural inputs with or without credit.

At the outset it must be clear that scientific irrigated agriculture is new to Ethiopia. Although, considerable irrigation development has taken place in one of our valleys mainly through pump and gravity irrigation system, we are not in a position to answer at this time the basic questions such as "long-term planning of water development and water use for expansion of agricultural production", "assessment of demand for horizontal and vertical expansion of irrigation and drainage, etc., as requested by ICID.

* Perspectives de l'agriculture irriguée, en l'an 2000. Rôle et activités de l'ICID et de ses Comités Nationaux pour faire face au défi.

However, noting the need and the importance of maximum exploitation of our resources in the valleys, namely, appropriate land utilization and water resources for irrigated agriculture, the Ethiopian Government has established "Valleys Agricultural Development Authority." It is hoped that this Authority would introduce scientific irrigated agriculture in the valleys.

For the intensification of irrigation agriculture development the Authority would:

(*i*) identify within its area of responsibility, area presently unused or underutilised—and susceptible of irrigated development in line with national or regional standards and needs;

(*ii*) undertake the inventory of resources and evaluate them;

(*iii*) prepare guidelines for development policies in the areas identified under (*i*) and (*ii*);

(*iv*) set up priorities for the development areas defined above;

(*v*) launch feasibility studies and initiate plans and programmes for integrated regional (in each river valley) development with participation of the people of the region including settlers;

(*vi*) undertake gradually the plan for integrated development of the areas previously selected. These plans will also include the identification of agro-industries, and deal with all relevant factors of a social, economic and enviromental nature;

(*vii*) approach local and foreign financial institutions in order to secure funds for the implementation of development projects in the valleys.

(*viii*) be a link between research and farmer association, rural corporations, settlement schemes operating under irrigated agriculture conditions, thus ensuring optimum use of improved methodology as it becomes available;

(*ix*) provide technical assistance to state farms, rural corporations, settlement schemes and farmers associations of the regions included in integrated development schemes;

(*x*) co-ordinate its plans and programmes with other Government entities to ensure a proper timing of development and utilization of resources;

(*xi*) ensure follow-up and feed-back.

The inception of irrigated agriculture settlements, co-operatives and/or state farms, and agro-industries in new valleys—often in areas without established farming traditions—requires the application of the integrated development concept. Physical inputs for productivity alone are not sufficient. They must be accompanied by the provisions of the necessary infrastructure and rural development services essential to the well-being of the agrarian population. The fact that development of modern farms was, and still is, a necessary component of the development strategy of the valleys. Those modern enterprises usually provide, if they are properly managed, a high value added source which can, and should, be used by the Government as a source of funds for the integrated rural development, including settlement schemes, co-operatives, etc., of other parts of the valleys.

This type of development must be seen as multidisciplinary undertaking where a number of components operate in a closely integrated manner. Team approach at planning and operational levels is indispensable. Similarly, the "package" approach for the organization of inputs and services is needed to perform a proper utilization of human, natural and financial resources. Furthermore, it is necessary to adopt a "built-in mechanism" through which the population would gradually take upon themselves their own development instead of a "self-perpetuating mechanism" of permanent assistance from the Government.

Briefly stated, it consists of attempting to relieve the densely populated highlands where agriculture depends mostly on rainfall, through an increased use (both quantitatively and qualitatively) of the water resources distributed within some 11 to 14 river valleys in the lowlands.

In the recent past, the more frequent occurrence of droughts should be a vivid reminder of the urgent need of exploiting available water resources to ensure better agriculture outputs.

A review of the past agricultural development of Ethiopia would show that relatively little use of the country's water resources has been made so far, in comparison with some of the neighbouring countries. It is for the reasons stated above that the scientific irrigated agriculture is given top priority in Ethiopia's agriculture.

THE RIVER BASINS

The main river basins of Ethiopia for the present purpose of discussion are:

The Blue Nile, the Baro-Akobo, the Awash River, the Wabe Shebelle, the Juba, the Rift Valley Lakes, the Mereb-Geash, the Atbara Tekezze and the Barka.

The list is impressive and represents a large area of water catchment resources. However, due to lack of data we cannot supply detailed information on likely irrigated agriculture in Ethiopia in 2000 A.D. However, Tables I and II give some preliminary data on some of the valleys of Ethiopia.

TABLE I

Major Valleys of Ethiopia

Name of Valley	*Total irrigable land in hectares*	*Presently irrigated land in hectares*
1. Blue Nile	438,760	Nil
2. Wabe Shebelle	265,000	3,000
3. Awash	152,000	50,000
4. Genale Dawa	Not surveyed	
5. Omo	Not surveyed	
6. Baro-Akoba	Survey not completed	
7. Barka	41,000	1,000
8. Mereb Geash	48,000	16,000
9. Tekeze	120,000	17,000

TABLE II

The existing irrigated and potential irrigable area—Awash River Basin

Location	*Area irrigated 1975/1976 Net ha*	*Total potential irrigable area net ha*
1	2	3
1. *Upper valley*		
Wonji	5,600	5,600
Tibila	6,257	8,800
Nura Era	3,160	4,000
Others	—	1,000
Total	15,017	19,400

(Continued)

TABLE II (*Continued*)

1	2	3
2. *Middle valley*		
Abadir	2,150	3,500
Metehara	4,912	9,000
Melka Sedi Amibara	4,800	14,600
Awara Melka	1,230 }	9,000
Kessem Kebena	800 }	
Angelele	—	4,100
Bolhamo	900	8,990
Maro Gala*	3,000	15,200
Total	17,792	64,300
3. *Lower valley*		
Logia	135	135
Dubti	5,732	9,050
Dit-Bahari	6,240	16,300
Assayita-Berga	10,218	37,200
Mille	1,000	1,500
Total	23,325	64,185
Grand total	56,134	147,885

* Gewani and NRD State farms included

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R. 8

LIKELY IRRIGATED AGRICULTURE OF 2000 A.D.

IRRIGATION AND DRAINAGE: A COUNTRY REPORT THE UNITED STATES OF AMERICA*

U.S. Bureau Of Reclamation, Department Of The Interior

INTRODUCTION

The United States of America, unlike many areas of the world, has almost always been a land of agricultural surplus. This is largely the result of its wealth of natural resources. The nation has encouraged industrial expansion and development which has in turn fostered agricultural mechanization. This has led, throughout all of this century, to significant so-called "surpluses" in staple grains and foodstuffs. Some writers have estimated that, "Currently American agriculture can feed about 50 million more people than live in the country, and some 20 per cent of all farm produce is exported".([7]) Its true potential is probably much greater.

With this production capability has come an international sharing and cooperation. Nationally, this manifested itself in the Marshall Plan during the post World War II years. More recently, AID (Agency for International Development) and the Peace Corps have attempted to export our technological expertise to developing nations, on a people-to-people basis, so that these nations may utilize their own resources in feeding themselves. There have also been various emergency and longstanding food programs under both national and United Nations auspices.

The United States Congress, September 25, 1975, passed a resolution (H. CON. RES. 393, S. CON. RES. 66) affirming the right of every human being to sustenance. Future legislative considerations include international cooperation for possible development of World Food Reserve Stockpiles to mitigate localized drought and famine disasters and plans for global conferences to prepare for anticipated population growth.

* L'irrigation et le drainage: Rapport national des Estats-Unis.

The United States has made massive outright gifts of food and grains to fend off starvation in many areas, but our efforts have sometimes encountered barriers. Logistics of end-country distribution and supply systems have faulted some of our efforts at equitable allocation of donated foodstuffs. United States' programs for rapid industrialization of developing nations, highly desired by those nations, may not be the optimum solution for them at this time. Gradual industrial development, consistent with the agricultural level of the particular nation, may be the best approach. Mechanized agriculture is very productive in terms of man-years applied; but highly intensive, land economizing agriculture is better suited to some high population density areas.([18]) Perhaps "the improvement of agricultural productivity" is the best method for overall economic advancement in the agrarian developing countries.([18])

The United States' National Committee of ICID, through its membership, is prepared to assist the developing nations of the world in developing their water and land resources for greater food and fiber production.

1. LONG TERM PLANNING OF WATER DEVELOPMENT AND WATER USE FOR THE EXPANSION OF AGRICULTURAL PRODUCTION

1.1 ASSESSMENT OF DEMAND FOR HORIZONTAL AND VERTICAL EXPANSION OF IRRIGATION AND DRAINAGE

1.1.1 Present land use and present role of irrigation and drainage

1.1.1-1. *Areas*

The total land area of the United States is approximately 916,041,000 hectares (2,263,587,000 acres)([1]).

1.1.1-1.1 *Total cultivated area*, in 1969, not including extended range or pasture for grazing, represented about 155,349,000 hectares (383,877,000 acres)([1]). Non-food and Non-feed crops (tobacco, cotton, golf courses, etc.) amount to less than 5 per cent of this grand total. In any given year, roughly 11 per cent of this land is permitted to lie fallow for soil improvement.

1.1.1-1.2 *Total rangeland* used for grazing in 1969, including open or cultivated pasture and unfarmed woodland area, amounted to 360,121,000 hectares (889,878,000 acres)([1]). Cultivated pasture represents 10 per cent of this total.

1.1.1-1.3 *The total irrigated land area* in the United States (1975) is in the vicinity of 21,989,000 hectares (54,336,000 acres)([11]). This includes recretaional (golf courses) and aesthetic uses (turf farms, nurseries, flowers, etc.) amounting to less than 1/2 per cent of the total irrigated area. Approximately 7 per cent of the total represents non-food, non-feed crops (cotton, tobacco)([11]).

1.1.1-1.4 *The total area equipped with drainage facilities* in the United States in 1969, the latest year available, was almost 24,099,000 hectares (59,551,000 acres)([3]).

1.1.1-1.5 *Areas with both irrigation and drainage.* Approximately 4,317,000 hectares (10,668,000 acres) or 20 per cent of land on irrigated farms was provided with drainage in 1969(3). This amount was primarily to avoid the creation of wetlands and land for rice growing served by dual purpose systems. Normal irrigation water drainage is not included.

1.1.1-1.6 *Permanent pasture* or hay crops are grown on over 4,887,000 hectares (12,075,000 acres) or about 22 per cent(11) of the total irrigated land area. No specific figures are available for areas of man-made drainage used for pasture; however, it is doubtful that there is any significant quantity of engineered drainage for cultivated pasture.

1.1.1-1.7 *Flood protected areas*: No specific figures are available for areas which would not be suitable for cultivation without existing flood protection measures but it is certain that, in the United States, some areas of such nature, protected by levees and dams, exist along and in the flood plains of large and small rivers. This is particularly true in the lower Mississippi Valley where a rough estimate of flood protected area might be in the vicinity of 5,000,000 hectares (12,000,000 acres). The entire Eastern United States could certainly have no more than 1½ or 2 times this value. The Missouri River Valley might estimate at 240,000 to 280,000 hectares (600,000 to 700,000 acres) of such flood protected land. Again no more than double this amount at most could exist in the remainder of the West. So a very, very rough guess for total flood protected land would be in the vicinity of 8,000,000 hectares (20,000,000 acres) or about 6 per cent of the total cultivated land area.

1.1.1-2. *Irrigation Regions*

1.1.1-2.1 In a country as large and sprawling as the United States, irrigation and drainage are most decidedly not uniform throughout the States. The contiguous United States can be divided into two large areas, the 17 Western States and the remaining Midwestern and Eastern States. This division is not politically significant, but merely represents a separation by convenient geo-political sub-division of those areas with relatively more or less significant amounts of rainfall and, hence, less or more amounts of irrigation requirements.

1.1.1-2.2*a* The 17 Western States are in general characterized by relatively low rainfall. Only three states in this region exceed the National annual average of 762 mm (30 inches) of rainfall and none of those exceed it by more than 130 mm (5 inches)(5). The region is predominantly semi-arid. There are some areas of desert. Roughly one-third of the region is mountainous and it is here that the six or seven major rivers of the region have their headwaters. And these rivers provide the source of irrigation water that has, through consciously devised political instruments such as the Desert Farm Act and the Carey Act of the 19th century and the Reclamation Act of 1902, encouraged the great American West into becoming a huge breadbasket for much of the world(7).

A significant portion of the irrigation project area is Federally sponsored through the Bureau of Reclamation, an arm of the United States Department of the Interior. This agency, as mentioned above, was set up specifically to encourage "family farm" development of the American West. Although originally conceived as a repayment loan scheme, the sale of hydro-electric power from the many large Reclamation projects in the West today pays about 85 per cent of the capital development costs for irrigation water. There are private and state owned irrigation systems and cooperatives, and the Federal Government provides irrigation service for significant areas of the 17 Western States. More than 20 per cent of the water for western irrigation projects is provided by the Federal Government.

The semi-arid region can grow certain crops such as wheat, sorghum, corn, etc., with dryland farming techniques, but with irrigation, consistency of production can be assured, and a variety of crop production is possible in virtually all of the region. The emphasis is on distribution of the available irrigation water, whose source is largely snowmelt runoff, to augment the meager growing season rainfall. The overall quantity of water is inadequate to fully develop all the land resource. With proper husbanding, through the use of large-scale storage projects and good diversion distribution systems, bountiful harvests are assured. Artificial drainage is necessary in parts of the West because of increasing high water tables and the high salt content of some of the soils in the region.

1.1.1–2.2b The eastern half of the country has, in general, more than adequate amounts of rainfall. There have been problems on occasion with optimum timing of rainfall for maximum crop production. For this reason more and more eastern farmers are using supplemental irrigation. Most of the irrigation in the Eastern United States is private.([8]) Hawaii and Alaska are geographically separate of course, but their rainfall characteristics and need for irrigation would place them more generally with the Eastern Region.

1.1.1–2.3 A wide variety of crops are grown in each region. However, if general regional characteristics are examined, the West tends more towards corn, grain, cereal crops, and rangeland or pasture while eastern agriculture is more evenly distributed among all types of crops([11]). Both are important in the United States' food production, although far greater land area is under irrigated cultivation in the West than in the East. The East-West breakdown of the land areas in paragraphs 1.1.1-1.1 thru 7 is given in Table I.

1.1.1–3. *Crops Yields*

The United States produces such vast quantities of agricultural foodstuffs that it is somewhat difficult to select the main crop or main crops. Forage and pasture are probably the largest in terms of area, but are of significance only in the production of livestock foodstuffs. Direct production is probably most significant in terms of the feed grains : wheat, corn, and soybeans ; and cotton as a fiber crop.

1.1.1–3.1 *Yields for main crops* : The areas harvested in 1974 in the United States for four representative crops are listed in Table II.

The yields, for these and some other specified representative United States crops for 1969, are shown in Table III on an index basis([8]).

The preceding tables reveal interesting trends. In the semi-arid Western United States, virtually all crops do considerably better with irrigation than without. In the lush eastern part of the United States,

TABLE I

Agricultural areas, United States

	East	West	Total	Year	Ref.
	(Thousand hectares)				
1.1.1–1.1 Cropland	78,923	76,426	155,349	1975	(1)
.2 Grazing	51,593	308,527	360,120	1975	(1)
.3 Irrigated	2,556	19,433	21,989	1975	(11)
.4 Drained	20,056	4,043	24,099	1969	(3)
.5 Irrigated and drained	2,042	2,276	4,318	1969	(3)
.6 Pasture	203	4,634	4,887	1975	(11)
.7 Flood land	7,600	400	8,000	1976	(est.)*
	(Thousand acres)				
1.1.1–1.1 Cropland	195,023	188,854	383,877	1975	(1)
.2 Grazing	127,489	762,389	889,878	1975	(1)
.3 Irrigated	6,316	48,020	54,336	1975	(11)
.4 Drained	49,561	9,990	59,551	1969	(3)
.5 Irrigated and drained	5,045	5,624	10,669	1969	(3)
.6 Pasture	501	11,575	12,076	1975	(11)
.7 Flood land	19,000	1,000	20,000	1976	(est.)*

* Based on rough extrapolation of approximate data from U.S. Army Corps of Engineers on Mississippi and Missouri River Valleys and South Atlantic Region.

TABLE II

Main agricultural crops harvested, 1974 (1)

Crop	East	West	Total
	(Thousand hectares)		
Winter wheat	4,156	14,912	19,068
Grain corn	21,698	4,685	26,383
Soybeans	18,900	2,330	21,230
Vegetables	751	594	1,345
	(Thousand acres)		
Winter wheat	10,269	36,848	47,117
Grain corn	53,618	11,576	65,194
Soybeans	46,702	5,758	52,460
Vegetables	1,856	1,468	3,324

TABLE III

Comparison indices of average yield for specified crops harvested from wholly irrigated and non-irrigated land
(100 = Average yield, United States, each crop)

Crop	Average yield (t/ha)	Average yield		East Irri.	East Non-irri.	West Irri.	West Non-irri.
Alfalfa	6·32	2·82	(tons/acre)	119	102	139	73
Grain corn	5·39	85·9	(bu/acre)	99	102	128	69
Silage corn	27·95	12·47	(tons/acre)	111	105	140	60
Grain sorghum	3·32	53·0	(bu/acre)	104	102	149	84
Winter wheat	2·00	29·8	(bu/acre)	115	121	148	93
Spring wheat	1·80	26·8	(bu/acre)	108	112	183	96
Barley	2·38	44·2	(bu/acre)	112	110	139	89
Oats	1·93	53·8	(bu/acre)	141	107	109	90
Soybeans	1·83	27·2	(bu/acre)	96	102	117	82
Field beans	1·48	1,320	(lbs/acre)	124	96	132	45
Cotton	0·48	0·9	(bales/acre)	137	110	148	58
Potatoes	24·28	216·7	(cwt/acre)	106	87	116	66
Sugar beets	40·28	17·97	(tons/acre)	93	77	107	76

For the following two crops, the yields are shown in American dollars per hectare and per acre, respectively.

	$/ha	$/acre				
Vegetables	948·46	383·83	169	52	146	37
Fruits and nuts	1,022·08	413·62	89	75	129	46

however, the importance of irrigation in improving yields appears much less marked. Other factors besides irrigation, such as soil quality, climate, irrigation management, fertilizer use, etc., may have been operative.

1.1.1–3.2 *Cropping intensity* is not an essential requirement for economic viability in most of the United States. Indeed, in many areas, restricted growing season length and the long maturation times of many crops combine to provide added discouragement for multiple crop farmers. Most farmers seem to prefer crop rotation under dryland conditions and allow fields to regenerate by lying fallow, in preference to risking capital, fertilizer, and water in an attempt to grow mediocre harvests in a less than optimum season for the particular crop. Only in the Southern United States is any extensive multiple cropping practical. There are no statistics available, even on a regional basis, for the significance of this aspect of agriculture in the United States.

1.1.1–3.3 *Value of irrigation*: The value of irrigation is clear in semi-arid regions. There is some value even in wetter regions as well, but its importance currently is not as definitive. More use of irrigation is underway in the East and its value seems to lie in the area of insuring sufficient moisture at critical growth stages for a particular crop. The dominance of a certain crop in a given region comes about as a result of the integration of a number of factors, both economic and agronomic[12]. The agricultural system of a region, in other words, must be attuned to more factors than just environmental adaptation.

1.1.1–4. *Complementary Information*

1.1.1–4.1 *The irrigation methods* used in the United States are primarily divided between sprinkler and gravity (Tables IV and V). Gravity, the

TABLE IV

Sprinkler systems
(25 per cent of total irrigation)

Systems	*1975 Approximate area percentages in current use*[11]
Towline/side roll	24
Center pivot	30
Hand move	33
Solid set	7
Gun	5
Drip/trickle	1
	100

TABLE V

Gravity systems
(75 per cent of total irrigation)

Systems	*1975 Approximate area percentages in current use*[11]
Open ditch/siphon	55
Underground valved	23
Gated pipe	12
Flooding	10
	100

older, first used system accounts for over 75 per cent of all irrigated area. In the West, the area ratio between gravity and sprinkler use is 77·4 per cent to 22·6 per cent. In the East, the areas irrigated are : 59·5 per cent by gravity, 40·5 per cent by sprinkler([11]).

Sprinkler methods are newer and require less labor but require higher energy inputs. Their use is growing. On newly developed lands in the West over the past 10 years, self-propelled center pivot sprinkler units have been popular. Another adaptable new method of sprinkler irrigation is the high-pressure gun, which is very adaptable to small plots. It enjoys greater than a two to one preponderance in the East over the West. With all other methods, there are larger irrigated areas in the West than in the East. The use of sprinkler systems grew almost 10 per cent from 1974 to 1975, while gravity system area usage increased only 2½ per cent([11]).

The sources of water for irrigation use are either surface (lakes, reservoirs, rivers, ponds, etc.) or subsurface ground water as shown in Table VI([8]).

TABLE VI

Sources of irrigation water

	Ground-water percentage	*Surface water percentage*
Eastern United States	59	41
Western United States	41	59
Total	42	58

The percentages for East and West are almost exactly reversed. Much of western water (42 per cent) is provided through irrigation organizations. Most of irrigation organization water is obtained from surface sources([8]).

The reliability of all water sources for irrigation in the United States is generally variable. In certain areas ground-water levels have been decreasing steadily during recent years. In Nebraska for example, some ground-water levels have declined consistently from 1 to 3 feet annually according to the University of Nebraska Irrigation Development Coordinator.([10])

Many irrigation systems in the United States are highly sophisticated. The trend of sprinkler irrigation seems to be toward center pivot systems where land ownership areas are relatively large and where configuration permits its use. Most farmers use their sprinkler systems to spread fertilizer and pesticides as necessary during growing seasons. Primary fertilizing is done with solid fertilizers during soil preparation and planting. The skill of the farmer to use irrigation is generally good.

Drip or trickle irrigation, where measured quantities of water are applied directly to individual plant root zones, provides very efficient use of water. At the moment the greatest utilization of this new technique seems to be in orchards, although ways are being studied to expand its use to less discretely planted crops.

1.1.1–4.2 *The importance of drainage*: Drainage is most prevalent in the Eastern North Central United States. Very little of this (less than 10 per cent) is installed to maintain the productivity of irrigated land. Only about 2,042,000 hectares (5.045,000 acres) total in the East([3]) are equipped for both irrigation and drainage. The vast preponderance of Eastern drainage is for the reclamation of wetlands.

In the West, 2,276,000 hectares (5,624,000 acres)([3]) are dual irrigation/drainage land. There are no specific figures but here it is estimated that the majority of dual land is so equipped to maintain productivity.

Only 12 per cent of the drained and irrigated area in the United States is irrigated by sprinkler systems. All other dual land is either flooded or irrigated by other gravity methods.

1.1.1–4.3 *Other Reclamation measures*: Continuing replacement or repair of existing older public and private dikes and levees along United States' rivers, originally created by individual farmers or combines, is expected to maintain this flood-protected segment of agriculture in a generally unchanged condition over the next 25 years. Although the results and benefits of irrigation programs and flood and navigation control programs may benefit agriculture, they have in some instances, been directed toward other primary aims. Efforts of the United States Department of the Interior, Bureau of Reclamation, were specifically directed toward the establishment of a family farm agricultural base in the Western United States by providing irrigation water. Its charter evolved so that now it also provides large amounts of hydro-electric power, recreation, municipal and industrial water, and environment enhancement. The United States Army Corps of Engineers, on the other hand, is primarily charged with flood prevention and river navigation enhancement. The indirect results here have been the increase of arable land along major rivers formerly flooded to varying degrees each spring. So the flood control and navigation measures taken were not introduced specifically for the sole benefit of agriculture, but have, to some extent, improved the agricultural capability of the United States.

1.1.1–4.4 *Degradation*: Land degradation in the United States does not, at this point, seem to be statistically significant. Water degradation is becoming increasingly significant. For example, because of natural salinity build-up in the Colorado River as well as leached salts in irrigation return flows to the river, the salt load in the water delivered to the lower basin and to Mexico gradually increased to the point that the water was becoming questionable for use in Mexican agriculture. As a result of discussions between the two countries, an international agreement was arrived at in 1973. Public Law 32, 93rd Congress, "The Colorado River Basin Salinity Control Project Statute of 1974" provides for the construction of a 378,540 m^3/d (100,000,000 gal/d) desalting plant to increase the quality of the river water. The quantity of land involved will not be statistically significant for the United States overall.

1.1.1–5. *Summary Assessment*

1.1.1–5.1 *The value of agricultural production* coming from the 14 per cent irrigated area amounts to more than 20 per cent of the total agricultural production of the United States(13).

No figures are available for the agricultural value of products from drained land. The value is significant at least to the extent of the percentage that drained area bears to the overall cultivated area, roughly 13 per cent.

Flood protected areas, such as along the great eastern river basins, especially the lower Mississippi River, amount to considerable quantities of land. In past years, much of this country suffered lost crops every 2 or 3 years due to flooding. That protected area now amounts to roughly 8,000,000 hectares (20,000,000 acres).

1.1.1–5.2 *Farm population*: There is no data subdivision of farm population with respect to irrigation, drainage, or flood protected areas. The total United States population in 1974 was estimated at 211,551,000 persons. The farm population was 9,264,000 or 4·4 per cent(1). This percentage has steadily decreased each year from 9·4 per cent in 1959 down to its present level. The rate of decrease has leveled off somewhat over the past 5 years. This indicates generally the increasing efficiency and productivity of the American farmer. It also indicates of the increasing mechanization of the farm and the increasing trend towards larger farms.

1.1.1–5.3 *The value of irrigation, drainage, and flood control* is difficult to assess in terms of areas or even in terms of the value of production. Irrigation and drainage are increasing in both area and value of production. The balanced development of the West was made possible through irrigation. As an example, at a relatively immature stage in the development of the Columbia Basin Project economy (a large Bureau of Reclamation irrigation project in the Western United States), it was found that already the population and number of business establishments in the project area were 17 times greater than in an equivalent adjacent dryland farming area. Total wages paid were 20 times greater(16). Economic development, provided through the encouragement offered by the Reclamation Act and the Bureau of Reclamation, grew much larger than the mere land area benefited by irrigation. It is in this larger context that these percentages must be viewed.

1.1.2 Trends towards changes in land use

1.1.2–0. *Demography*

In 1850, the population of the world was one billion people. In 1930, it was two billion, having doubled in 80 years. By 1960 it had reached three billion. In 1976, it passed four billion, having doubled again in only 46 years.

Even if low fertility rates could be achieved within 5 years, our present 4 billion would grow to about six billion by the year 2000. Without extensive control, population could easily double by 2000(4).

In any demographic transition, the particular society in question moves from a stage of high birth rates and high death rates to a stage of low birth rates and low death rates, the latter usually preceding the former by several generations, resulting in growth(6).

The United States, with an annual birth rate of 15 per 1,000 and a death rate of 9 per 1,000, appears to be in the latter stages of this tranition with a growth rate of 0·8 per cent per year[17]. As a result from a nutrition standpoint, pressure for increased food production is not expected in the United States over the next 25 years.

It is expected that the percentage of United States' population employed in agriculture will decline slightly. The percentage of irrigated agriculture as a portion of total agriculture will probably continue to increase. Populations employed in agriculturally oriented industries (farm and irrigation machinery) will probably increase, due to the requirements for more efficient use of water provided by sprinkler irrigation systems, coupled with trends towards larger, machine intensive vice man intensive farming.

1.1.2-1. *Demand and Policy for Expansion of Agricultural Production*

1.1.2-1.1 *Local demand for production*: During periods of overproduction of food, the American farmer has at times been subsidized by the Government. Extensive sales to foreign nations, a generally indeterminate and unpredictable variable, govern profit to an extent, but when these sales are not forthcoming, the United States Government protects the farmer to some degree against economic loss by various subsidy and supply control programs. Thus, high consumer demand is seldom functional as a strong incentive for agricultural development. As United States' population gradually increases, agricultural production available to meet foreign needs will gradually decline.

1.1.2-1.2 The United States Government does not engage in extensive long term planning for agriculture, but responds as necessary to agricultural situations as they arise. The United States continues to use food supplies in humanitarian endeavors throughout the world, as it has in the past.

1.1.2-1.3 *Resource allocations*: The United States Government monitors and supervises large sale of foodstuffs to foreign nations. This is done partly for protection of the economic system of agriculture in the United States as well as insuring that the Nation's emergency stockpiles are not overly depleted.

1.1.2-2. *Trends in Changes of Land Use*

1.1.2-2.1 *Production trends*: There have been trends toward intensification of cultivation. Agricultural research has continually been attempting to study alternative methods of pest control, fertilization, crop rotation, and irrigation; but, these are adopted on a large scale only as they become economically feasible for the farmer. The greatest single trend is probably toward more capital intensive, mechanized operation in all areas. Many of the new methods are as yet experimental and have not been fully developed to the point of being operationally feasible on a large scale, but they do show encouraging promise.

1.1.2-2.2 *Land use trends*: Most land use trends in the United States today seem economically motivated; for example, the encroachment on rural areas by expanding cities and their housing developments. The projected conversion over the next quarter century is predicted to be about 5,000,000, hectares (12,000,000 acres)[15]. There are some socio-economic trends observable; for example, some, families are seeking out small farms in an effort to return to a more rural, unhurried way of life. These trends do not generally indicate any economic or production change in overall agricultural output.

Drainage of some irrigated areas is being accomplished through the installation of tile drainage rather than abandonment of the land for new areas. Before these efforts, 2,800,000 hectares (7,000,000 acres) were adversely affected in the West because of past neglect([2]).

Institution of drains is markedly cheaper than attempting to develop new irrigated areas and water supplies in virgin locations. In summary, the projected increase for land use in agriculture is about 4 per cent([15]). Certain fluctuations, from strip mining activity for example, are expected to be temporary during this period with eventual reconversion to agriculture by the year 2000([15]).

1.1.2-2.3 *Government influence*: The influence of Government in these areas involves advice and regulation. Government aid programs control of the use of harmful pesticides or fertilizers, encouragement of agricultural and environmental research, restrictive erosion control measure, and various agricultural output monitoring devices such as subsidies and agricultural extension service advice centers are examples of such activity.

1.1.2-3. *Summary Assessment*

The major foreseeable demand for increased United States' agricultural production is in meeting foreign export sales. The exportation of agricultural technology will doubtless be another area where the United States will be called upon by the nations of the world. As evidenced by congressional resolutions in September of 1975 (H. CON. RES. 393, S. CON. RES. 66, The "right of food" resolution,), we are ready to help. In the United States the number of people directly involved in farming will probably decrease slightly. The cultivated land area may increase somewhat to meet world and national demands as they occur and more intensification of production is expected through technological advances.

1.1.3 Demand for water development and use

1.1.3-1. *Horizontal Expansion of Irrigation/Drainage*

1.1.3-1.1 *increases*: Technological advances, mentioned in the previous section, will provide much of the anticipated increased production. It is also expected that a good portion of this will be provided by the extension of irrigation and drainage to those cultivated areas not now served by irrigation or drainage. Increases in irrigated area greater than 2·5 per cent annually would not be unreasonable nor inconsistent with projected past experience in the West. The percentage would probably be somewhat less in the East.

1.1.3-1.2 *Local trends initiative*: Farmers are borrowing money to develop irrigation. An independent study of irrigation equipment distributors indicates definite planned expansion. Twenty-six per cent of the distributors forecast greater than 100 per cent growth in the next 5 years. The center pivot system accounts for 35 per cent of the current sprinkler irrigation equipment market. Only three per cent of the respondents to a survey anticipated no growth at all([14]).

1.1.3-1.3 *Government support* involves mostly large projects designed to enhance water supplies. It also encourages and sponsors technical research and development, and becomes involved in mediation when different states have conflicting claim on water from various rivers.

1.1.3-2. *Vertical Expansion of Irrigation/Drainage*

1.1.3-2.1 *Increases*: Renovation and updating of existing systems with an eye to more efficiency and economy in the use of water will be the major impact in the vertical expansion of irrigation.

1.1.3-2.2 *Local demand*: Economically, as water costs and the cost of energy to extract water soar, individual farmers must modernize outdated systems to keep a viable profit margin for their efforts.

1.1.3-2.3 *Government support.* Here again, Government support involves research and development activity, mostly in the quest for water and energy to operate new irrigation systems. These will be discussed in more detail under section 2. Continuing development of major river systems and precipitation management research by the Bureau of Reclamation will be a significant share of Government support for major water resource projects. It seems clear that the limits of United States' agricultural productivity have not yet been reached([7]).

1.1.3-3. *Other Reclamation Measures*

Here, the expansion of flood protected areas is not anticipated, but some greater degree of protection may be provided. It will simply be an ongoing modernization and rehabilitation program on older public and private levees and dikes with minimal expected changes in overall cultivated land area as a result.

1.1.3-4. *Summary Assessment*

The expected demand for expansion of the water supply will be great, both for agriculture and for other uses, such as municipal and industrial applications. In order to have this water available, the prime thrusts of effort will have to be economical and efficient use of existing supply, extensive major water resource development, and concomitant technological development to effect both of the above as well as increased quantities (if possible) and improved distribution of water.

1.2. ASSESSMENT OF THE POTENTIAL FOR HORIZONTAL AND VERTICAL EXPANSION

1.2.1 Known potential to expand irrigation

National projects are centered generally in either the Bureau of Reclamation for the West or the U.S. Army Corps of Engineers for the entire Nation. The West is the only region with specific Government direction to foster and develop water resources for irrigation. Eastern irrigation development is primarily on a private commercial basis. The Corps of Engineers encourages agricultural indirectly through flood control and river navigation projects which enhance productivity on flood plain area land. The Soil Conservation Service has had, since 1935, a responsibility for developing and carrying out a national soil and water conservation program, primarily by cooperating with landowners at the farm level. They also cooperate with other Federal, State, and local agencies in studying waterways and river watersheds, including river basin surveys which serve as a basis for the development of coordinated programs.

The known current major projects therefore are only in the West and include 1,955,000 hectares (4,830,000 acres) in additional land for full irrigation service. In addition, service to 211,000 hectares (522,000 acres) already irrigated will be improved. New supplemental irrigation will be provided to 870,000 hectares (2,149,000 acres) and supplemental irrigation water facilities improved for 751,000 hectares (1,855,000 acres) of existing land. All of these additions and improvements are either in feasibility study, advance planning, or early stages of actual construction by the Bureau of Reclamation, United States Department of the Interior.

1.2.2 Potential for increased water use in agriculture

The possibilities in the United States lie in several main areas. First is the increased utilization of large rivers, such as the Missouri, through extensive Federal development of water control and storage facilities. The second potential source is the relatively new and experimental technique of atmospheric water management or "rainmaking" and "snowpack augmentation".

Really, the joint concern with these augmenting sources should be more efficient use of water, rather than simply more water. The time has passed when profligate use was an acceptable alternative. Husbandry of all resources is and should be a primary concern for all government, the United States in particular.

1.2.3 Capacity to develop potential

In the United States there is no question as to the ability to develop the potential. The knowledge is here, the money is available, and the people can do it.

1.2.4 Final assessment plans

A National Water and Agricultural Policy formulation might help in future planning. Other than that, free operation of the market place, including dispersion of technology, will continue to hold the United States' food and fiber production at high levels.

2. CONTRIBUTIONS EXPECTED FROM ADVANCED TECHNOLOGIES AND IMPROVED WATER MANAGEMENT

2.1. In this section is a list of the various new production techniques currently being explored in varying degrees in the United States. These techniques are in various stages of development and implementation. Some are virtually in full-scale use, others need more study and engineering before acceptance. All are proper subjects for research studies and for possible application to other cultures. It should be emphasized that what is now best for the United States may not be appropriate for all nations, especially those with high population densities. Studies are needed in this area.

2.1.1 New technologies directed toward more efficient use of existing supplies of water and land

trickle or drip irrigation
sprinkler irrigation
drains
irrigation tailwater recovery and reuse
scheduled, computer timed irrigation
neutron probe measurement of soil-moisture content
sprinkler application of fertilizers/pesticides
remote satellite infrared sensing of crop condition
precision land leveling and forming with laser beam control
treated sludge for soil enrichment
full automation of irrigation

2.1.2 New technologies involved in the distribution and control of water

river stabilization and control
canal linings to avoid seepage loss and lower maintenance cost
closed pipe conveyance to cut evaporation
ground-water pumping to lower high-water tables
new storage and conveyance projects

2.1.3 New technologies involved with new or previously unused sources of water

tertiary treatment of municipal wastewater
treatment of industrial wastewater
desalination plants
atmospheric water management
    rain augmentation
    snowpack augmentation

3. EXPECTED CONSTRAINTS AND PROBLEMS

It is expected that there will be many problems affecting further development of irrigation and drainage in the United States over the next 25 years. This section divides those constraints into four major areas: economic, legal, physical, and social.

3.1. ECONOMIC

The economic obstacles to further expansion of irrigated agriculture are primarily (1) competition with other uses for water supplies, (2) rapidly increasing investment and energy costs for large scale developments, and (3) increasing onfarm production costs relative to prices received. In the absence of any expected decrease in the supply costs of future agricultural production, output expansion will occur only in response to increased demand as reflected in higher prices on the world market for food unless the U.S. Government adopts an expansionary policy of increasing subsidized agricultural production to meet world food needs.

3.2 LEGAL

Despite the "Right to Food" resolution, there are conflicting legislative acts regarding such topic as:

Water Pollution Control Act of 1972 and recent court decision controlling the quality of irrigation return flows.

In summary, consideration of the adverse environmental impacts from agricultural production activities may prove to be a major constraint on resource development in the next quarter century([15]).

3.3 PHYSICAL

The limitations here are the quantities of water and how to augment, conserve, reuse, and recycle the supply. The lowering water tables in some areas, rising tables in others, depleted aquifers, high salinity, etc., all present limitations. Flood situations are an infrequent problem in the overall agriculture picture of the United States, but they do pose problems from time to time. "Water supply limitation will however be the most significant restraint on agricultural expansion"([15]).

3.4 SOCIAL

Cultural resistance to changes in accepted methods is of more concern to some developing nations than to the United States. While the loss of the traditional family farm and its experienced heritage in the United States may be undesirable on social grounds, it probably will not adversely affect food production overall. Highly specialized production of food may indeed be a less personal, but more efficient, wave of the future in agriculture.

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R. 9

LIKELY IRRIGATED AGRICULTURE OF 2000 A.D.

IRRIGATION AGRICULTURE IN MEXICO IN THE YEAR 2000 A.D.*

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SUMMARY

The construction and improvement of hydro-agricultural infrastructure will contribute to solve some of the problems posed by the sector of agriculture and livestock because it helps the development and increase of the added value.

At present about five million hectares—spread-over in various irrigation and drainage districts, irrigation units for rural development and private properties—are equipped with hydro-agricultural infrastructure which represent 30 per cent of the national cultivated area supplying 50 per cent of total farm produce and ample variety of basic products.

Taking into account the established features at national level the following objectives in irrigation and drainage have been fixed:

—to contribute to the increase of agricultural and livestock production by a system and an equitable and efficacious use of hydraulic resources in order to produce adequate food for the population and ingredients for national industry and to provide productive employment to the rural people and to take advantage of the opportunities that are available in the international market.

—to encourage rural development by means of hydraulic works.

* L'agriculture irriguée en Mexique en l'an 2000.

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—to utilize to the maximum the built-up infrastructure. The planned goals for the year 2000 signify doubling of (in next 25 years) the area equipped with hydro-agricultural infrastructure in the course of last 50 years in order to increase it to 10 million hectares at the end of the century. According to the regional strategy, 58 per cent of the new land will be selected in the Gulf Zone and in the South-East because of minimum social and ecological problems of the humid tropics, and pilot projects will be installed as a first step towards accomplishing large projects in this area and will be followed by specific investigation programmes of training and publicity which will be undertaken by the Institute of Tropical Development.

These programmes, involving investment of 266,000 million pesos (1975) will enable within the next 25 years to attain an annual increase of 2·3 per cent in area, 1·5 per cent in output and 0·2 per cent in variety of crops which represent an increase in rate of production of 4 per cent and an opportunity of 820,000 permanent employments at an average unit cost of 185,000 pesos (1975).

With these programmes the area equipped with hydro-agricultural infrastructure would contribute, in the year 2000, as much as 65 per cent of total agricultural production. It will, therefore, be possible to satisfy the demand of agricultural and livestock products, assuming that an increase in the regional production of seasonal crops would coincide with the earlier recorded trends and the present policies.

SOMMAIRE

La construction et l'amélioration de l'infrastructure hydro-agricole contribuera à la solution de quelques uns des problèmes qu'affronte le secteur agro-pastoral, étant donné qu'elle permet le développement de la productivité des terres, la génération d'emplois et une augmentation de la valeur ajoutée.

Actuellement sont dotés d'infrastructure hydro-agricole près de 5 millions d'hectares distribués en districts d'irrigation et de drainage, unités d'irrigation par le développement rural et propriétés privées, qui représentent les 30 pour cent de la superficie nationale cultivée, fournissent les 50 pour cent de la production agricole totale et une ample variété de produits de base.

En tenant compte des traits établis à niveau national, les objectifs suivants en matière d'irrigation et de drainage ont été fixés:

—Contribuer à l'augmentation de la production agro-pastorale par une conduite et un usage équitable et efficace des ressources hydrauliques destinées à fournir une alimentation suffisante à la population et des moyens à l'industrie nationale, ainsi qu'un emploi productif aux paysans, et

—à utiliser les possibilités que présente le marché international.

—Encourager le développement rural par des ouvrages hydrauliques.

—Utiliser au maximum l'infrastructure construite.

Les limites fixées à l'an 2000 signifient le doublement, en vingt cinq ans

de la superficie dotée d'infrastructure hydraulique mise en service au cours des cinquante dernières années, pour atteindre 10 millions d'hectares à la fin du siècle. En accord avec les stratégies régionales, les 58 pour cent des nouvelles terres seront choisies dans la Zone du Golfe et au Sud-Est où, étant donné les problèmes minimes, tant sociaux qu'écologiques du tropique humide, seront installés des projets pilotes comme première étape vers les grands projets à réaliser dans cette région accompagnés de programmes spécifiques d'investigation, de formation et de diffusion qui seront réalisés par un Institut de Développement tropical.

Ces programmes, qui impliquent un investissement de 266 mille millions de pesos de 1975, permettront d'obtenir, durant les prochains vingt-cinq ans, une augmentation annuelle de 2,3 pour cent en superficies, de 1,5 pour cent en rendements et de 0,2 pour cent en variétés de cultures, ce qui représente un taux d'augmentation de la production de 4 pour cent et un supplément de 820.000 emplois permanents d'un coût unitaire moyen de 185.000 pesos de 1975.

Grâce à leur réalisation, les superficies dotées d'infrastructure hydro-agricole pourront, en l'an 2000, contribuer 65 pour cent de la production agricole totale. Il sera donc possible de satisfaire la demande de produits agro-pastoraux, en supposant une augmentation de la production des régions de cultures saisonnières coïncidant avec les tendances enregistrées antérieurement et les politiques actuelles.

INTRODUCTION

AGRICULTURE

In Mexico the agricultural and livestock sector contributes more than one half of the value of merchandise exports. Its participation in this item was 57·8 per cent in 1950, 66·7 per cent in 1960, and 55·7 per cent in 1972. It represented 20 per cent, 16 per cent, and 10 per cent of the Gross National Product for the same years. It absorbed 40 per cent of the total of the economically active population in 1970. Between 1950 and 1972 the value of agricultural production grew at an annual rate of 5·9 per cent at constant prices. Nevertheless agriculture faces serious structural problems at the present time.

—93 per cent of the units of production, a total of 2·8 million in all, are classified as traditional and of subsistence, and their participation in the national agricultural production in 1968 was only 55 per cent.

—Seasonal unemployment and underemployment in the sector represented 68 per cent of the workforce officially defined as under-employed in 1970.

—There has been a material decline in the annual rate of growth in the past few years.

RESOURCES

In order to quantify agricultural dynamics in this period, indices were constructed for each of the components which determine the trend of production, such as area, physical yield per hectare, composition and prices.

In the yield index all the elements causing change therein are lumped together, viz., land improvement, capital, the human element, and technical know-how, among others. The product of the growth indices of crop yield and composition defines the economic yield index; the latter, multiplied by the area increase index, gives the production growth index at constant prices.

The analysis embraced all national agricultural production and two production groups are to be distinguished therein: the first, composed of maize (Indian crop) and beans; and the second, made up of the rest of the crops.

An irrigation district's production has great importance in the total production. For this reason its production was analyzed, separating cotton, in order to compare its trend with the remaining crops.

The trend of agricultural production in the 1950 to 1972 period shows a 5·9 per cent average annual growth, based exclusively on a growth by equal parts in area and yield, as changes in the crop pattern had very little impact on production (Table I).

DEMAND

From 1950 to 1972 domestic demand for agricultural and livestock products showed an accelerated growth due principally to factors such as:

—Population growth at a 3·5 per cent annual rate, generating at least similar growth in direct demand.

—An increase in the demand for livestock products and the low efficiency in the transformation of vegetable matter into food products of animal origin, accelerating the demand for grains, fodder, and other products for feeding animals.

—An increase in the needs of the basic commodities of processing industry. This industry has maintained an average annual growth of 6·5 per cent.

The average capacity to satisfy the basic necessities for food has existed, in spite of acceleration in the growth of population and per capita income, producing an increase in the volume and diversification of demand. Nutritional problems are caused, on the one hand, by the low income level of a good part of the population and their limitations of purchasing power for this reason and, on the other hand, by a lack of knowledge of a proper diet.

From 1973 to 1975 the deficiencies in domestic production led to importation of some products, mainly necessary cereals. Milk production went up from 3,092 to 5,357 million liters from 1955 to 1969 while imports thereof grew from 30 to 227 million liters.

Projections of external market demand, as recent experience shows, are a great deal less clear than for the domestic market. Transportation costs and competition by producers with a favorable geographical location have up to now limited the introduction of Mexican products into European and Japanese markets.

TABLE I*

Summary of agricultural growth rates

A = Area; *Y* = Yield; *V* = Value of production at constant prices

	1950-1972			*1950-1955*			*1955-1960*			*1960-1965*			*1965-1972*		
	A	*Y*	*V*	*A*	*Y*	*V*	*A*	*Y*	*V*	*A*	*Y*	*V*	*A*	*Y*	*V*
Country's total production															
All crops	2·8	2·8	5·9	4·6	3·4	7·8	2·3	1·9	5·3	5·5	4 8	8·6	—0·7	0·6	1·6
Maize and beans	2·8	2·8	5·7	4·9	3 7	8·8	2·5	2·9	5·4	7·2	3·0	10·2	—2·8	2·0	—0·5
Less maize, beans, and cotton	3·1	4·1	6·9	1·9	3·3	5.7	3·7	2·2	6·7	2·9	4·9	7·6	4·1	1·4	5·2
Irrigation district production															
All crops	4·0	5·0	7·5	11·4	4·3	15·4	1·4	4·4	3·2	2·9	7·9	7·7	2·3	1·6	3·5
Less cotton	7·2	4·8	11·4	13·4	1·7	13·8	7·2	4·5	12·5	7·3	4·6	10·2	3·4	3·0	7·1

* Source: PNH. *Dynamics of Agricultural Production*, 1975.

Prospects for the majority of basic agricultural products are attractive for the long term, due to rapid growth of the world's population and the relatively limited availability of land with an agricultural potential in the rest of the world, especially in Third World countries, which could be put under intensive production in a short time. The possibility of a world-wide scarcity of food and the uncertain conditions of the international market make a flexible agricultural policy necessary which may be capable of orientation with future opportunities, and at the same time assuring sufficient production to cover basic commodities needs.

SECTOR OBJECTIVES

The following targets are considered to be the goals already established by CONACOSA (National Co-ordinating Commission of the Agricultural and Livestock Sector):

—Attain an annual short-and long-term growth of 4·8 per cent and 5 per cent respectively, in the value of production.

—Achieve a sustained 5 per cent growth in the export of agricultural and livestock products, and

—Create 70,000 short-term jobs annually.

All of these goals serve to indicate the necessity for vertical and horizontal expansion in the irrigation and drainage infrastructure.

DIAGNOSIS

The drainage and irrigation infrastructure makes it possible to obtain higher productivity in the irrigation districts, in the rural development irrigation units, and in the drainage districts. Approximately 50 per cent of total agricultural production comes from these zones which covered almost 5 million hectares in 1976 and contributed a wide range of basic products.

The value of total agricultural production displayed quite a dynamic average growth during the 1950–1966 period, promising satisfaction of the needs of a growing population. However beginning in 1967, a shortage in the supply position was observed which was associated with two main factors: (*a*) investment in the agricultural and livestock sector decreased from 20 per cent of Federal investment in 1952 to less than 10 per cent at the end of the last six-year period; (*b*) production of basic crops in the irrigation districts was discouraged, as the excess was exported at unfavorable prices, contributing to keeping the prices fixed while production costs increased. Nevertheless, with this price policy the cost of living was controlled, particularly in urban areas, and commercial agriculture partially stimulated; but, on the other hand, production of basic crops was discouraged, more so in subsistence agricultural zones.

The growth of the value of agricultural production in real terms is explained by three sources: (*a*) increase in area, (*b*) increase in productivity, and (*c*) changes in the composition of crops.

(*a*) Increase in area

Extensive irrigation: In 1926, the year in which the Irrigation Law was passed and the National Irrigation Commission was created, application of hydraulic policy was begun by the construction of extensive irrigation works. The orientation of these works was towards the utilization of large land areas in arid zones in which the transfer of technology, tested in other countries, was feasible. Its production was delivered to national and international urban markets, and high economic financial returns were obtained thereby. Up to 1976, some 169 irrigation districts had been created which covered a total area of 2,639,500 hectares (Table II); 70 per cent of this is distributed in the arid regions in the north of the country—VI Bravo, II Northwest, and XI Closed Northern Watersheds. Ten of these districts have areas in excess of 100,000 hectares and contain 60 per cent of the total area; 25 have between 10,000 and 100,000 hectares, representing 30 per cent of the total area; and each of 119 embrace less than 10,000 hectares and make up 10 per cent of the total area. New works made up 65 per cent of the irrigation districts and the rest was accomplished by improvement works.

TABLE II

Areas with hydro-agricultural infrastructure up to 1974

Program	*Up to 1970*	*1971–74*	*Up to 1974*
	in 1,000 ha		
Extensive irrigation*	2,415·0	224·5	2,639·5
Drainage	74·0	9·0	83·0
Rural development	544·1	112·5	656·6
Total	3,033·1	346·0	3,379·1
Rehabilitation**	1,244·1	234·4	1,478·0
PLAMEPA***	—	466·4	466·4
Counselling, irrigation units	—	642·0	642·0

* Including 194,300 hectares incorporated by private parties.

** Reported by the General Directions of Irrigation Districts and Irrigation and River Control.

*** Land Parcel Improvement Plan (PLAMEPA). By interpolation of available data, 699,400 hectares are estimated for the 1971-76 period.

Source : Secretariat of Hydraulic Resources.

Drainage : Control works for water intrusion and drainage were begun recently to develop flooded lands with high agricultural potential on the coast of the Gulf of Mexico. In this area intensification of agricultural and livestock production faces problems demanding new, suitable solutions for the Mexican humid tropical environment as outlined in Chapter III (PNH). To date only 83,000 hectares have been incorporated into agricultural and livestock production, but in the future this will represent a high percentage of area growth in this sector. In spite of the fact that the Federal Water Law incorporates the creation of drainage and flood-protection districts, preparation of a more explicit regulation in this respect is needed particularly insofar as the delimitation thereof is concerned.

Hydraulic works for rural development : These works are constructed where socio-economic conditions are bad and limited amounts of water and land are available; and these works make a contribution to the distribution of income by providing small or inadequate and meagre irrigation works in the rural environment. This program has made feasible the construction of works for the irrigation of 657,000 hectares distributed more uniformly than irrigation districts.

(*b*) **Increase in productivity**

The program for an increased utilisation of water resources and land productivity was begun soon after the institutionalization of the Directive Committees, including PLAMEPA actions, irrigation district and unit rehabilitation, and counselling irrigation districts for rural development. Agricultural research has contributed in a most important manner to the increase of yields by means of research, among other factors, on sowing dates and the production of new varities. Due to these programmes it has been possible to increase the financial returns on public investments made in the past and to complete the structures lacking in some districts, and to promote the improvement of irrigation techniques. Its application is considered at the present time as parallel to the incorporation of new irrigation areas. In 20 principal irrigation districts of the country, whose area represents 60 per cent of the area under cultivation in irrigation districts in 1971, overall irrigation efficiency is estimated at 46 per cent. It was determined for the same group of districts that there was an increase of 4 per cent in the said efficiency in the 1967-1973 period, permitting the addition of 56,000 hectares to agricultural and livestock production by means of repeating crops on the same areas (Table III). Further, an increase has been achieved in the physical yields of the crops at an average annual rate of 5 per cent. On the other hand, only about 15 per cent of the total investment is covered by the income from rates and fees, including conservation and maintenance expenses[1]. A possibility exists for an increase in the efficiency of water usage and for solving conflicts and increasing production in this manner. Among the matters which influence the efficiency most in water use are:

—The number and location of the farm outlets.

—Water delivery and collection systems, and rates and fees.

—Seepage losses in canal network, including those controlled by users.

—Volume control systems applied and the degree of scrupulousness respecting the value of the water.

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* PNH = National Hydraulic Plan

(1) Secretariat of Hydraulic Resources : National Hydraulic Plan Documents, 1975 *Studies of Water Prices*.

TABLE III

Results of rehabilitation and PLAMEPA programs in the irrigation districts

Increase in efficiency (1967-1973)	4 per cent
Increase in irrigated areas due to efficiency increases (1967-1973)	56,000 ha
Overall efficiency*	
Parcel efficiency	79 per cent
Efficiency in conveyance and distribution	58 per cent
Total efficiency	46 per cent

* Corresponding to 20 principal irrigation districts, representing 60 per cent of the area under cultivation in 1971.

—Topographical conditions, soil properties and irrigation methodology and techniques.

In 1971 the irrigation unit advisory program for rural development was begun, providing organization and assistance to small and medium irrigation works. Up to 1974 some 642,000 hectares had been supervised.

In the distant future, the increase in productivity will be of much greater importance since the availability of water and lands is limited and does not allow indefinite growth of production solely by means of the incorporation of new areas.

(*c*) **Composition of crops**

In the last 20 years the evolution of the composition of crops has had a negative effect on the increase in the value of production in the irrigation districts, originating basically in the decrease of the areas devoted to the cultivation of cotton. This phenomenon is due to the stagnation of international prices and to difficulties in pest control, mostly in the Northwest.

Up to 1970 investments in irrigation works represented an average cost, at 1970 prices, of the order of 10,500 Pesos per hectare. It has been possible to prove the efficiency of our investments, as there is a 2·5 cost-benefit relation calculated from the benefits up to 1970, without taking into consideration the supplementary investments or indirect benefits. Investment in irrigation works has been effective in increasing agricultural production, promoting exports, fostering regional development, and influencing production growth in adjacent seasonal zones. On occasions, the introduction of irrigation works has emphasized the dichotomy between traditional and advanced agricultural sectors.

PROJECTION OF FUTURE DEMAND

The extensive literature on the demand for agricultural and livestock products leads to the conclusion that a direct relation to income is displayed by family consumption. Eventhough on the average nutrition levels meet the goals as determined by international agencies like the FAO, the low purchasing power of more than 70 per cent of the population and the lack of dietary education are the principal causes of nutritional problems.

For the purpose of consideration of the increase in medium and long-term demand in future projects, a methodology was designed, leading to a model for projection of domestic demand for agricultural products at a regional level. The said demand was estimated for five-year periods up to the year 2000. Reliability of the projections was confirmed by means of tests of the model, simulating the past demand and comparing it with the apparent demand; and only slight differences were indicated.

The projections carried out on the model were estimated from regional consumption preferences and at the family income level. The preferences were obtained from the inquiries made into family incomes and expenses by the Bank of Mexico in 1963 and 1968 and adjusting the data with present information to apparent consumption(2). Taking this information, the average regional consumption patterns at four income levels were calculated in order to satisfy the minimum 2,600 kilo calories daily diet per inhabitant, recommended by the National Nutritional Institute (NNI) and the FAO.

The consumption patterns, the regional population projections and the income distribution at the four levels, permitted projections of demand in the 13 established regions of the National Hydraulic Plan. Results were obtained for 25 products. In those of direct consumption, such as maize, beans, and vegetables, an estimate of the demand for grains and of the shrinkage due to commercialization was included. The demand for intermediate consumption products used as raw materials in the production of oil, meat, eggs, and milk, was calculated by means of a raw material-physical product matrix. Finally the indirect demand for industrial non-food products was calculated, based on the per capita demand estimated by several agencies(3). In brief, projected demand was reckoned in terms of the consumer in order to determine production demands in the countryside.

Economic improvement in this country would have significant repercussion in the increase or decrease of demand for certain products, like beans, tomatoes and meat. Estimates of demand for three products for 1980, prepared by several agencies, are set out in Table IV. Taking into account the 10 per cent that the said estimates considered as a regulatory reserve, there are slight differences between them and the estimates of the National Hydraulic Plan.

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(2) Rodriguez Cisneros and others : *Characteristic of Mexican* Agriculture.
Secretariat of Agriculture and Livestok : *The Market for Edible Oils.*
Secretariat of Industry and Commerce : *1973 Statistical Annual*
National Sugar Industry Commission : *1973 Sugar Statistics*

(3) National Commission for the Sugar Industry; Planning Sub-secretariat of the Secretariat of Hydraulic Resources; Secretariat of Agricultnre, General Direction of Agricultural Economy.

TABLE IV

Comparison of the demand estimated by the National Hydraulic Plan with the estimates of other agencies

Unit 1,000 tons

Source	Maize		Wheat		Rice	
	1975	1980	1975	1980	1975	1980
CONACOSA-DGEA-SAG	10,500	12,300	2,700	3,300	500	600
DGEA-SAG	10,600		2,800		500	
SRH-(EIDESA)	10,200	12,000	2,600	3,200	500	600
National Plan for Agriculture (SAG)	10,500	12,300			500	
PNH-Stage I	9,500	11,400	2,300	2,700	400	500
PNH-Stage II	9,300	11,000	2,400	2,900	450	600
PNH-Stage III	9,300	11,100	2,350	2,900	550	600

* CONACOSA and DGEA-SAG data take into consideration a regulatory reserve of approximately 10 per cent.

CONACOSA : National Agricultural Livestock Co-ordinating Commission.

DGEA-SAG : General Direction of Agricultural Economy of the Secretariat of Agriculture and Livestock.

SRH (EIDESA) : Secretariat of Hydraulic Resources according to a study under a contract with the Eidesa consulting company.

PNH : National Hydraulic Plan. Estimates in accordance with the stages the conditions of which are set out in Chapter I.

In spite of the changing situation in international markets, agricultural and livestock sector exports have permitted the capture of foreign exchange and have aided in industrial development. The perspectives for the future are not very attractive in respect of fruits, vegetables, coffee, cotton, sugar, and perhaps meat, due to the stagnation of commerce and trade with the United States of America and the difficulties in opening new markets. Basic product demand will increase rapidly due to world population growth; in spite of this the demand could be limited by a lack of economic resources for the purchase of products, above all, in third world countries.

The degree of ignorance of the future evolution of the international market requires a flexible productive apparatus, capable of adapting itself to demand and of taking advantage of market fluctuations. Increase in exports could be conservatively considered at a rate of expansion similar to that of world market, particularly for products such as sugar and cotton, which could reach 3 per cent per year, annually.

OBJECTIVES

In setting up the objectives in the matter of irrigation and drainage, actions were grouped in three programs: Extensive irrigation and drainage, hydraulic works for rural development, and increasing production. Considering the features established by CONACOSA, the following objectives were identified:

(1) A contribution to increase agricultural and livestock production with a harmonious, efficient, and equitable use and management of hydraulic resources, in order to supply to the population with sufficient food and the national industry with raw materials, to provide productive employment to the people in the countryside, and to take advantage of the opportunities offered by the international market.

(2) Encourage rural development through hydraulic works.

(3) Make maximum use of the built-up infrastructure.

GOALS

Goals were set in accordance with an analysis of the resources and demand for agricultural and livestock products and the possibility of carrying out regional programs to contribute to achieve the foregoing objectives (Table V).

M. 1 Increase from 50 per cent to 65 per cent of national agricultural production by the participation in agriculture of irrigation or drainage zones about the year 2000.

M. 2 Provide hydraulic works for rural development to 50 per cent of rural localities about the year 2000.

M. 3 Increase the export of production under irrigation or drainage at a 4 per cent average annual rate during the 1975–2000 period.

M. 4 Increase productivity indices by an average annual growth of between 1·5 per cent and 2·0 per cent in the 1975–2000 period, provided that there is a feasible potential.

M. 5 Achieve a more efficient use of the built-up infrastructure:

1982—Eliminate subsidies in the operation, conservation, and improvement of irrigation districts.

1982—Incorporate 100 per cent of irrigation areas into the irrigation districts and irrigation units for rural development.

2000—Increase irrigation efficiency by 15 per cent.

2000—Utilize 100 per cent of the zones with an irrigation infrastructure and as far as possible secure double crops.

TABLE V

Agricultural livestock sector goals

Concept	*Irrigation and Drainage districts*			*Irrigation Units for Rural Development*			*National Total*		
	1975-76	*1977-82*	*1983-2000*	*1975-76*	*1977-82*	*1983-2000*	*1975-76*	*1977-82*	*1983-2000*
Area (in million hectares)	2·9	3·4	6·5	2·1	2·5	3·5	16·5	18·9	25·3
Increase in yield (annual per cent)	1·5	1·5	1·5	1·5	1·8	2·0	1·5	1·7	1·9
Participation in the value of production (per cent)	32	34	42	18	20	23	100	100	100
Employment							55,000 to 90,000 jobs a year		
Composition of the crop pattern	Improve crop patterns at the regional level on the basis of comparative advantages in the use of water and soil, providing flexibility in the production of basics.			Improve the rural diet giving impulse to crops with a high absorption rate for manual labor.			Achievement of self-sufficiency in basic products and contribute to product growth at an annual 0·2 per cent rate of change in the composition thereof.		
Increase in exports (Annual per cent)	4	4	4				4	4	4
Increase in production (Annual per cent)	4·5	4·5	4·5	3·5	3·5	3·7	4·0	4·0	3·7

In order to accomplish the first three goals, extension of the hydro-agricultural infrastructure up to 10 million hectares is required by the year 2000.

POLICIES

CO-ORDINATION

—Use multiple-purpose criteria in planning, design, construction and operation of irrigation works.

—Make timely reports on the needs for equipment and materials in order to facilitate programming of national production.

—Seek central and regional co-ordination with agencies of the agricultural and livestock sector to secure timely concurrence of all the factors of production in areas with an hydro-agricultural infrastructure.

—Participate in crop programming in zones with an infrastructure to assure flexibility in meeting domestic demand and foreign markets.

—Integrally program extensive and small irrigation, granting preference to the latter when a conflict for water exists.

PROJECTS AND PROGRAMS

—Introduce a process for the generation of projects.

—Global, realistic, dynamic, and flexible programming consistent with national and regional development policies.

—Minimize project maturity and construction periods.

—Consider integral programs, composed by infrastructure, institutional actions and supports.

—Carry out the projects step by step.

—Include pilot projects as the initial step in large-scale actions where little experience and information is available.

OPERATION

—Apply optimum rules for the operation of surface storage and subterranean waters.

—Promote through DR and URDR directive committees maximum utilization of the hydro-agricultural infrastructure.

PARTICIPATION AND IMPLANTATION OF SCRUPLES

—Participate in permanent educational programs for creation of scruples respecting the rational use of water, and promote user participation in planning, construction and management.

TRAINING OF HUMAN RESOURCES

—Give an stimulation to the formation, training and motivation of skilled human resources at all levels.

INVESTIGATION, EXTENSION AND INFORMATION

—Stimulate and organize suitable basic and applied research in the Mexican context for better usage, re-use and control of water quality.

—Co-ordinate measurement of water uses with the national hydrological network.

—Consider the necessity for information on projects and programs on identification of the national hydrological network.

—Push the evolution of existing information systems.

—Continue incorporation of areas into the technical URDR program.

—Pay greater attention to agricultural research and extension.

FINANCING

—Assure participation of users in proportion to their use of water.

—Reduce subsidies for financing, operation, conservation, and improvement of works.

PROGRAMS

INFRASTRUCTURE WORKS

The strategies for achievement of the proposed goals are considered as reduced to units of action, that is, the projects. The Project portfolio has been formulated at a regional level, based on petitions of the present users and those provided for potential users, and based on the regional proposals channelled through state management commissions, and the regional offices of the Secretariat of Hydraulic Resources and other agencies.

Water balance has been realized with the help of digital simulation models in order to determine the individual and joint hydro-logical feasibility of the projects taking into account future demand for water for all uses and land availability. Therefore, projects were suppressed in some zones which, although hydrologically feasible, individually came into conflict with water use upon joint analysis.

In this way 5·5 million hectares have been identified to be equipped with an agricultural infrastructure, distributed as follows:

Zone	*Million hectares*
Gulf and Southeast	3·3
Northern and Central Pacific	1·5
Central	0·5
Northern	0·2
Total	5·5

In a like manner 1·5 and 1·5 million hectares have been identified in projects corresponding to rehabilitation and PLAMEPA, respectivley. Area increases in the following regions are generally limited by water restrictions: Lower California Peninsula (I), Northwest (II), Bravo (VI), Closed Northern Watersheds (XI), Lerma (XII) and Valley of Mexico

Watershed (XIII). The figures cited correspond to projects where irrigation technology similar to the present technology and an increase in water use efficiency derived from the PLAMEPA and rehabilitation Programs is being considered. Research into new irrigation methods now under way acquires paramount importance in the following regions: Central Pacific (III), Balsas (IV), Southern Pacific Isthmus (V), Papaloapan (VIII), and Grijalva-Usumacinta (IX); restrictions against increase in area lie principally in the land potential and the lack of drainage and flood protection.

In accordance with the foregoing, an adjustment was made in the project portfolio, solely considering such as were hydrologically feasible, and were organized in order of importance as functions of: evaluation indices; the nearest entrance data in harmony with the level of studies; the construction of multiple-use projects; above all the hydro-electric generation of electricity; and the obligatory sequence of some projects. In this manner the programs for the study and execution of new and rehabilitation works for extensive irrigation and drainage were prepared.

If the identified new projects were carried out in the next 25 years, it is possible to achieve the production goal referred to. However in 90 per cent of these projects, only studies exist in the great dream stage. This gives rise to the urgency for continuing with the preparation of studies, with which a portfolio of projects fulfilling national needs, feeding the short, medium and long-term investment programs, allowing selection of the most suitable programs and reducing uncertainty in the programs can be counted upon.

Regionally, the largest new area is located in the Gulf and South-east Zone, where an infrastructure based on drainage and flood prevention works is proposed. Of particular importance in the execution of these projects is the immediate realization of 12 pilot projects covering approximately 25,000 hectares, each one of which is representative of the ecological and social conditions of a broad zone. These pilot projects reduce the maturity periods of the large projects and permit testing of the schemes most suitable for local conditions on a commercial scale. In the Northern and Central Pacific Zones short term local use of water is made, and medium and long-term transfer from South to North are foreseen.

Hydraulic works for rural development were programmed in accordance with the level of studies of each project(4) and with water and land availability, priority being given to the zones with the most precarious socio-economic conditions. The total area considered in these programs reaches 1·2 million hectares, the distribution of which is set out in Table VI.

The Parcel Improvement Plan is supported by the specific studies(5) carried out in 52 irrigation districts, priority being given to users who utilize irrigation schedules which are larger than average in each district, in order to provide technical assistance, and construct gauging structures. Of the 1·5 million identified hectares, during the period 1971–1977, it will be

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(4) Secretariat of Hydraulic Resources: National Hydraulic Plan Documents Hydraulic Works for Rural Development. Engineer Eduardo Nestre, 1975.

(5) Secretariat of Hydraulic Resources, General Direction of Irrigation Districts: Irrigation Technicalization Project, 1971.

TABLE VI

Rural development hydraulic works program

Zone	*Programmed areas in hectares*			
	1975-1976	*1977-1982*	*1983-2000*	*1975-2000*
Northern and Central Pacific	13,921	89,825	332,886	436,632
Northern	16,898	49,256	135.000	201,154
Central	23,232	75,548	200,963	299,743
Gulf and South-east	26,017	74,027	161,515	261,559
Total	80,068	288,656	830,364	1,199,088

necessary to intensify these programs in the future, in order to include them in the total irrigation-equipped area of the country.

INSTITUTIONAL ACTIONS

—Promote the appointment of technical consultants and assistants to the irrigation and drainage districts directive committees, and to those of the irrigation units for rural development, as the Federal Water Law provides.

—Put the necessary organizational mechanisms into operation, for planning agricultural production in order to establish efficient co-ordination between central and outside offices, for the purpose of :

(*a*) Carrying out the supplementary measures to the infrastructure works, to assure their maturity as soon as possible.

(*b*) Programming crops for the satisfaction of domestic demand and to take timely advantage of international markets.

—The incorporation in 1982 of all of the irrigation areas outside the districts into the irrigation units for rural development. This would imply the incorporation on that date of slightly more than 1 million hectares into the said units, at a rate of 170,000 hectares per year. Up to 1975 the incorporation of 800,000 hectares at a rate of 160,000 hectares per year has been accomplished.

—Provide permanent counselling in 1985 to all the areas incorporated into the irrigation units for rural development.

At present only 29 per cent of the 800,000 hectares incorporated are receiving this type of counselling. This means attending to about 1·8 million hectares more around 1985, representing an increase of 180,000 hectares per year.

—Make an annual check of the fees for the areas with a hydro-agricultural infrastructure, in accordance with operation, maintenance, conservation, and improvement costs.

SUPPORT ACTIONS

—Continue with the realization of socio-economical, hydrological and financial identification, broad view, perfectibility, and feasibility studies which would permit full programming of optimum utilisation of water and land usage. Study operational policies and the form of financing of each project, taking into consideration the fullest participation of users in the planning and construction of the works, and taking steps favorable to payment therefore, particularly in the case of rehabilitation of the hydro-agricultural infrastructure.

—Continue the development of tools which will permit programming of crop patterns in irrigation or drainage zones, in accordance with conditions of domestic and international demand and the production capabilities of each zone.

—Continue with the counselling programs for improvement of water use and train the users by issuance of irrigation formulas and demonstrations on test parcels. Change the water delivery system so that collection is made by volume, and for this purpose it is considered that the installation of around 150,000 metering structures at the parcel level will be necessary by the year 2000. The latter implies the need for installation of about 6,000 structures per year so as to cover all of the irrigated areas by the year 2000. It is estimated that there are 33,000 metering structures in existence at the present time, covering an area of 1·5 million hectares.

—Design and put the Tropical Research Institute into operation, which, in connection with the pilot projects, will permit training of personnel, and agricultural, economic, and social research to be carried out for better utilization of the resources of the tropical zones of the Gulf plains.

—Intensify the training of medium level technicians through the creation of regional, technical, training centers, and at a higher level by means of the establishment of scholarship programs and supporting the educational system, and all of this in accordance with the programs and needs set out in Chapter XVII (PNH).

—Intensify the studies on the formation of agro-industrial combines, especially in the Northern Zone, and within it, of the Lower Bravo (Rio Grande), Lower San Juan, and Laguna irrigation districts, and in those located in the Northwest as well.

PROGRAM EVALUATION

Attainment of national goals implies doubling in the next 25 years, of all of the hydro-agricultural infrastructure constructed throughout the

—history at a rate of 200,000 hectares per year, until completion of 10 million hectares under irrigation or drainage by the end of the century, which would permit equipping 50 per cent of the agricultural communities in the country with a hydro-agricultural infrastructure. During 1974 the equipping of 100,000 hectares with a hydro-agricultural infrastructure was achieved, which indicates a need for doubling the efforts in the future in order to accomplish the works proposed. In addition, an increase in rehabilitation and PLAMEPA programs is planned.

Through realization of the programs for new irrigation and drainage works, hydraulic works for rural development and an increase in production during the next 25 years the achievements will be an annual 2·3 per cent increase in areas, 1·5 per cent in yields, and 0·2 per cent in crop make-up, producing, in real terms, a 4·0 per cent rate of growth in the value of production in zones having a hydro-agricultural infrastructure. By the year 2000 some 820,000 permanent jobs at an average cost of 84,000 Pesos (1970) will be created, the same being 130,000 in the Northern and Central Pacific Zones, 53,000 in the Northern, 60,000 in the Central, and 78,000 in the Gulf and South-east Zones. This means creation of 33,000 jobs annually, which will contribute close to 50 per cent of the goals proposed by CONACOSA. By means of the programs planned, it should be possible for areas having a hydro-agricultural infrastructure to contribute 60 per cent of total agricultural production, in production value, by the year 2000.

The said programs would allow accomplishment of export goals provided it is feasible to place new products on the international market, such as fruits and meats and to increase markets for the products which have been exported traditionally.

By a crop pattern orientation similar to the present one, the cost-benefit relation of the projects is greater than what is obtained with a policy tending towards selfsufficiency in the basic products item, which, nevertheless, is necessary if imports are to be avoided. The national average is 2·6, while in the Northern and Central Pacific Zones it is 3·5, varying between 0·9 and 4·7 in the Baluarte and Carrizo Continuation projects, respectively; the mean is 2.5 in the Northern Zone, and varies between 3·9 and 0·8 in the Las Lajas and Trujillo projects; it is 1·9 in the Central Zone, and varies between 7·2 and 0·8 in the Los Reyes and El Gallo projects; in the Gulf Zone it is 2·4, and varies between 4·7 and 0·8 in the Panuco Shore and Tonameca projects.

BALANCES

The results which are obtained with these programs, in which an increase in production in seasonal zones consistent with tendencies recorded in the past is assumed, would permit the inference that it is possible to satisfy the demand for agricultural and livestock products.

The systems constituted by the projects which make up the programs are hydrologically feasible, while still considering multiple-use hydraulic utilization.

Soil studies exist which provide assurance for realization of the hydro-agricultural projects. It is estimated that total land requirements around the year 2000, of the order of 25 million hectares, can be adequately covered by the land availabilities identified in the inventories, but intensification is required of the actions directed to soil and water conservation in the watersheds in which intensive use of these resources now exists or will exist.

All the projects proposed in the programs imply an investment of 121 million Pesos (1970) during the next 25 years. As much as 74 per cent of this sum corresponds to extensive irrigation and drainage, 16 per cent to hydraulic works for rural development, and 10 per cent to programs for increasing productivity (Table VII).

TABLE VII

Hydro-agricultural sector investment program

Program	*Investment in million Pesos (1970)*			
	1975–1976	*1977–1982*	*1983–2000*	*1975–2000*
Extensive irrigation	4,381	12,026	60,307	76,714
Drainage	384	1,746	11,955	14,085
OHDR (Hydraulic Works for Irrigation Districts)	1,237	4,436	13,126	18,799
Increase in Productivity	2,186	6,644	2,765	11,595

In respect of the total investment assigned to the 1971–1976 six-year period, the extensive irrigation and drainage program lost a 20 per cent increase, principally due to the drainage works planned for the Gulf and Southeast Zone. There is a 6 per cent decrease in the program for hydraulic works for rural development, and a reduction of 14 per cent in the program for an increase in productivity. Investment calculated for the next 25 years is compatible with budget increase in past years, and with the greater support of the agricultural and livestock sector considered for the future.

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SESSION SPECIALE DE TEHERAN 1977

R. 10

LIKELY IRRIGATED AGRICULTURE OF 2000 A.D.

PRESENT AND ANTICIPATED EFFECT OF LAND RECLAMATION ON THE AGRICULTURAL OUTPUT INCREASE IN CZECHOSLOVAKIA*

ING. TÁŠKÝ JOSEF**

ING. HELDI ANTON**

INTRODUCTION

The Czechoslovak agriculture has an enormous task ahead to provide in the nearest future the maximum degree of self-sufficiency in food production. The achievements of the socialistic agricultural production, reached hitherto, especially the results attained within the five-year plan (1971-1975), have shown the feasibility to achieve this goal.

For the systematic growth of agricultural production the utilization of all potential sources of production is inevitable. Proceeding from the present state of investments, expended chiefly in crop production in the form of constantly increasing fertilizer doses, quality of new varieties of agricultural crops, and in most cases also on the full production mechanization—almost all factors of production intensity are safeguarded.

As far as the proper agricultural land is concerned in relation to climatic factors, there are still considerable reserves for providing a complex co-operation of potential factors of cropping intensity. To attain optimum fertility conditions in all agricultural lands and at the same time to maintain constantly this state, it is necessary to carry out land reclamation interventions on about 3·5 million hectares. These reclamation

* Conséquence actuelle et envisagée des améliorations foncières sur l'accroissement du rendement agricole en Tchécoslovaquie.

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interventions being effective separately or in combinations are of short-term (reclamation, liming, etc.) or long-term (drainage, irrigation, etc.) character.

Based on the analyses of present state of agricultural production intensity of the soil factor the national authorities in co-operation with agricultural enterprises have worked out a land reclamation project for the whole Czechoslovak territory which has become a part of the national-economic plan. At present, within the scope of the long-term agricultural development forecasting towards the year 2000, the forecasts in the land reclamation branch are also being processed.

1. PRESENT STATE OF AGRICULTURAL LAND AND LAND RECLAMATION

Czechoslovakia is one of those countries which have a low per capita land area. At the beginning of 1975 only 0·48 ha of agricultural land fell to one inhabitant and from that only 0·33 ha was plough-land. While about half of the total acreage does not reach the optimum degree of production capacity due to unfavourable physical or chemical soil properties, a continuous decrease in agricultural land acreage on the other hand has been experienced due to rapid urbanization, industrial growth, development of residential areas, and highways. Over the last 25 years the agricultural land acreage dropped by almost 7 per cent. From this it follows that an extraordinary careful management of agricultural land and the necessity of a systematic care for soil fertility increase are indispensable for the future development in Czechoslovakia.

As to cope with the negative impacts caused by the agricultural land losses and to provide further agricultural land intensification, environmental protection, and creation of a livable environment among others, reclamation measures of investment and non-investment character are gradually realised.

There is a long tradition in the field of agricultural land reclamation in Czechoslovakia. Since 1949 the land reclamation measures, namely drainage, had been carried out at many sites, though only on small land acreage. The establishment of collective farms made possible to carry out reclamation measures to a greater extent. Conditions created by land replotting and series of other land reclamation measures, emphasized by an extensive state subsidy policy, enabled the development of large irrigation systems on areas up to 20,000 ha of extensive drainage works in the East Slovakian Plain.

The extent of reclaimed areas and their percentages as compared to the total agricultural land area is presented in Table I.

1.1 AREAS REQUIRING LAND RECLAMATION MEASURES

Geological and morphological conditions in Czechoslovakia, characterized as non-uniform and heterogeneous, had influenced the potential

TABLE I

Reclaimed land area in Czechoslovakia by January 1975

Item	*Area in ha*	*per cent of agricultural land*
Agricultural land	7,042,000	100
Plough land	4,943,000	70·2
Land under irrigation	244,000	3·5
Drained land	755,000	10·7
Drained and irrigated land	76,000	1·1
Recultivation	415,000	5·8
Liming	700,000	9·9
Regulation of streams	9,500 km	

soil fertility, were affected to a great extent by hydrological and climatic conditions of the Czechoslovak territory. By means of the analysis of the described conditions, and of the actual state of soil fertility, the territories requiring respective types of reclamation were assessed.

1.1.1 Irrigation areas

Irrigation under Czechoslovak conditions has a character of supplementary irrigation, applied when soil moisture content is at minimum in relation to other growth factors. Water from natural precipitation is distributed unevenly not only spatially but also in time within the growing period of a year, and in the corresponding years.

With regard to water management conditions in the country it is to be mentioned that the natural discharges of the main water courses, which, except for the Danube River, fluctuate to a great extent, have to be considered as basic water resources for large-area irrigation systems. Due to long duration of low discharges the quantitative and seasonal irrigation water requirements cannot be met, and thus the providing of water off-takes is jeopardized. On these watercourses the construction of storage reservoirs and barrages should provide sufficient water for consumption.

With respect to above mentioned facts the assessment of irrigation areas and determination of their acreage has been made according to watersheds, taking into account also the climatic and pedologic conditions of respective regions.

On the basis of the cited criteria the potential possibility of irrigation—basically identical with the required demand—has been determined as 1, 366,400 ha [Table II (*a*)].

TABLE II(*a*)

Irrigation regions in Czechoslovakia

Region rivers	*Potential possibility ha*	*Characteristics of regions*		
		50-year Temperature °C	*Precipitation mm*	*Type of soil*
Danube	(578,000)	9·8	570	light sandy
Váh	578,000	9·4	590	sandy loam
Hron	87,337	9·0	600	brown forest soil
Bodrog, Hornád	191,540	8·6	620	clayey (medium heavy)
Labe	75,510	9·0	575	light
Vltava	38,875	8·5	600	medium
Ohře	33,406	8·4	600	medium
Dyje	50,539	9·0	600	medium
Morava	79,404	9·3	620	medium
Others	231,789	8·5	650	medium
Total	1,366,400	8·9	600	medium

1.1.2 Agricultural land requiring other reclamation measures

A considerably larger acreage—as compared with irrigation—is required for agricultural land, the physical and chemical properties of which should be modified. These reclamation interventions with their quantitative requirements are presented in [Table II (*b*)].

The collection of data both for the federal republics and the overall Czechoslovak territory was effected by the circumstances that the number of respective actions within the scope of each reclamation measure was very high and they cannot be separately enumerated and areally traced and assessed. We assume that this review will be sufficient for the purpose of contribution to this session and for getting an idea of the existing reclamation measures in Czechoslovakia. It is however to be noted in this connection that in several cases the corresponding reclamation measures are not applied separately, but in combination or successively.

TABLE II(*b*)

Agricultural land requiring other reclamation measures

Reclamation measure	*Territory*	*Potential possibility requirement*
1	2	3
Drainage	ČSR* SSR** ČSSR***	1,250,000 ha 426,000 ha 1,676,000 ha
Fertilization of soils with extreme physical properties	ČSR SSR ČSSR	1,000,000 ha 779,000 ha 1,779,000 ha
Liming	ČSR SSR ČSSR	1,167,000 ha 1,834,000 ha 3,001,000 ha
Fertilization of meadows and pastures	ČSR SSR ČSSR	700,000 ha 495,000 ha 1,195,000 ha
Lands dammaged by erosion	ČSR SSR ČSSR	1,500,000 ha 350,000 ha 1,850,000 ha
Barren and devastated lands	ČSR SSR ČSSR	19,000 ha 114,000 ha 133,000 ha
Regulation of streams	ČSR SSR ČSSR	16,000 km 5,770 km 21,770 km

* ČSR = Czech Socialist Republic

** SSR = Slovak Socialist Republic

*** ČSSR = Czechoslovak Socialist Republic

1.2 PRODUCTION INCREASE OF MAIN CROPS ON RECLAIMED LANDS

The justification of reclamation interventions carried out so far and the necessity of their further implementation in agricultural land under Czechoslovak conditions can be demonstrated by the yield increase of all crops on reclaimed lands. The production results obtained on reclaimed lands planted with main crops were evaluated on an average for the period 1971–1975, as well as for the most costly reclamation measures with respect to investment cost. These data represent simultaneously also the means from the most important localities of the both federal republics (Table III).

For a more complex information concerning the effect of main reclamation measures on the agricultural production intensification we present an increase of the value of overall plant production (as compared with the yields of main crops—Table III) per hectare of the reclaimed area and the total contribution of reclamation expressed as the production increase on reclaimed areas within the overall Czechoslovak territory (Table IV).

TABLE III

Annual production increase of main crops on reclaimed soils

Crop	*Irrigation*		*Drainage*	
	t/ha	*Kčs/ha*	*t/ha*	*Kčs/ha*
Wheat	1·07	1,819	1·10	1,870
Barley	1·48	2,220	1·10	1,870
Maize	0·99	1,498	—	—
Sugar beet	15·10	3,775	16·5	4,125
Multi-year fodders (hay)	2·53	1,012	2·70	1,080

1.3 ADDITIONAL INFORMATION

1.3.1 Irrigation

The transition from the individual to collective farming has brought about also the change of the system of choice and realization of irrigation areas and equipment. Small-area irrigation conditions were inappropriate with respect to gross-production conditions due to their pretentious claims for manpower and high water consumption. The concept of large-area and medium-area irrigation systems is suitable for the new production forms of management since it requires minimum labour and introduces maximum mechanization.

Large-area irrigation systems include several agricultural enterprises, their area being over 10,000 ha. In cases where gravity supply is not feasible,

TABLE IV

Annual production intensity increase on reclaimed areas

Reclamation measures	*△ production in Kčs/ha*	*Total in mil. Kčs*	*Share on the gross production intensity growth (nation-wide)*
Drainage	2,803	2,116	5·0
Irrigation	1,947	475	1·1
Other reclamation measures (recultivation, liming)	1,100	1,227	2·9
Total	1,800	3,818	9·0

stationary or floating pumping stations are constructed for water pumping and conveyance, which bring irrigation water to the concerned territory. By means of a system of pumping stations having a capacity of 20–30 m^3/min, the irrigation water is pumped into asbestos-cement sub-surface pipelines with a system of overground hydrants. Water is distributed over irrigation fields by means of portable aluminium pipes, or strip irrigation equipment, moving forward by means of a hydromotor, or recently by means of wide-gauge track sprinklers of the type of Fregat, Volžanka, etc. With an exception of about 10,000 ha all the present and envisaged or designed irrigation systems make use of sprinkler irrigation.

Administration, operation and financing of irrigation systems—starting with the water resource and ending with the water supply to the irrigated field—are provided by the budgetary organization through the detached workplaces, or through the co-operative organizations financed by it.

The agricultural production enterprises ensure the proper operation on the irrigated field in active co-operation with the State Reclamation Board.

1.3.2 Drainage

In Czechoslovakia drainage is linked up with regulation of streams, consisting in the interception and diversion of surface waters from the adjacent territory.

Drainage of the territory is effected through drainage systems, the purpose of which is to divert surface waters from the catchment area and to make possible—by suitable design—also the gravitational evacuation of surplus ground waters from the drainage network systems. The drainage system comprises a group of water structures on a large area of the territory, from which waters are collected by means of a widely branched net of canals, disembogueing into the main drainage canal. The main canal delivers these waters to the pumping station in case of a dammed receiving stream. From there they are pumped during high water stages. During low discharges in receiving streams the runoff is facilitated by means of a free outlet on the pumping station and by means of dam structures. These complicated structures represent a basis of the drainage system and therefore have to be constructed before the detailed drainage construction is started and have to be consistent with the requirements for the extent, capacity, and depth of the drainage detail. The drainage network represents a systematic or sporadic drainage or eventually the drainage ditches for further water runoff.

1.3.3 Regulation of water courses and flood control

The most common method of river training aimed at flood control was the damming of the stream, removing of meanders with resulting increase of flood water discharge, or also the fortification of concave river banks. Recently new methods of flood control apply, namely, the training of river channels, thus removing the sharp meanders which hinder water flow and induce ice jams formation and concentration of water from branched river arms into the main channel, creation of regular longitudinal and suitable cross-sectional profile, and corresponding fortification as to prevent undermining and washing away of river banks. Within the scope of a complex project of East Slovakian Plain protection also the storage volumes of reservoirs and polders have been used for the interception of flood waves. The most recent methods of river training have solved, besides flood control, also the channel stabilisation achieved by systematic training of water courses.

The extent of reclamation activity can be gauged besides the areal expression (Table I) also by the extent of investments expended on reclamation construction, as shown in Table V, as compared with investments (after their realization as basic funds). The submitted sums should be completed

TABLE V

Value of basic funds in Czechoslovakia, January 1975

Index	*in mil. Kčs*	*Percentage of total basic funds*
Total basic funds	1,839,322	100·0
Total funds in production sphere	1,041,519	56·6
Total funds in agriculture and forestry	165,619	9·0
Total funds in land reclamation	15,413	0·8
Total funds in irrigation	3,756	0·2
Total funds in drainage	11,325	0·6

with so called non-investment land reclamation measures, as for instance land reclamation—liming, recultivation of low-productive meadows, devastated areas, etc.

In the last ten-year period the cost for these works amounted to 250 million Kčs annually.

Proceeding from the assumption that the demand for reclamation measures is to be satisfied on approximately half of the agricultural land acreage, it can be schematically stated that about 6 per cent of the active Czechoslovak population (or approximately 880,000 inhabitants) is engaged (Table VI) on it.

TABLE VI

Demographic information about Czechoslovakia (1974)

Index	*Number of inhabitants*	*Percentage*
Number of inhabitants	14,738,000	x
Employed in the national economy	8,827,000	100·0
Employed in the production branches	7,357,000	83·3
Employed in agriculture	1,058,000	12·0

1.4 PRESENT TRENDS IN RECLAMATION DEVELOPMENT

According to the 6th five-year plan of the national economy development a realization of main reclamation measures is assumed to the extent presented in table VII. These data do not include some kinds of reclamation measures and smaller actions of already mentioned measures. The total sum of financial allocations, invested into reclamation in this period, would be 15·6 milliard Kčs.

It is assumed that through the horizontal expansion of reclamation mentioned above, proceeding from present knowledge on increasing yield of agricultural production on reclaimed areas, this increase would work out as 2,200 Kčs/ha of increased production on reclaimed area, representing on a nation-wide scale the total contribution of 7,021 millon Kčs (Table VIII). In this manner the increased plant production on reclaimed areas will contribute 12 per cent to the total plant production in Czechoslovakia.

1.5 ESTIMATION FOR THE POTENTIAL HORIZONTAL AND VERTICAL EXPANSION OF RECLAMATION

According to the worked out forecasts of the Czechoslovak agriculture development it is assumed that up to the year 2000 the substantial part of

TABLE VII

Present trend of reclamation measures development in Czechoslovakia

Reclamation measures	Plan for the year 1976-1980	
	Area in ha	Investment in million Kčs
Drainage	255,000	2,960
Irrigation	64,000	1,210
Other reclamation measures/recultivation, liming, replotting	1,080,000	6,800
Training of water courses	1,600 km	930

TABLE VIII

Increase of production intensification on areas to be reclaimed upto the year 1980

Reclamation measure	Production	
	Kčs/ha	Total in million Kčs
Drainage	3,360	3,394
Irrigation	2,340	721
Other reclamation measures	1,320	2,897
Total	2,200	7,012

agricultural land, requiring reclamation measures, should be in the optimum conditions of fertility.

More accurate estimates up to the year 1990 (Table IX) assume an acceleration of the trend in all reclamation measures. In this way the drainage of 86·5 per cent of land will be accomplished by this year and 38·4 per cent of irrigation systems will be constructed, considering the nation-wide requirements.

TABLE IX

Estimation of the potential horizontal reclamation expansion till 1990

Reclamation measure	Extent	
	Total	Annual trend
Drainage	1,450,000 ha	44,000 ha
Irrigation	525,000 ha	22,000 ha
Other reclamation measures	3,300,000 ha	200,000 ha
Training of water courses, km	15,600 km	500 km

Other reclamation measures of non-investment character, where the service life is from 5-15 years, the completion of reclamation processes on all lands requiring those measures is assumed so that after this dead line only permanent rehabilitation will take place.

Within the long-term plans of the Czechoslovak agricultural development —in accordance with the goal to ensure the self-sufficiency in foodstuff production—an increase of fertilizer consumption is anticipated, as well as introduction of more productive varieties and successive automation of operation and production processes. The described intensification measures are planned also for the reclaimed soils and thus the reclamation effect would be substantially multiplied, and it would be possible to increase up to that date the production increment on these areas up to 2,880 Kčs/ha. On the nation-wide scale the production increment would amount to 14,174 million Kčs per year (Table X).

TABLE X

Estimation of the potential and vertical expansion of reclamation measures (annual production) up to 1990

Reclamation measure	Production		Annual trend
	Kčs/ha	Total in million Kčs	
Drainage	4,500	6,840	315
Irrigation	3,115	1,526	70
Other reclamation measures	1,760	5,808	305
Total	2,880	14,174	690

1.5.1 Potential demand for irrigation water up to 1990

Increasing water demand as a concomitant phenomenon of the social and economic development was observed and evidenced until recently. Due to the ever-increasing tension between the balance of requirements and the water resources it was urgent to deal with more thoroughly the basic components of water demand. That was also the reason why in 1953 the State Water-management Plan was worked out, solving the complex problems of water resources development and management in Czechoslovakia. On the basis of extensive study, surveys and balances the Directive Water Management Plan was worked out in 1973, involving detailed balance of water management conditions and concretely designed prospect tasks up to 2015 A.D.

Within the scope of the complex solution of water supply for industry, agriculture, and population the project of a net of water reservoirs had been suggested—nowadays partly realized—which could cover the planned water demand. If the construction of water schemes, namely on main water courses, would proceed in accordance with the development of irrigation systems, the required water demand for irrigation of 525,000 ha in 1990 would be provided (Table XI).

TABLE XI

Present and envisaged water demand for irrigation

Year	*m^3/ha*	*Total million m^3*
1975	1,100	268
1980	1,250	380
1990	1,500	788

2. THE CONTRIBUTION ANTICIPATED AS A RESULT OF ADVANCED TECHNOLOGIES APPLIED IN CONSTRUCTION AND EXPLOITATION OF RECLAMATION STRUCTURES

In connection with general trends and assumed growth and agricultural production intensification in Czechoslovakia, it is to be mentioned that the contribution from advanced technologies is at present taken into account, and in the future a more complex contribution of reclamation measures is assumed as a stabilization and intensification factor together with other intensification factors (fertilization, new techniques, more productive varieties). Thus, considering the interaction of intensification factors, the increasing significance and efficiency of reclaimed soils, including the effect of irrigation water has to be realized in this connection.

2.1 ESTIMATION OF WATER EFFICIENCY UNDER IRRIGATION CONDITIONS

Proceeding from the conducted investigations and analyses of water consumption and its effect on the growth potential of irrigated crops, an estimation of production increment per unit of 1,000 m³ of irrigation water was realized in connection with the assumed production growth trend.

2.2 TENDENCIES OF THE WATER MANAGEMENT POLICY AND ECONOMICS

For covering the present requirement of population, industry and agriculture for water the still unutilised capacities of the completed multi-purpose reservoirs have been used. In the next period the development of water resources would be adapted to the requirements and needs of the respective branches of the national economy.

The construction of multi-purpose systems will exert an influence on large watersheds. Diversion of water from one watershed into another will take place, as well as automation and remote control and operation of water management systems.

Up to the year 2000 almost threefold increase of investments needed for water schemes construction is envisaged as compared with the present state. Realization of water schemes on the Danuba River, (Gabčíkovo-Nagymaros), Labe, Vltava, Váh and other rivers is considered.

Simultaneously with the investments in plant production the increase of actual soil fertility is assumed together with the production increase due to irrigation. The considered power consumption for 1,000 m³ of water is based on the assumption that the distance of irrigated lands from the irrigation water source would successively increase, thus necessitating higher energy for irrigation water transport (Table XII).

TABLE XII

Estimation of the irrigation water efficiency increase

up to the year	*Production per 1,000 m³ of irrigation water*	*Power consumption per 1,000 m³ kWh*	*Labour consumption per 1,000 m³ hours*
1975	1,770	330	12·8
1980	1,872	340	8·5
1990	2,077	360	6·3

The growth of labour productivity in irrigation operation is based on the assumption of the step-wise modification of techniques and technologies of water delivery on the irrigated field, from transportable surface pipes to hydro–or electromotor driven strip and wide-gauge track sprinklers.

2.3 ORGANIZATIONAL AND ADMINISTRATIVE ENSURANCE OF THE WATER MANAGEMENT POLICY REALIZATION

The water management policy and economy is governed by the state through the federal Departments—Ministries of Forestry and Water Management and Ministries of Agriculture and Nutrition. The respective divisions of Regional and District National Committees are the further administration link, namely in the sphere of concepts and inspection of water management activity realization.

Design activity carried out on the basis of orders from the state enterprises is provided by two big design centres (HYDROPROJEKT PRAGUE and HYDROCONSULT BRATISLAVA), and by several specialized regional water management and agricultural design institutes.

The River Boards, existing as independent economic units with their detached and specialized work-places, are entrusted with investigation, inspection, and management activity in the field of water resources development and water conservancy. The State Reclamation Board performs similar activity in the field of land reclamation.

The organization system of the water management and agriculture branch includes also the branch research with four specialized research institutes (Water Research Institute, Prague ; Water Research Institute, Bratislava ; Research Institute for Reclamation, Prague; Research Institute for Irrigaton Farming, Bratislava).

2.4 PRESENT STATE AND THE ANTICIPATED RESEARCH REQUIREMENTS

Research in the field of water management (water resources development) and land reclamation has been dealing with topical tasks and issues corresponding to the planned requirements from practice and with respect to the assumed water-management and reclamation development, construction, and exploitation. Besides the departmental or branch research institutes also the research institutes of the Czechoslovak Academy of Science, Slovak Academy of Science, and Universities participate in solving tasks required for practice.

Research results are summarized in Final Reports on achieved research tasks which are provided to the interested organizations and enterprises and are further published as papers in scientific and professional journals. Another form of scientific information dissemination is the organizing of conferences, seminars, and symposia in which qualified experts from Czechoslovakia and from abroad participate. With regard to the circumstance that the plan of respective research institutions is worked out according to topical requirements of directing, management, design, and production organizations of the water management and reclamation branch, the requirements of practice are safeguarded to the maximum extent from the points of view of present and prospective needs.

Research, design, and development organizations execute also consulting activity in the field of water resources development and land reclamation.

Czechoslovakia has an established system of international co-operation in the sphere of research and application of new knowledge, namely with member countries of the Council for Mutual Economic Aid, with the Committee for Water Resources Development within the scope of the European Economic Commission UNO, and with other specialized organizations of UNO (FAO, WHO, WMO, IARA), and with further international organizations dealing with the problems of water resources development and land reclamation.

3. EXPECTED CONSTRAINTS AND PROBLEMS IN CONNECTION WITH RECLAMATION DEVELOPMENT AND CONSTRUCTION

3.1 PHYSICAL (MATERIAL CONSTRAINTS)

Limitations in this sphere have to be considered when time co-ordination would not be observed among the irrigation construction and drainage, and water availability from water reservoirs, between the construction of the reclamation details, and drainage canals, and construction of facilities for pumping internal water into water courses.

3.2 ECONOMIC AND ORGANIZATIONAL CONSTRAINTS

Limitations of this kind may result from inter-departmental balances of construction materials and machines in connection with the requirements for reclamation construction. The unsteady and locally uncontrolled manpower ebb may have an econcmic effect on the regular introduction of reclamation facilities into operation and exploitation. Though, it is assumed, that the number of active population in agriculture would keep the present decreasing trend due to ever-increasing mechanization and automation of production processes.

CONCLUSIONS

The present brief review on the development achieved so far, and on reclamation development outlook in Czechoslovakia has shown the significance of the reclamation contribution to the increase of agricultural production in the country and thus for providing food for the population. We can assume that experience and success gained in this sphere represent a sound basis for the fulfilment of challenging tasks of the present five-year plan, as well as of the pretentious tasks in the future. We would like to use this opportunity to develop, within the frame work of our international organization, the maximum effort aimed at the international experience exchange.

TEHRAN SPECIAL SESSION 1977

IRANIAN NATIONAL COMMITTEE OF ICID

COMITE NATIONAL IRANIEN DE L'ICID

SESSION SPECIALE DE TEHERAN 1977

R. 11

LIKELY IRRIGATED AGRICULTURE OF 2000 A.D.

CONTRIBUTION PROBABLE A PARTIR DE L'IRRIGATION, DU DRAINAGE ET DE LA MAITRISE DES CRUES, POUR FAIRE FACE AUX BESOINS DE LA PRODUCTION AGRICOLE VERS L'AN 2000. ROLE ET ACTIVITE DE LA CIID ET DE SES COMITES NATIONAUX

RAPPORT DU COMITE NATIONAL FRANCAIS

Il est toujours agréable, presque excitant, de raisonner sur le futur. C'est un exercice sans danger, puisque la sanction des faits est hors de portée. C'est aussi, soyons sans illusions, un exercice peu efficace s'il n'a pas pour raison d'être d'infléchir le présent. Qui en effet, dans 25 ans, prendra la peine de lire les rapports présentés à cette session spéciale de 1977, et qui, les ayant lus, si clairvoyants soient ces rapports, s'estimera autorisé à en tirer un enseignement ? C'est le phénomène d'obsolescence qui frappe toute étude. Et cela n'empêchera pas nos collègues de l'an 2000 de réfléchir au devenir des irrigations, du drainage et de la maîtrise des crues en l'an 2025.

Nous devons donc aborder le sujet dans un esprit de modestie. Abordons le aussi avec mesure, en ne perdant pas de vue que le laps de temps qui nous sépare du XXIème siècle est finalement bien court, et n'apportera sans doute pas en la matière de révolutions majeures. Ne confondons pas, dans une perspective trop aplatie, l'an 2000 en réalité tout proche et l'an 2050 chargé d'inconnues inaccessibles.

Sachons qu'en 2000, quels que soient les progrès de la chimie de synthèse, ce sera encore l'agriculture et la pêche qui nourriront le monde; les icebergs ne seront pas remorqués vers les côtes arides, la pluie provoquée n'aura pas fait de miracles, le dessalement de l'eau de mer continuera à n'apporter que des solutions très locales.

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* Probable contribution from irrigation, drainage and flood control to meet the requirements of agricultural production towards the year 2000. Role and activities of ICID and its National Committees.

Des études et des réflexions nombreuses et intéressantes ont été faites sur l'évolution de l'agriculture pendant les prochaines décennies. Leurs résultats ne concordent pas toujours. En présence d'hypothèses et de tendances multiples qui continueront à foisonner, nous devons rechercher aujourd'hui celles qui paraissent les plus intéressantes, les plus plausibles, les mieux susceptibles d'orienter l'activité de la Commission internationale et des Comités nationaux. Mais nous devons aussi savoir que ces hypothèses et ces tendances demanderont à être révisées au cours des années.

I. PEUT-ON EVALUER QUANTITATIVEMENT LE DEVELOPPEMENT DE L'IRRIGATION ET DU DRAINAGE PENDANT LES 25 PROCHAINES ANNEES ?

Il a été souligné lors du 25ème anniversaire de la CIID que, pendant ces 25 ans d'activité, la superficie irriguée dans le monde avait doublé. En sera-t-il de même pendant les 25 années suivantes ?

1. LES TENDANCES ET LES OBJECTIFS POUR LE MOYEN TERME

Même pour les pays qui font les plus grands efforts pour planifier à long terme leurs investissements, une bonne prévision n'est pas possible. Le questionnaire qu'a bien voulu préparer le docteur Horning, auxquels les pays-membres vont répondre après la session spéciale, apportera cependant quelque lumière, et montrera que, quantitativement, ce sont les pays en voie de développement qui verront se développer l'essentiel des irrigations nouvelles.

La conférence mondiale de l'alimentation qui s'est tenue à Rome en novembre 1974 a estimé que "le montant annuel global des investissements agricoles dans les pays en voie de développment devrait passer du niveau actuel (1974) de 8–10 milliards de dollars à 16–18 milliards de dollars au cours des 5 années 1975–1980". C'était là, soulignons le bien, des objectifs pour faire face aux besoins alimentaires minimum, et non des prévisions.

Au regard de ces objectifs, qui représentent en admettant une croissance régulière, 60 milliards de dollars en 5 ans pour les investissements agricoles de toute nature, la Conférence mondiale de l'alimentation a cherché à évaluer les aménagements prioritaires des terres et des eaux à réaliser dans les pays en voie de développement sur une période de 10 ans, de 1975 à 1985.

Si l'on considère que, dans la colonne relative à la mise en valeur de nouvelles terres, le drainage et l'assainissement occupent une place importante, on voit que la Conférence mondiale de l'alimentation estime indispensable de consacrer sur 10 ans environ 70 milliards de dollars à l'aménagement agricole des eaux, c'est-à-dire plus que l'ensemble des investissements agricoles, hydraulique comprise, prévue sur 5 ans.

Il apparaît bien que, dans l'esprit des participants à la conférence mondiale, l'hydraulique agricole est de loin, pour les prochaines années, la première catégorie d'investissements susceptible de faire face aux besoins alimentaires de la population du monde.

On notera que la croissance des superficies irriguées préconisée par cette conférence pour les années 1975–1985 est pour certaines régions à peu près le double de celle qu'avait proposée, pour ces mêmes régions et pour cette

Régions	*Rénovation et amélioration des zones irriguées existantes*		*Nouvelles irrigations*		*Mise en valeur de nouvelles terres arables*		*Total des investissements pour la période 1975–1985 (objectif)*
	millions d'ha	*Coût en millions de dollars*	*millions d'ha*	*Coût en millions de dollars*	*millions d'ha*	*Coût en millions de dollars*	*millions de dollars*
Extrême-Orient	28	11 700	15	22 000	24	9 500	43 200
Afrique du Nord et Proche-Orient	12	6 700	3	7 400	10	2 500	16 600
Afrique continentale	1	500	1	2 400	34	1 500	4 400
Amérique latine	5	2 100	4	6 200	85	12 800	21 100
	46	21 000	23	38 000	153	26 300	85 300

même période 1975–1985, le Plan indicatif mondial de la FAO qui a été achevé en 1969.

2. LA PROJECTION A LONG TERME

Une conscience de plus en plus vive est ainsi prise de l'importance de l'aménagement agricole des eaux dans l'évolution des pays en voie de développement.

Peut-on projeter cette tendance sur les 25 années à venir ?

Il faut pour cela répondre à deux questions :

—la maîtrise des eaux est-elle et restera-t-elle le facteur limitant pour le développement de l'agriculture ?

—les disponibilités en eau permettront-elles de maintenir ou d'accélérer le rythme de développement des irrigations ?

Sur le premier point—l'eau facteur limitant dans l'agriculture au champ—la réponse semble être affirmative pour de nombreux pays industrialisés. Cela est beaucoup moins net pour les pays en voie de développement, où d'immenses progrès restent aussi à faire en matière de machinisme agricole et de mécanisation, d'emploi des engrais, d'adaptation et de sélection des variétés, de méthodes culturales, de conservation, de conditionnement et de distribution des produits, de formation des agriculteurs.

Sur le second point—disponibilités en eau—tout est cas d'espèce et certaines régions du monde verront nécessairement leur développement limité par leur pauvreté en eau. Cependant trois considérations doivent, globalement, nous guider dans ces réflexions sur l'avenir. D'une part les énormes économies de la matière—eau qui peuvent être faites, sur les réalisations existantes ou futures, par une amélioration des conceptions, des techniques et de la pratique des irrigations et par une utilisation prudente des eaux de drainage. D'autre part la certitude que l'industrialisation progressive des pays en voie de développement, si elle est bien conduite, ne doit pas à terme, pour satisfaire ses besoins en eau, entrer en concurrence avec les besoins de l'agriculture. L'eau industrielle, véhicule de déchets ou de calories, ou l'eau utilisée par la navigation qui n'intervient que par son niveau, n'est pas une matière première consommable. L'inscrire d'emblée au passif du bilan général des eaux serait prendre son parti d'un gaspillage évitable. Enfin d'immenses ressources en eau douce sont encore inutilisées dans le monde, qu'il s'agisse d'eaux souterraines ou de l'apport de grands bassins fluviaux, qui laissent l'avenir largement ouvert.

Nous pouvons donc avoir l'assurance que les aménagements hydro-agricoles, irrigation, drainage et maîtrise des crues, sont à long terme un facteur primordial, peut-être le facteur essentiel, de l'amélioration de l'alimentation des hommes, quelle que soit l'évolution, explosive ou mesurée, de la population mondiale. Et si les pays en voie de développement représentent en surface l'essentiel des progrès à faire, l'amélioration et l'extension des aménagements hydro-agricoles dans les pays aujourd'hui industrialisés seront loin d'être terminés à la fin du siècle.

Mais il est certain que les données économiques des aménagements hydro-agricoles se modifieront profondément. Les grands équilibres économiques mondiaux seront peut-être bouleversés dans 25 ans; la crise actuelle de l'énergie évoluera dans une direction encore mal ressentie; l'industrialisation progressive apportera des ressources nouvelles et des besoins nouveaux; les prix des denrées alimentaires sont appelés à monter fortement; enfin la valeur et les conditions du travail humain seront de plus en plus des éléments déterminants.

II. UN SUJET DE REFLEXION ET D'ACTION : LE SAHEL AFRICAIN

Le monde entier a connu et ressenti comme une catastrophe planétaire la sécheresse meurtrière qui a dévasté les pays sahéliens de l'Afrique au sud du Sahara au cours des années 1972 à 1974. Ces pays sahéliens, parmi les moins favorisés du monde, dont l'économie agricole et pastorale a toujours reposé sur un fragile équilibre entre les hommes, les troupeaux, la terre et l'eau, ont vu cet équilibre brutalement rompu par un cycle d'années de sécheresse certes très exceptionnel mais qui peut se reproduire. La solidarité mondiale, l'aide des grands organismes internationaux et de plusieurs pays amis, et heureusement le retour d'une pluviosité normale, ont aidé ces pays sahéliens dans leur effort pour survivre et s'acheminer vers un nouvel équilibre.

Outre les aides immédiates des programmes d'investissement à court et moyen terme ont été dressés, des financements rassemblés, des réalisations commencées. Mais ce qui intéresse le plus notre session spéciale est sans doute la création au début de 1976 d'un "Club des amis du Sahel" qui, prenant le recul nécessaire, s'est donné pour tâche de réfléchir profondément aux problèmes de ces pays et de faire ressortir quelles peuvent être, à très long terme, selon une approche nouvelle, les orientations qui doivent être encouragées. Cet organisme informel de réflexion et de conseil regroupe, avec les hauts responsables des Etats directement concernés, un certain nombre de hautes personnalités représentant de grandes organisations internationales : ONU, FAO, OCDE, BIRD, Communauté européenne, ou représentant des pays décidés à poursuivre avec les Etats du Sahel une collaboration de longue haleine.

On doit souhaiter qu'à l'occasion de cette session spéciale d'autres rapports de pays plus directement intéressés aient fait état de ce Club des amis du Sahel, dont les premières réflexions nous apportent des sujets de méditation de grande importance, souvent transposables à d'autres régions du monde.

Les réflexions du "Club" vont se poursuivre sur la base d'un certain nombre d'idées par ses membres lors de ses premières réunions. On citera ci-dessous quelques extraits du compte rendu de la première réunion du Club, afin de situer la nature de ses préoccupations.

—"Les méthodes de programmation devront être modifiées. Certains projets, pris à titre individuel, ne paraissent pas rentables, mais l'équation coûts—bénéfices peut changer considérablement si les méthodes de programmation sont plus globales".

—"Le potentiel d'irrigation est pratiquement intact; les sols cultivables sont suffisants...; les technologies sont disponibles. La tâche de l'avenir est de gérer judicieusement les ressources existantes en donnant à l'agriculture une priorité absolue..."

—"La FAO a chiffré l'ordre de grandeur d'un programme indicatif d'investissements d'environ 7 milliards et demi de dollars pour les 15 prochaines années, devant être réparti à raison d'un tiers pour les investissements nouveaux et de deux tiers pour les dépenses récurrentes."

—"Il convient d'étudier de près l'adaptation des technologues et les modifications du comportement social qui devront accompagner la transformation de l'agriculture traditionnelle."

—"Le Sahel dispose de ressources en eau suffisantes pour assurer son développement et sa protection contre les cycles de sécheresse. Le schéma de mise en oeuvre de ces ressources...constitue une charte pour le développement du Sahel."

—"Il n'existe pas de dualité entre la petite et la grande hydraulique, mais une complémentarité."

—"Les grands aménagements hydrauliques.. seront effectués dans le cadre d'un contrat de génération."

—"Le Club marque une étape - La formule peut fonctionner en vue d'une concertation permanente sur les éléments d'une stratégie de développement."

Pourquoi avons-nous parlé un peu longuement dans ce rapport de cette formation particulière qu'est le Club des amis du Sahel ? Parce que, devant ce problème du Sahel, essentiellement basé sur l'aménagement des eaux, et qui est l'un des grands problèmes mondiaux des vingt-cinq prochaines années il est frappant de constater qu'un seul des six Etats sahéliens de l'Afrique de l'ouest appartient à la CIID, et que notre Commission internationale ne participe pas aux réflexions auxquelles il donne lieu. Nous reprendrons cette constatation dans les conclusions de ce rapport.

III. QUELQUES TENDANCES OU PROBABILITES D'EVOLUTION POUVANT GUIDER L'ACTION DE LA CIID PENDANT LES 25 PROCHAINES ANNEES

Nous énoncerons ici, sans presque les commenter, un certain nombre de tendances qui pourraient marquer à long terme l'évolution des irrigations, du drainage et du contrôle des crues dans le monde. Certaines peuvent être d'ores et déjà constatées. D'autres sont probables; d'autres sont seulement plausibles. Dans le cadre de ce rapport, nous n'apporterons pas de justification, nous bornant à les mentionner sous forme d'affirmations prudentes pouvant servir de base à des discussions. Aucune de ces affirmations n'est d'ailleurs très nouvelle, et la plupart ont déjà fait l'objet de réflexions et de travaux.

1. QUELQUES TENDANCES D'ORDRE GENERAL

—L'évolution des aménagements hydro-agricoles sera liée étroitement à l'évolution de l'agriculture elle-même. La recherche agronomique, par les données nouvelles qu'elle apportera, orientera la conception et l'utilisation de ces aménagements; mais réciproquement le développement des irrigations et du drainage doit orienter cette recherche agronomique. La CIID est appelée à jouer un rôle important dans cette orientation de la recherche, notamment en matière de sélection variétale et d'utilisation des engrais.

—L'agriculture irriguée évoluera vers une agriculture de plus en plus intensive et maîtrisée. L'obligation d'alimenter une population plus nombreuse et de valoriser au maximum la terre et l'eau, les progrès des techniques agronomiques, rendront nécessaire et possible cette évolution.

—L'agriculture de montagne peut être appelée à un nouvel avenir. C'est ainsi qu'en Asie du sud-est ou de l'est, à côté de plaines ou de deltas surpeuplés, les zones de montagne, pour des raisons historiques ou coutumières, sont restées souvent peu peuplées et représentent un potentiel de développement encore important. Ce développement fera appel à des méthodes particulières aux pays de montagne, notamment en matière d'hydraulique.

—L'urbanisation qui accompagne le développement industriel verra peut-être son rythme relatif se ralentir à la fin du siècle, par une organisation nouvelle de la vie rurale, mais elle restera un phénomène essentiel de l'évolution du monde. Lié à ce phénomène, le développement de l'environnement maraîcher des villes est un sujet qui doit retenir toute l'attention de la CIID.

—L'utilisation de plus en plus intensive de l'eau va conduire la CIID à donner une place essentielle, dans ses préoccupations, aux problèmes de l'économie de la quantité d'eau d'irrigation utilisée au champ. Les progrès à faire dans ce domaine peuvent être scientifiques, techniques, agronomiques, juridiques.

2. EVOLUTION POSSIBLE DE CERTAINES TECHNIQUES

—Les techniques et le matériel d'irrigation continueront à évoluer. Les 25 dernières années ont vu naître et se développer l'irrigation par aspersion et la micro-irrigation. Il est peu probable que les 25 années suivantes voient de gros bouleversements dans ces domaines, bien que l'irrigation souterraine, bien décevante jusqu'à maintenant, puisse donner lieu à certains progrès. Mais il n'est pas impensable que des méthodes toutes nouvelles apparaissent, qui soient basées sur l'apport et le maintien d'humidité dans l'environnement aérien direct des plantes cultivées, permettant des économies massives d'apport d'eau dans le sol.

—Dans le domaine du gènie civil et du terrassement. les travaux et équipements d'irrigation, de drainage et de contrôle des crues bénéficieront des progrès d'ordre général qui seront faits en la matière. Ainsi, dans le domaine du terrassement, on peut penser que l'évolution se fera dans deux sens très différents, qui ne s'excluent pas :

—amélioration des techniques lourdes: perfectionnement et tendance au gigantisme du gros matériel de terrassement; peut-être début de mise au point des méthodes de terrassement de masse utilisant sans intermédiaires l'énergie nucléaire;

—recherche et mise au point de méthodes légères, qui soient bien adaptées, dans des conditions d' humanité et de dignité acceptables, à l'énorme potentiel humain inemployé que l'on trouve dans beaucoup de pays et qui constitue une de leur richesse.

—Les besoins de l'agriculture en énergie ne peuvent qu'augmenter. La CIID doit se pencher sur ce problème et réfléchir aux meilleures utilisations des sources d'énergie nouvelles, telles que l'énergie solaire, pour le pompage ou le dessalement des eaux.

3. LA CIID DOIT TIRER DES ENSEIGNEMENTS DES ECHECS QUI ONT ETE CONSTATES

—L'expérience du passé, et plus spécialement des vingt dernières années doit être profondément méditée. A côté de succès incontestables, qui ont transformé la vie agricole et économique locale, il faut constater que certains grands aménagements hydro-agricoles ont abouti à des échecs plus ou moins prononcés, provisoires ou définitifs, allant parfois jusqu'à une dégradation irréversible du patrimoine naturel. C'est un des rôles de notre Commission internationale que de réfléchir sur ces échecs. Les causes en sont le plus souvent bien connues a posteriori. Lorsqu'elles sont d'ordre physique ou technique (par exemple le défaut de drainage), elles peuvent être clairement exprimées et l'on peut espérer que, l'expérience aidant, le développement futur des aménagements hydro-agricoles sera à l'abri de telles erreurs. Mais force est de constater que dans bien des cas les causes profondes d'échecs sont d'ordre humain. Le facteur humain restera toujours le plus difficile à analyser et à maîtriser. Ainsi, lorsqu'un nouvel aménagement hydro-agricole réunit les conditions physiques et agronomiques permettant de passer d'une récolte annuelle à deux récoltes, l'adaptation des agriculteurs à ce supplément de travail peut être très difficile et très longue, et relever de facteurs sociaux et politiques qui échappent à l'ingénieur. Dans ce domaine pourtant essentiel, notre Commission devra se résigner à n'avoir qu'un rôle modeste.

4. L'AMENAGEMENT HYDRAULIQUE DES GRANDS BASSINS FLUVIAUX

L'amélioration de la connaissance des données de toute nature et les possibilités accrues de traiter ces données devraient permettre d'établir pour les grands bassins fluviaux du monde des schémas directeurs d'aménagement plus fiables que ce qui peut être fait actuellement. Mais les initiatives qui ont les meilleures chances de réussir resteront les initiatives locales. Les schémas généraux ne devront pas être suspensifs ni rigides; une initiative locale, sauf si elle compromet d'une façon évidente d'autres aménagements locaux, doit trouver sa place dans le cadre que constitue le schéma général, quitte à modifier périodiquement ce schéma. Un schéma général d'aménagement doit être un moteur plus qu'un frein.

Pour les très grands bassins fluviaux, tels que l'Amazone, le Niger, le Congo, qui sont encore à peu près vierges d'aménagement, et même pour les grands bassins qui ont déjà fait l'objet d'études et de certaines réalisations, les réflexions sur leurs possibilités d'aménagement présentent un intérêt à l'échelle du monde. La Commission Internationale des Irrigations et du Drainage doit s'y intéresser. Les pays ou organismes directement concernés par ces aménagements ont tout à gagner à connaître sur ces problèmes les avis et suggestions des spécialistes de tous horizons que regroupe la CIID. C'est pourquoi, bien que cela ne soit pas actuellement dans les habitudes, il n'y aurait que des avantages à retenir pour les séances techniques de nos congrès à venir des sujets portant sur l'aménagement de grands bassins fluviaux déterminés. Sur ces sujets, tous les pays, même ceux qui sont extérieurs à la région, pourraient présenter des rapports. Si la Loire ou le Rhône étaient des grands fleuves mondiaux, ce qui malheureusement n'est pas, la France ne verrait que des avantages à ce que leur aménagement fasse l'objet de réflexion ou d'appréciation de la part de n'importe quel membre de notre Commission internationale.

IV. LES PROBLEMES DE FORMATION ET DE TRANSFERT DE TECHNOLOGIE

La formation des agriculteurs et leur adaptation aux données nouvelles est une condition absolue du succès d'une opération d'aménagement, et notre Commission doit souligner chaque fois qu'elle en a l'occasion que tout projet d'aménagement hydro-agricole doit comporter un volet consacré à cette formation. Mais il s'agit d'un problème trop vaste et trop lié aux conditions locales et aux problèmes généraux d'éducation pour que la CIID puisse prétendre avoir dans ce comaine un rôle actif. Tout au plus peut-elle apporter aux gouvernements, ou aux grandes organisations internationales et notamment à la FAO, des conseils ou des suggestions.

Par contre la CIID ne doit pas se dérober à un examen sérieux du problème de transfert de la technologie et de l'expérience des pays les plus développés vers les pays les moins développés.

1. LES SUGGESTIONS DU COMITE NATIONAL DU BANGLADESH A BANFF

Le problème a été posé clairement par la délégation du Bangla Desh devant le Conseil exécutif de notre Commission qui s'est tenu l'an dernier à Banff. Nous reproduisons ci-dessous la communication du Comité national du Bangla Desh qui a constitué le point 26 de l'ordre du jour du Conseil de 1976.

> "L'on estime qu'il existe de vastes étendues pour une amélioration générale dans les techniques d'irrigation, du drainage, et de maîtrise des crues, notamment dans les pays en voie de développement. Les pays développés disposent de la connaissance technique ainsi que la capacité pour les facilités de recherche pour améliorer le savoir faire de sorte que la population mène une meilleure vie. Mais le cas des pays en voie de développement est différent. Dans plusieurs pays en voie de développement, la pratique actuelle d'irrigation, du drainage et de maîtrise des crues est encore primitive. Plusieurs pays ne disposent d'aucune facilité de recherche. Etant sous-développés, il n'est pas possible pour plusieurs pays d'envoyer assez de délégués aux pays lointains du monde, pour voir les progrès des pays avancés dans le domaine de l'irrigation,

du drainage qui constitue un besoin vital pour leur économie nationale."

"Il est suggéré que la CIID qui vient de célébrer son 25ème anniversaire prenne une démarche positive pour aider à développer le savoir faire technique d'une façon positive. Les suggestions suivantes sont soumises à l'examen du Conseil :

(*i*) Il faut organiser chaque année dans un pays développé quelconque un bref stage de 3 à 6 mois, avec une formation pratique pour les ingénieurs, les scientifiques et les agriculteurs dans le domaine de l'irrigation, du drainage et de maîtrise des crues.

(*ii*) Il faut organiser des bourses pour une ou deux années pour les facilités de recherche dans le domaine de l'irrigation, du drainage et de maîtrise des crues dans certains pays développés.

(*iii*) L'organisation ou le gouvernement hôte doit supporter les frais de déplacement et les indemnités pour les participants au cours de formation. Alternativement, la CIID pourrait saisir diverses agences de l'ONU telles que FAO, UNESCO, etc...pour le financement du projet.

"L'on pense que l'action visée ci-dessus améliorera largement l'image de la CIID et contribuera réellement au développement de l'irrigation, du drainage et de la maîtrise des crues dans les pays en voie de développement."

Le Conseil exécutif de Banff a décidé que la question posée par le Comité national du Bangla Desh serait examinée à l'occasion de la session spéciale de Téhéran.

2. EXAMEN DES SUGGESTIONS DU BANGLA DESH PAR LE COMITE NATIONAL FRANCAIS

La Commission internationale des irrigations et du drainage n'est pas un organisme gouvernemental. Les déclarations et suggestions des Comités nationaux ne peuvent donc en elles-mêmes engager leurs gouvernements, notamment en matière de financement. C'est pourquoi, après en avoir discuté, il appartiendra au président de notre Commission de saisir s'il le juge utile les gouvernements intéressés en leur demandant d'approuver les propositions faites à Téhéran par les Comités nationaux, dans la mesure où elles auront été adoptées par l'assemblée, et de susciter leur mise en application.

C'est dans ces limites que le Comité national français, reprenant les propositions du Comité national du Bangla Desh, qu'il approuve dans son ensemble, fait les suggestions suivantes.

(*i*) Stages de formation pratique

La France dispose des éléments permettant d'organiser régulièrement sous le signe de la CIID, une fois tous les 6 ans, un stage pratique de formation d'une durée de 4 mois destiné à des ingénieurs et à des scientifiques des pays en développement sur des thèmes relatifs à l'irrigation, au drainage ou à la maîtrise des crues. Ces stages, dont les sujets précis seraient annoncés deux années à l'avance, par la Commission internationale aux pays membres, se dérouleraient pour l'essentiel sur le territoire national, mais pourraient comporter, avec l'accord des pays intéressés, des visites, dans d'autres régions du monde, de réalisations auxquelles auraient été associées les techniques françaises. Les stages se dérouleraient en langue française et en langue anglaise, langues officielles de la CIID, et pourraient être ouverts à trente stagiaires choisis par le bureau central de la Commission. Pour la France, le premier de ces stages pourrait être organisé en 1980; le suivant aurait lieu en 1986. D'autres pays développés devraient être sollicités par la CIID pour organiser de tels stages, de façon qu'ils puissent avoir lieu chaque année.

Dans la résolution présentée à Banff, le Bangla Desh s'adresse aux pays "développés". En ce domaine, il ne s'agit pas seulement des pays hautement industrialisés; des pays ayant une grande expérience en matière d'aménagements hydrauliques, et qui disposent et disposeront de plus en plus dans les années à venir de spécialistes de valeur, pourront être aussi sollicités pour organiser ces stages. On peut penser à des pays tels que l'Inde, la République arabe d'Egypte, éventuellement plus tard la Chine, et plusieurs autres.

Les gouvernements sollicités, selon leurs moyens et également en fonction des activités de même nature qu'ils poursuivent en coopération technique bilatérale, pourront dans des proportions différentes supporter tout ou partie des charges afférentes à ces stages. Un concours financier, qui selon les cas irait de 0 à 100 pour cent du montant de ces charges, serait demandé par la CIID aux grandes organisations internationales, notamment la FAO, qui de ce fait seraient associées à l'organisation des stages.

Pour sa part, le Comité national français n'est pas encore en mesure d'indiquer dans quelle proportion pourrait intervenir son gouvernement, mais il fera son possible pour que lorsque la question sera posée par la CIID, la réponse française fasse état d'une participation financière notable.

(ii) **Bourses de longue durée**

Le Comité national du Bangla Desh suggère que dans certains pays développés soit organisée l'attribution de bourses d'une ou deux années pour permettre à des spécialistes des pays en voie de développement d'approfondir leurs connaissances et d'être associés aux travaux de recherche dans le domaine de l'irrigation, du drainage et de la maîtrise des crues. Il s'agirait de bourses accordées par la CIID, dont le bureau central ferait bénéficier des candidats de pays membres, qu'il choisirait en fonction de directives générales que lui donnerait le Conseil exécutif. Mais, s'agissant d'études et de recherches plus spécialisées et plus approfondies que celles faisant l'objet des stages, ce sont les pays-hôtes eux-mêmes qui en définiraient les sujets. Les candidats devront avoir une connaissance suffisante de la langue du pays-hôte.

Contrairement aux stages, qui se tiendraient régulièrement chaque année dans un pays différent, ces bourses ne feraient pas l'objet d'un programme d'ensemble défini à long terme. Leur attribution par le bureau central serait fonction de la valeur des candidats, des propositions des pays-hôtes et des facilités de financement dont seraient assorties ces propositions. Le Comité National Français n'est pas encore en mesure de faire des propositions concrètes au nom de son pays.

(*iii*) **Autres mesures**

Il n'est pas sans intérêt de signaler à titre d'exemple de portée nouvelle, une initiative de coopération en cours d'étude entre la France et le Maroc : non seulement la formation complémentaire, quand cela est nécessaire, d'ingénieurs marocains serait poursuivie mais en sens inverse de jeunes spécialistes français pourraient normalement acquérir une formation complémentaire au sein même des structures d'enseignement et de recherche marocaine les rendant, en outre, ainsi plus sensibles aux réalités concrètes de pays différents du leur.

Plus généralement la CIID ne pourrait-elle pas s'intéresser à tous les problèmes de l'enseignement des disciplines qui la concerne voire à ceux de l'animation liée à leur mise en oeuvre. Nous pensons non seulement à la formation des ingénieurs, des spécialistes, des techniciens ou des chercheurs mais aussi à celle au niveau de la pratique des agriculteurs eux-mêmes. Un échange d'information sur les expériences concrètes de chaque pays dans ce domaine serait certainement utile, en liaison avec l'UNESCO et l'OAA.

V. CONCLUSIONS—LE ROLE ET L'ACTIVITE DE LA COMMISSION INTERNATIONALE DES IRRIGATIONS ET DU DRAINAGE ET DE SES COMITES NATIONAUX DANS LE DERNIER QUART DE SIECLE

En décidant de tenir cette session spéciale de Téhéran, la Commission internationale des irrigations et du drainage a cherché à s'interroger sur son avenir. Devant le développement prévisible des irrigations, de drainage et des aménagements pour le contrôle des crues, cet avenir est largement ouvert.

Riche de l'adhésion de 67 pays, notre Commission internationale peut être satisfaite de l'action qu'elle poursuit depuis 27 ans. Elle doit continuer à mener cette action, en la complétant ou en l'infléchissant sur un certain nombre de points.

(1) La CIID doit s'efforcer d'obtenir l'adhésion de pays nouveaux, notamment en Amérique du Sud et surtout en Afrique au sud du Sahara.

(2) Il est souhaitable que la CIID suive de près certains grands problèmes mondiaux. Nous avons cité en exemple le "Club des amis du Sahel" d'où elle est actuellement absente. Le Comité national français est en mesure de proposer au bureau central le nom d'un de ses membres qui pourrait si elle le désire représenter la Commission internationale au sein du Club.

(3) Le questionnaire préparé par le Docteur Horning va être envoyé à tous les Comité nationaux des pays membres de la CIID. Il serait

intéressant que le bureau central l'envoie également aux gouvernements des pays non membres, de façon à avoir une vue aussi complète que possible des perspectives de développement des aménagements hydro-agricoles dans le monde.

(4) La CIID dispose d'un certain nombre de Comités ou groupes de travail permanents ou temporaires qui recouvrent une grande part des questions auxquelles devra s'intéresser la Commission dans les années qui viennent. Parmi eux, le "Comité permanent chargé d'attirer l'attention sur les nouveaux développements" et le "Comité permanent des rapports" vont devoir, à la lumière des conclusions de la session spéciale, proposer la mise à l'étude d'un certain nombre de thèmes nouveaux ou renouvelés, orientés vers les évolutions d'avenir, tels que ceux que nous citons plus haut au paragraphe III. De nouveaux groupes de travail devront sans doute être créés à cet effet, mais il importe qu'ils restent peu nombreux.

(5) Les sujets qui seront choisis pour les prochains congrès auront à tenir compte de ces orientations prévisibles. Mais outre les sujets d'ordre général, il est souhaitable que, contrairement aux habitudes acquises, certains sujets spécifiques, portant sur l'aménagement des bassins des grands fleuves mondiaux, puissent être également retenus et proposés à la réflexion de tous les pays membres, même si ces derniers n'en sont pas riverains.

(6) En matière de transfert de technologie, les suggestions présentées devant le Conseil Exécutif de Banff par les délégués du Comité national du Bangla Desh méritent d'être retenues. Des stages bilingues anglais et français, placés sous le signe de la CIID, pouraient être organisés à raison de un chaque année, dans les pays ayant acquis de l'expérience en matière d'irrigation, de drainage et de maîtrise des crues. Le Comité national français estime que la France peut organiser de tels stages tous les 6 ans à partir de 1980; il s'efforcera d'obtenir de son gouvernement une participation financière. Comme le suggère le Comité national du Bangla Desh, une aide devrait être également recherchée du côté des grandes organisations internationales.

(7) Un échange d'information sur les expériences de chaque pays en matière d'enseignement de l'irrigation, du drainage, de la maîtrise des crues et des disciplines connexes pourrait être entrepris par la CIID en liaison avec l'UNESCO et l'OAA concernant tous les niveaux de formation.

(8) La présente session spéciale et le questionnaire qui la suivra auront été l'occasion pour les comités nationaux de réfléchir à l'avenir des irrigations, du drainage et du contrôle des crues à la fois dans leur propre pays et dans le monde L'intérêt qu'aura suscité chez eux cette réflexion doit se maintenir.

Les comités nationaux de la CIID sont de statuts divers, plus ou moins proches de leurs gouvernements, et disposent de plus ou moins de ressources. Il ne paraît pas utile de modifier cet état de choses, mais il en résulte nécessairement un certain flou dans le rôle que peuvent jouer individuellement ces comités nationaux. Ce rôle doit être avant tout d'animation et de réflexion dans leur propre pays et d'information régulière à l'égard du bureau central.

Les colloques et manifestations régionales, axés sur des sujets propres à la région, complètent de façon utile les congrès mondiaux et doivent être encouragés.

(9) Notre Commission internationale a maintenant plus de 25 ans d'expérience et ses avis sont écoutés. Bien que n'étant pas une organisation gouvernementale, elle peut dans certains cas être amenée à faire, ce qui n'est pas actuellement dans ses habitudes, des recommandations aux gouvernements eux-mêmes, les comités nationaux s'employant à soutenir ces recommandations auprès de leur propre gouvernement. Un exemple a été donné plus haut à propos de l'organisation de stages.

Nous pouvons penser en conclusion que, devant les problèmes du monde, notre Commission internationale, qui a déjà fait ses preuves depuis un quart de siècle, est appelée à voir son rôle et son audience s'accroître dans les vingt cinq prochaines années. Il apparaît de plus en plus certain que les problèmes de la production agricole et de la vie rurale seront parmi les problèmes dominants des prochaines décennies, et que l'aménagement des eaux est bien souvent la clef de ces problèmes. Il appartient à notre Commission d'essayer de prévoir le futur, de s'y adapter, et même dans une certaine mesure, pour reprendre une formule qu'a faite sienne le Club de Rome, d'inventer ce futur.

Il apparaît de plus en plus que, même dans les pays industrialisés, la dynamique des besoins en eau va dans le sens d'une gestion qui, les besoins industriels pouvant être réduits et les besoins de la consommation humaine restant faibles, sera presque entièrement orientée vers les besoins de l'agriculture. La Commission Internationale des Irrigations et du Drainage est ainsi appelée à devenir le principal organisme international ayant à connaître des problèmes de l'eau du monde.

TEHRAN SPECIAL SESSION 1977

IRANIAN NATIONAL COMMITTEE OF ICID

COMITE NATIONAL IRANIEN DE L'ICID

SESSION SPECIALE DE TEHERAN 1977

R. 12

LIKELY IRRIGATED AGRICULTURE OF 2000 A.D.

PROBABLE CONTRIBUTION FROM IRRIGATION, DRAINAGE AND FLOOD CONTROL TO MEET THE REQUIREMENTS OF AGRICULTURAL PRODUCTION TOWARDS THE YEAR 2000 A.D.—COUNTRY REPORT*

INDIAN NATIONAL COMMITTEE, ICID**

SUMMARY

The net cultivated area in India at about 140 million hectares has tended to become stationary indicating that the upper limit to new land being brought under plough is being approached. The population which was 361 million in 1951 had reached upto 547 million in 1971 and is expected to be around 935 million by the turn of the century. The increasing demands of food and fibre have, therefore, to come essentially from increased yields per hectare under plough. This is possible only if irrigation, which is a basic input for increased agricultural production, is made available to more and more areas.

The ultimate irrigation potential of the country has been estimated as about 110 million hectares comprising 70 million hectares from surface water schemes and 40 million hectares from ground-water schemes. By the end of March, 1974, i.e., by the end of the Fourth Five-Year Plan, the potential developed was estimated to be of the order of 44 million hectares which is expected to go upto 86 million hectares by the turn of the century comprising 53 million hectares from surface water schemes and 33 million hectares from ground-water schemes. The anticipated increase between

* Contribution probable à partir de l'irrigation, du drainage et de la maîtrise des crues, pour faire face aux besoins de la production agricole vers l'an 2000.

** This report has been prepared, on behalf of the Indian National Committee, by Mr. C.V. Gole, Member, Central Water Commission and Ex-Officio Joint Secretary to Government of India.

1974 to 2000 would thus be 42 million hectares. The Fifth Five-Year Plan which ends in March, 1979 envisages creation of an additional potential of 12·2 million hectares—an annual increase of over 2·4 million hectares. In the subsequent Plans, even if this tempo is maintained, it will easily be possible to touch the target of 86 million hectares by 2000 A.D.

The utilisable annual surface runoff has been estimated at 70 million hectare metres of which by the end of the Fourth Five-Year Plan, the utilisation was estimated at 25 million hectare metres. The ultimate ground-water potential is estimated at 27 million hectare metres of which 13 million hectare metres was estimated to have been utilised by 1974. The National Commission on Agriculture has projected a demand of 42 million hectare metres from surface water and 21 million hectare metres from ground water by the turn of the century, for utilisation for irrigation. The demand for other uses such as industrial requirements and domestic water supply are estimated to be 8 million hectare metres for surface water and 4 million hectare metres from ground water. For developmental activities upto 2000 A.D., there will thus be adequate supply of water resources. The estimated utilisable surface water resources and ground-water resources are likely to undergo an upward revision with advance of technology and development of water resources.

Land preparation works and provision of drainage facilities are also expected to be provided in an increasing measure in the coming years. These would also increase the land productivity. Provision of adequate agricultural extension services will have to be ensured on an increasing scale for transferring the improved technological practices to farmers.

Monitoring of important projects has been started recently with a view to ensure the orderly implementation of the schemes and fulfilling construction schedules and there are no slippages in the targets laid down for completion of the projects. The requirement of funds needed for meeting the physical targets is being examined from time to time and steps taken to provide adequate funds. Facilities for loan assistance from International Agencies are also being availed for supplementing the financial resources.

RESUME

La surface cultivée en Inde d'environ 140 millions ha, restée stationnaire, indique qu'on est arrivé à la dernière limite du défrichement de nouvelles superficies. La population qui était de 361 millions en 1951 a atteint 547 millions en 1971 et serait d'environ 935 millions à la fin du siècle. Les demandes accrues en aliments et en fibres doivent par conséquent émaner essentiellement des rendements accrus par hectare de terre. Ceci n'est possible que grâce à la disponibilité d'irrigation à de nouvelles surfaces, l'irrigation étant une entrée de base pour la production agricole accrue.

Le potentiel d'irrigation ultime du pays a été estimé à environ 110 millions ha, 70 millions ha desservis par les projets d'eau de surface et 40 millions par les projets d'eau souterraine. En fin mars 1974, c'est-à-dire, vers la fin du Quatrième plan quinquennal, le potentiel développé a été estimé à près de 44 millions ha, qui touchera probablement 86 millions à la fin du siècle, 53 millions ha desservis par les projets d'eau de surface et 33 millions ha par

les projets d'eau souterraine. L'accroissement anticipé entre 1974 et 2000 serait donc de 42 millions ha. Le Cinquième plan quinquennal prenant fin en Mars 1979 envisage la création d'un potentiel supplémentaire de 12,2 millions ha, ce qui représente une augmentation annuelle de plus de 2,4 millions ha. Gardant cette allure, il sera possible dans les Plans à venir d'atteindre le but de 86 millions ha vers l'an 2000.

Le débit annuel utilisable a été estimé à 70 millions hectares mètres, desquels l'utilisation en fin du Quatrième plan quinquennal serait de 25 millions hectares mètres. Le potentiel définitif d'eau souterraine est estimé à 27 millions hectares mètres desquels 13 millions hectares mètres ont été utilisés jusqu'en 1974. La Commission Nationale de l'Agriculture a projeté une demande, pour la fin du siècle aux fins d'irrigation, de 42 millions hectares mètres à partir des eaux de surface et 21 millions hectares mètres à partir des eaux souterraines. La demande pour les autres besoins industriels et l'alimentation en eau potable est estimée à 8 millions hectares mètres à partir des eaux de surface et à 4 millions hectares mètres à partir des eaux souterraines. On disposerait ainsi jusqu'en 2000 pour les activités de développement un apport suffisant de ressources en eau. Avec les progrès technologiques et la mise en valeur des ressources hydrauliques, les ressources en eau de surface et en eau souterraine qu'on peut utiliser vont probablement augmenter.

Les années à venir verront l'exécution accélérée des travaux de préparation de terres et de provision des facilités de drainage, ce qui augmenterait la productivité des sols. Pour que les exploitants bénéficient des pratiques technologiques modernes, il faut veiller à une provision de services de vulgarisation agricole d'une manière suffisante.

On a entamé le contrôle des projets importants pour veiller à une mise en application efficace des projets et pour réaliser les programmes de construction sans aucun échec. On révise de temps en temps les besoins en fonds nécessaires pour atteindre les buts physiques et pour garnir de fonds nécessaires. Pour augmenter les ressources financières, on saisit également des facilités d'aide financières accordées par les agences internationales.

INTRODUCTION

India is the seventh largest and second most populated country in the world. It covers an area of 328 million ha and the present population is estimated at about 600 million. A very large part of the land area consists of extensive plains watered by great rivers, of which the Indo-Gangetic Plain is the most noteworthy. Forests constitute over a fifth of the total geographical area.

2. The mean annual rainfall in India has been estimated to be 1,190 mm but there is considerable variation from region to region. Areas like the windward side of the Western Ghats and parts of Brahmaputra valley in the north-east receive more than 2,500 mm of rainfall, while Western Rajasthan

receives less than a tenth of this amount. The South-West monsoon which occurs during the period June to October is the principal contributor of rainfall over major portions of the country. But the year to year sequences of monthly rainfall as well as the total annual rainfall show considerable variations. In general, areas of low rainfall experience a higher year to year variation of 100 per cent or more. Large tracts are also liable to receive excessive rainfall through heavy downpours caused by cyclonic storms and depressions.

3. The river systems of India can be broadly classified into two groups viz. (*i*) the perennial rivers of the Himalayan region; and the rivers of the Peninsular India. The main Himalayan river systems are those of the Indus, the Ganga and the Brahmaputra, which are among the major rivers of the world. The Godavari and the Krishna are the major peninsular rivers. The average annual flow in the rivers is estimated at 178 million ha metres, of which only 70 million ha metres is considered utilisable at present. Preliminary estimates indicate that the ground-water potential is of the order of 27 million ha metres, but this is likely to undergo upward revision with the advance of technology and development of water resources.

4. The four major soil groups in India are (*i*) alluvial soils (*ii*) black soils (*iii*) red soils and (*iv*) laterite soils. Alluvial soils which are generally suitable for irrigation form the most predominant group. This group is followed by black soils which have a high capacity for conserving moisture. The red soils react well to the application of water for irrigation on account of their being well drained.

AREAS

5. According to the provisional statistics for 1971-72 (the latest year for which data has been published) the net area sown in the country is about 140·2 million ha. The total cropped area in the country, including area sown more than once, is about 165·2 million ha. An area of about 13·1 million ha is classified as permanent pastures and other grazing land. Nearly 61·2 per cent of the total cropped area is under cereals, 23 per cent being under rice alone, while another 13·6 per cent is under pulses. Thus, nearly three-fourths of the total cropped area is under food grains. 9·4 per cent of the total cropped area is accounted by oil seeds, half of which is under groundnut.

6. The gross irrigated area in 1971-72 was about 38·9 million ha while the net irrigated area was about 31·9 million ha. Government canals accounted for 37·7 per cent of the net irrigated area while wells accounted for 38·1 per cent. Irrigated rice accounted for 37·9 per cent of the gross irrigated area in the country, while wheat accounted for 26·8 per cent, irrigation potential was created for an area of 46 million ha in 1974-75.

7. Bulk of flood damage in India takes place in the States of Bihar, U.P., West Bengal and the Brahmaputra valley in Assam. Drainage congestion is a problem in several parts of the country, specially in the deltaic regions of the peninsula and the irrigated Indo-Gangetic plains.

8. A total area of 20 million ha of land is prone to flooding and drainage problem in the country and it is estimated that 16 million ha can be afforded reasonable protection. Upto the end of the Fourth Five-Year Plan, about 7,700 km of new embankments, 12,400 km of drainage channels and 2,019 town protection works have been constructed in the country. These works have been planned to benefit about 7·7 million ha of area, most of which is located in agricultural lands in rural areas. The actual figures of areas provided with both irrigation and drainage facilities are not available.

9. Permanent pastures are usually rainfed. Provision is made for irrigating fodder crops in some irrigation projects particularly for raising summer fodder. Fodder crops are also grown as follow-on crop on irrigated lands, after harvesting the irrigated crop, on residual moisture. The cultivable areas which are susceptible to flood damage are also usually cultivated but their success depends on magnitude and duration of flood. In years of severe floods and resultant drainage congestion the crops sustain heavy damage. But irrigation cannot be introduced successfully in areas prone to flooding unless they are freed from it.

IRRIGATION REGIONS

10. The irrigation and drainage facilities provided so far are spread all over the country but these are not uniformly distributed. Provision of these facilities is influenced by necessity for such works on agro-climatic conditions, availability of water resources for development and historical reasons. For instance, in high rainfall regions with annual rainfall of 1,150 mm and above the percentage of net irrigated area to net area sown is the lowest, being about 17 per cent. In medium rainfall regions, where the annual rainfall is between 750 mm and 1,150 mm and in which regions nearly 36 per cent of the net area sown in the country is located, this percentage is the highest, being about 22·3 per cent. Low rainfall areas where the annual rainfall is upto 750 mm and which account for a third of the net sown area are in need of irrigation facilities to a greater extent but water resources available for development are limited. The percentage of net irrigated area to net area sown in these regions is 18·3 per cent.

11. Wheat is grown in the winter season when very little rainfall is received for the crop and supplementation by irrigation is necessary. Consequently nearly 54 per cent of the wheat is grown under irrigation. The percentage of irrigated area to total area under crops is highest in the Punjab, being 76·5 per cent owing to historic reasons of prior development of available water resources, and predominance of wheat crop in the area which requires irrigation facilities. But Madhya Pradesh which has sizeable water resources has lagged in providing irrigation facilities, probably owing to fragmentation of administrative units under numerous princely states till a few years ago and the retentive nature of soils. The percentage of irrigated area to total area in this State is among the lowest, being only 8·2 per cent. On an average about 23·5 per cent of the total area under crops is irrigated, and nearly half the States in the country are below this percentage.

12. The dependence of India's agriculture on the capricious monsoons has led to the development of irrigation facilities in almost all the regions in the country. In areas of high rainfall like Assam in the north east and Kerala in south-west, irrigation is necessary to a limited extent for the first monsoon season crop, for providing moisture to crops during the gaps within the monsoon period, but the major demand is for supporting multiple cropping. A third of the country is prone to drought and irrigation is essential even for a single assured crop in such areas. Drought-prone areas are located in the States of Andhra Pradesh, Karnataka and Tamil Nadu in the South, Madhya Pradesh, Maharashtra, Gujarat, Rajasthan, Haryana, Punjab, Uttar Pradesh, Bihar and West Bengal, in the rest of the country. But the chronically drought affected areas are limited to western parts of Rajasthan and Kutch region in Gujarat.

13. Usually the heavy rainfall regions like Assam aud Kerala have limited land available for cultivation and there is need for multiple cropping by irrigation for self-sufficiency in foodgrains. In most other parts of the country, it is the water availability which is a constraint. In such areas, the available water resources will have to be put to beneficial use for supporting the principal crop in the first instance, and to provide irrigation to subsequent crops to the extent feasible. Thus, there are no well defined irrigation regions from the view point of necessity. But, there are regions where irrigation facilities are better developed compared to many others.

14. The reporting area, total cropped area and gross irrigated area in different States of the Union for the year 1971-72 as estimated provisionally are given in Table I.

15. From Table I, it is seen that nearly 21 per cent of the gross irrigated area in the country is located in the State of Uttar Pradesh alone. The four States of U.P. and Punjab in the north and Andhra Pradesh and Tamil Nadu in the south, between them, account for over 51 per cent of the gross irrigated area in the country. This is due to the large alluvial plains and deltas of major rivers located in these states and development of large irrigation systems over a number of years.

CROP YIELDS

16. The two major food crops of the country are rice and wheat. Table II shows yield of rice both under irrigated and unirrigated conditions for the years 1972-73 and 1973-74 in different States. The Table II also indicates the percentage of irrigated area to total area under the crop during 1972-73.

17. It is seen that the yields both under irrigated and unirrigated conditions vary from State to State and from region to region. The yield under irrigated conditions is maximum at 2,303 kg per ha in Punjab and minimum at 1,023 kg per ha in Gujarat. Under unirrigated conditions, the yield in Kerala was maximum at 1,378 kg per ha and minimum in Bihar at 734 kg per ha.

18. The yields of wheat in principal wheat-growing States—both under irrigated and unirrigated conditions and percentage of irrigated area to total area under the crop are given in Table III.

TABLE I

(Areas in 1,000 ha)

State	*Reporting area*	*Total cropped area*	*Gross irrigated area*	*Percentage of irrigated area to total area under principal crops*
Andhra Pradesh	27,440	12,652	3,786	29·9
Assam	7,795	2,834	572	20·2
Bihar	17,330	10,683	2,788	26·1
Gujarat	18,898	10,446	1,549	14·8
Haryana	4,402	5,048	2,284	45·2
Himachal Pradesh	5,076	901	159	17·6
Jammu & Kashmir	4,523	868	330	38·0
Karnataka	19,045	10,988	1,598	14·5
Kerala	3,859	2,958	612	20·7
Madhya Pradesh	44,237	20,892	1,705	8·2
Maharashtra	30,758	18,115	1,622	9·0
Manipur	2,211	147	75	51·0
Meghalaya	2,249	193	37	19·2
Nagaland	1,653	102	29	28·4
Orissa	15,540	7,042	1,624	23·1
Punjab	5,031	5,724	4,377	76·5
Rajasthan	34,287	16,773	2,440	14·5
Tamil Nadu	13,008	7,642	3,530	46·2
Tripura	1,048	356	24	6·7
Uttar Pradesh	29,833	23,025	8,090	35·1
West Bengal	8,852	7,271	1,541	21·2
Union Territories	9,145	529	137	25·5
All India	3,028,758	165,189	38,909	23·5

19. It is seen from the Table III, that yields both under irrigated and unirrigated conditions are the maximum in Punjab at 2,250 kg per ha and 969 kg per ha respectively. It is minimum in Uttar Pradesh at 1,089 kg per ha under irrigated conditions. Under unirrigated conditions, it is lowest at 620 kg per ha in Rajasthan.

20. The net non-irrigated area sown in the country (1971-72) was about 107·86 million ha, and the area sown more than once about 17·6 million ha. This indicates that nearly 16·3 per cent of the net non-irrigated area in the country is cropped more than once in a year. In the case of irrigated area, it is seen that over 22 per cent of the net irrigated area is cropped more than once. This clearly indicates that irrigation facilities help in extending multiple cropping, besides increasing the yields of crops.

TABLE II

Showing yield of rice

State	Yield under irrigated conditions kg/ha		Yield under unirrigated conditions kg/ha		Percentage of irrigated area to total area under the crop
	1972-73	1973-74	1972-73	1973-74	1972-73
Andhra Pradesh					
Abi	N.A.	1,740	N.A.	865	94·0
Tabi	N.A.	1,527	N.A.	733	
Assam					
Autumn	N.A.	N.A.	N.A.	N.A.	33·8
Winter	N.A.	N.A.	N.A.	N.A.	
Bihar					
Autumn	835	949	535	544	33·4
Winter	823	936	670	810	
Summer	1,094	1,110	643	734	
Gujarat	684	1,023	402	962	32·3
Haryana	1,561	1,919	975	1,296	90·4
Himachal Pradesh	1,189	1,456	957	1,115	55·1
Jammu and Kashmir	2,310		1,255		92·6
Karnataka					
Kharif	1,699		1,182		64·1
Rabi	2,468				
Kerala					
Autumn	1,841	1,532	1,409	1,378	58·4
Winter	1,708	1,383	1,394	1,328	
Summer	2,008	1,269	1,893	1,355	
Madhya Pradesh	952	1,069	643	806	14·6
Maharashtra	668	1,286	531	1,187	25·9
Orissa					
Autumn	637	755	493	579	24·6
Winter	1,121	1,125	930	982	
Summer	1,357	1,305			
Punjab	2,058	2,303	1,466	1,078	91·8
Tamil Nadu	2,135	2,143	1,185	1,156	92·3
Uttar Pradesh	N.A.		N.A.		19·2
West Bengal					
Aus	2,383		1,440		28·7
Aman	2,114		1,582		

Source : Directorate of Economics and Statistics (1976)—Estimates of Area and Production of Principal Crops in India, 1974-75.

TABLE III

Showing yield of wheat

State	Yield under irrigated conditions kg/ha		Yield under unirrigated conditions kg/ha		Percentage of irrigated area to total area under the crop
	1972-73	1973-74	1972-73	1973-74	1972-73
(1)	(2)	(3)	(4)	(5)	(6)
Bihar	629	1,235	535	840	48·4
Gujarat	1,587	2,159	467	692	64·0
Haryana	1,859	1,655	1,164	808	83·5
Himachal Pradesh	1,634	1,369	1,088	928	18·9
Jammu and Kashmir	1,541		775		21·2
Madhya Pradesh	1,021	1,400	674	720	21·0
Punjab	2,327	2,250	1,024	969	88·4
Rajasthan	1,400	1,261	780	620	73·7
Uttar Pradesh	1,348	1,089	924	688	69·3

Source : Directorate of Economics and Statistics (1976)—Estimates of Area and Production of Principal Crops in India 1974-75.

IRRIGATION METHODS IN THE COUNTRY

21. There are three general methods of applying irrigation water to the land—surface method, sprinkler method, and subirrigation method. By and far, surface irrigation methods are the ones mostly used in India. Basin methods, border strip methods, furrow methods, corrugation methods are all used in different parts for irrigating different crops. However, basin method is the most popular. This is primarily used for paddy irrigation and also for orchards. A type of check basin is used for light irrigated crops where the topography is generally flat. The border strip method is

used where the land has been developed by modern methods with narrow and long plots. This is used for irrigation of crops like wheat in Punjab, Haryana, U.P. etc. The furrow methods are used for irrigation of row crops like maize, sorghum, bajra and arhar (pigeonpeas), sugar cane and cotton in different states in the country. Corrugation method is used for the close growing crops on sloping and rolling lands and where the soil is heavy. Although, in some parts of the country, all the above surface methods are adopted after proper land preparation, where land development has not been done, flooding methods are also used. In States like Punjab, Gujarat, Haryana and Tamil Nadu, sprinkler irrigation has come up recently. However, this is restricted to the progressive farmers and for high value crops. It is also used for irrigation of tea gardens and for orchards. Sub-irrigation methods are very rarely used in this country. The drip irrigation method which has come up recently is still on an experimental stage in India.

22. Canals fed by storages and diversion structures account for over 40 per cent of the net irrigated area. Over 38 per cent of net irrigated area in the country is served by ground-water resources comprising tubewells and dugwells. As the reliability of irrigation supplies from canals fed by diversion works depends on the availability of river water from time to time, which is widely varying, increasing emphasis is being laid on construction of storage works. The gross storage capacity of reservoirs in the country is estimated to have gone up eight fold during the last twenty-five years and is now of the order of 14·7 million ha metres. The cost of irrigation works from surface sources varies, depending whether the main structure on the river is storage or diversion, the agro-climatic and soil conditions and the type of crop grown. In general, the average capital cost of irrigation works under progress varies from about Rs. 2,500/ha in Northern and Eastern States to over Rs. 4,700/ha in southern States. These costs exclude the outlay on command area development.

23. Farmers in traditionally irrigated areas possess a developed sense of judgement for use of irrigation facilities. In areas newly brought under irrigation farmers require guidance from extension agencies. There is generally a tendency for over-irrigation in areas of good supply with the result that areas located in tail reaches usually experience short supplies.

24. Provision of drainage facilities in irrigated areas has begun receiving attention only in recent years. The drainage facilities being provided are usually of surface type. These drains are being taken up for removing stagnation of water in the cropped area and increasing the yields by facilitating aeration to the root zone.

25. The provision of irrigation facilities has improved the water availability to crops and has resulted in increased yields. Provision of drainage facilities and flood control measures has rendered sizeable areas free from damage to crops caused by inundations and stagnant water. We do not have data to indicate the percentage of the value of agricultural production coming from irrigated areas, other reclaimed areas and flood protected areas.

TRENDS TOWARDS CHANGES IN LAND USE

26. The net area sown in the country has shown considerable increase in the first five years of planned development. It rose from 118·7 million ha in

1950–51 to 129·2 million ha in 1955–56. It has risen further since but has remained more or less static around 139 million ha in recent years. This fact indicates that the upper limit in respect of new land capable of being brought under the plough is being approached.

27. The population of the country, on the other hand, has shown a high rate of increase. It rose from 361 million in 1951 to 439 million in 1961 and to 547 million in 1971. The decennial growth rate per thousand was 24·80 during the period 1961–71. While no firm population projections for the year 2000 A.D. are available, rough forecasts indicate it to be around 935 million—an increase of 71 per cent over the population of 1971. The food and fibre needs may, however, increase by about 100 per cent because of the likely rise in the standard of living. It would be possible to cope up with such a demand only if more and more areas are brought under irrigation, which is a basic input for increased agricultural production, particularly in a country like India where about 67 per cent of area is arid or semi-arid.

28. Nearly 80 per cent of the population of the country is rural where agriculture is the main occupation. About 70 per cent of the total workers in the country are either cultivators or agricultural labourers. This trend is expected to be more or less maintained in future also for quite some time; there has been no significant change in the percentage between 1961 and 1971.

DEMAND AND POLICY FOR EXPANSION OF AGRICULTURE PRODUCTION

29. The production of total foodgrains during 1970–71 was of the order of 108·4 million tons, comprising 96·6 million tons of cereals and 11·8 million tons of pulses. The production of rice, the single largest cereal crop was about 42·2 million tons, while the production of wheat was about 23·8 million tons. It is reasonable to assume that the demand would double up by the turn of the century. The production of food grains is neither steady nor growing at a constant rate and is dependent on agroclimatic conditions prevailing in the year. For instance, during the period 1970–71 to 1973–74, the total production of foodgrains decreased from the 1970–71 level, in all the following years. The index number of agricultural production of food grains has however, doubled up during the period 1950–51 to 1973–74. This indicates that it is physically possible to achieve a doubling up of food grain production, provided proper care is taken for providing necessary inputs.

30. The agricultural food grain production is largely oriented towards home consumption. Imports are made for improving the food grain public distribution system in bad years. The object of the future programme is to avoid such imports and build up buffer stocks from indigenous production.

31. The increase in agricultural output will have to be accomplished by creating conditions favourable for multiple cropping and by adopting modern agriculture technology for improved yields. Irrigation facilities available have doubled up over the last twenty five years. There has been sizeable step up in the use of fertilizers also. The consumption of fertilizers has increased from a mere 0·3 million tons in 1961–62 to 2·7 million tons in 1974–75. A

substantial part of the increase in fertilizer use has been brought about by the increase in indigenous production. The indigenous production of nitrogen and phosphate fertilizers which was only 27,000 tons in 1951–52 rose to over 1·5 million tons in 1974–75 and is expected to increase considerably in future. But irrigation which is the basic input for increased production and for multiple cropping will have to be provided in a big way and this has been taken care of in the immediate plans.

32. In the Fifth Plan (1974–79), it is proposed to create an additional potential of 12·2 million ha consisting of 6·2 million ha from major and medium surface water schemes, 1·5 million ha from minor surface water schemes and the rest 4·5 million ha from ground-water schemes.

33. The 20 Point programme announced in 1975 envisages creation of irrigation potential of 5 million ha during the last four years of the Fifth Plan from major and medium projects. The rate of increase envisaged is two and a half times the average rate of the past few years.

34. Table IV gives the perspective of irrigation development for future as expected to be upto 2000 A.D.

TABLE IV

Year	*Million hectares*		
	Surface water schemes	*Ground-water schemes*	*Total*
1974	28·0	16·0	44·0
1979	35·7	20·5	56·2
2000	53·0	33·0	86·0

35. Simultaneously steps have been taken to increase the crop yields from irrigated areas by providing all the necessary infrastructural and extension facilities, through establishment of integrated command area agencies for major irrigation projects. These agencies are responsible for taking steps for land preparation, provision of field channels, introduction of scientific crop pattern, provision of adequate drainage facilities, agricultural extension services and credit facilities.

DEMAND FOR WATER DEVELOPMENT AND USE

36. In the context of examining the demand for future use, it would be necessary to take an overall view of water availability, its present use and availability for long-term use. The average annual flow in the river systems of India has been roughly assessed at 178 million ha metres. Owing to limitations of dependability of supply, topography, availability of dam sites,

and present status of technology, the utilisable flow has been reckoned at 70 million ha metres. The approximate utilisation in 1974 is estimated at 25 million ha metres. The ground-water potential is estimated at 27 million ha metres of which 13 million ha metres was estimated as utilised, in 1974.

37. In the field of projections of water demand, the picture is still at an evolving stage. Recently, the National Commission on Agriculture have given rough forecasts of requirements of fresh water for the more important consumptive use of water in India. The rough projections made by the National Commission on Agriculture are given in Table V.

TABLE V

Requirements of fresh water

Object of use	*Requirements in million ha metres*			
	1974		*2000*	
	Surface water	*Ground water*	*Surface water*	*Ground water*
Irrigation	24	11	42	21
Other uses	1	2	8	4

38. The utilisable water resources available are thus ample to meet the requirements by the turn of the century. Further, the estimated utilisable surface water resources are likely to increase with advancements in technology, and the ground water potential is also likely to undergo an upward revision with advance of technology and development of surface water resources. There is also general awareness regarding the economic and efficient use of irrigation water supplies and steps have been initiated towards achieving this object. We can, therefore, presume that the available water resources would be able to sustain our irrigation development activities for quite some time beyond 2000 A.D.

39. For vertical expansion of irrigation and drainage, two major steps have been taken up in recent years. The first one is the setting up of command area development agencies which would provide suitable facilities for introducing scientific water management practices, including provision of drainage facilities. The projects identified so far for constituting C.A.D. (Command Area Development) agencies would cover about 13 million ha of area under major and medium irrigation projects. The second step taken up is modernisation of old and early plan irrigation works so as to render them suitable for meeting the exacting demands of modern irrigated

agriculture, in which introduction of high yielding varieties of crops which require adequate water at specific timings plays an important role. These two measures are expected to bring about an intensification of production in areas already under irrigation. A National Flood Commission has been set up recently to evolve a national programme for flood control.

KNOWN POTENTIAL TO EXPAND IRRIGATION

40. The ultimate irrigation potential of the country has been estimated at about 110 million ha, comprising 70 million ha from surface water schemes and 40 million ha from ground-water schemes. The ultimate irrigation potential from major and medium surface water schemes alone is estimated at about 57·3 million ha. Thus, there is ample irrigation potential available in the country for realising a target of 86 million ha by 2000 A.D. The anticipated increase in irrigation potential between 1974–2000 would be 42 million ha. The Fifth Plan envisages the creation of an additional potential of 12·2 million ha from major, medium and minor works, which means an annual increase rate of over 2·4 million ha. Even if this tempo is maintained, it would be possible to easily touch the target of 86 million ha by the turn of the century. Major portion of minor irrigation works will go into the private sector while the major and medium surface irrigation works and deep tubewells will be normally provided by the Government agencies.

41. The irrigation systems planned for future would be predominantly of the storage type, as far as surface water projects are concerned because the more easy diversion projects have been largely exhausted. Further, in view of the large variations in river flows from season to season storage works would be necessary for conserving the monsoon surpluses in the rivers. Some of the dam sites may be located in regions known for seismic activity and where foundation conditions may be rather problematic. Improved technological methods are expected to aid the planning and construction of such structures. Pumped canals which have come up in recent years may develop further, for commanding areas outside the conventional gravity flow. In the field of ground-water development conjunctive use with surface water is expected to increase as also the exploitation by deep tubewells.

POTENTIAL TO INCREASE INTENSITY OF WATER USE

42. Most of the old and early plan irrigation systems in the country were planned on the basis of conventional practices which did not take into account the crop water requirements at different stages of crop growth. The high yielding varieties of paddy and wheat which have become popular during the last decade are sensitive to water shortages. The existing canal capacities will be reviewed and improved with a view to ensuring adequate capacities for meeting the peak requirements of the new varieties. It is also proposed to provide adequate backing up of storage and ground-water facilities to these systems and modernise them. These measures and the activities of command area development agencies can be expected to bring about sound water management practices and improve land productivity by intensifying water use under irrigated agriculture.

43. Land preparation works and provision of drainage facilities are also expected to be provided in an increasing measure in coming years.

These would also increase land productivity. Improved irrigation methods like sprinklers are yet in an evolving stage. But sprinkler irrigation can be expected to develop in future, as some State Governments have begun subsidising the installation costs. Provision of adequate agricultural extension services will have to be ensured on an increasing scale for transferring the improved technological practices to farmers. The farmers are usually well trained in traditionally irrigated areas but in areas newly brought under irrigation, they would require some training in irrigated agriculture which can be imparted through extension services.

THE CAPACITY TO DEVELOP

44. It has already been pointed out that, judged by the targets set for the Fifth Plan, it would be possible to create an annual additional irrigation potenial of about 2·5 million ha. While the minor schemes do not require much time for implementation, major and medium irrigation schemes take considerable time for their investigation, planning and construction. The present policy is to take up investigations in sufficient advance so that enough number of projects would be available on the shelf for implementation. Guidelines for investigation of projects to be put up for consideration by the National Planning Commission have also been prescribed for guidance to State Governments who are incharge of such investigations.

45. Financial means were a constraint for realising the physical targets set for different Plans. Consequently, slippages did occur in the targets. In the light of this experience, monitoring of important projects has been started recently with a view to ensuring the orderly implementation of schemes and fulfilling construction schedules. The requirement of funds needed for meeting the physical targets is being examined from time to time and steps being taken to make adequate provisions. Facilities for loan assistance from international agencies like I.D.A. (International Development Association) are also being availed for supplementing the financial resources. In view of the above steps, financial resources may not be a major constraint in future and the targets will not be difficult to be realised.

46. Usually construction of irrigation works is carried out in this country by a combination of manual labour and machinery, so as to provide employment to local labour available in plenty and also to ensure a reasonable quick rate of construction. Traditionally skilled earth work labour and masons are available in most parts of the country and they can be employed for construction work.

47. The country has enough technical know-how, expertise and experience for taking up all the jobs connected with water conservation projects. The construction material is available indigenously and most of the construction machinery required for these schemes is manufactured in the country.

PLANS FOR FINAL ASSESSMENT

48. Water is a State subject in India and the State Irrigation or Public Works Departments provide the basic planning machinery for water

resources development for irrigation. Investigation, planning and implementation of minor schemes which usually cost upto Rs. 2·5 million is solely attended to by the State Governments. The medium schemes which have a culturable command area of upto 10,000 ha are also investigated and planned by the State Governments but the schemes are examined on a proforma basis in the Central Water Commission of the Union Ministry of Agriculture & Irrigation, before they are accepted by the Planning Commission at the Centre. Major schemes which have a culturable command area of 10,000 ha and above are examined in detail on the basis of detailed project reports sent by the State Governments in the (C.W.C.) Central Water Commission before these are accepted by the Planning Commission. The design and construction of irrigation projects is normally attended to by the State Government Departments which are assisted by design and research organisations and construction engineers. Guidance in the field of design and research, is rendered by the specialist agencies of the Union Government whenever called for.

49. In the case of inter-State rivers which flow through more than one State, the Union Government can give advice to State Governments for their regulation and development. There is also provision for referring inter-State river water disputes for adjudication, if found necessary. In recent years, disputes relating to three major inter-state rivers, viz., Krishna, Godavari and Narmada have been referred to Tribunals. As the process of adjudication takes considerable time, interim agreements have been entered into among the concerned States under the aegis of the Union Government, so that the immediate development of water resources is not held up merely due to inter-State disputes for sharing of waters. This trend of arriving at mutually acceptable solutions by negotiations is expected to increase the tempo of development of water resources.

50. At present, the bulk of the activity for water resources development pertains to the irrigation sector. There is a need for evolving an inter-departmental machinery for orderly development of water resources for various uses. The establishment of such a machinery is under consideration for inter-departmental, inter-sectoral co-ordination and for laying broad policy guidelines for development of water resources. Setting up of river basin commissions for preparing master plans for development of water resources is also under consideration.

51. The schemes for development of water resources are dovetailed into the overall plans for economic development drawn up by the National Planning Commission. This Commission is the main planning and coordinating agency for evolving economic plans for development, providing requisite funds for their implementation and appraise their progress from time to time.

EXPECTED CONSTRAINTS AND PROBLEMS

52. The general constraints expected to be experienced in the planning and implementation of schemes for realising targets for creating additional irrigation potential are the non-availability of adequate number of thoroughly investigated schemes for implementation, technological problems in design and construction of complex structures, the problem of floods, inadequacy

of funds for implementing the schemes and slippages in construction schedules owing to various reasons. Another constraint could be in the field of provision of adequate infrastructural and other facilities for prompt use of irrigation facilities made available from new irrigation works. Absence of agreements in the case of inter-State disputes could also impede the rate of development. As already indicated earlier, steps have been initiated to overcome these constraints and problems by political, administrative and technical measures. It can, therefore, be safely presumed that the constraints and problems that may be encountered in the following quarter century will not come in the way of realising the targets.

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LIKELY IRRIGATED AGRICULTURE OF 2000 A.D.

LIKELY IRRIGATED AGRICULTURE OF 2000 A.D.* (GREECE)

C. SALAPAS**

1. SOIL RESOURCES

Many things have been written from time to time on the poorness or the bareness of Greek soils. In spite of the rocky nature of the land, Greece is endowed with a lot of relatively productive land, with a multitude of various features, on which flexible exploitation systems may be adopted. This is valid mainly for the flat area of Greece.

1.1 EXISTING BALANCE BETWEEN LAND RESOURCES

The total area of Greece works out to 13·19 million ha. Table I gives the actual distribution of land resources of Greece. From the above 13·19 million ha, the 29·9 per cent are flat areas, 27·1 per cent semi-mountainous and the 43 per cent mountainous. Basic disadvantages of the above land category repartition are the following:

Firstly, a considerable part of areas available for agriculture (about 45 per cent) is mountainous and semi-mountainous. These lands have marginal yield and are not fit for modern agricultural exploitation because their uneven relief renders irrigation as well as the application of modern methods of mechanical cultivation difficult.

Secondly, the areas suitable for ranges with a satisfactory range capacity (estimated to about 2 million ha) are not considered as suitable for the development of cattle-breeding to the desired extent.

Thirdly, areas covered by forests are insufficient, considering country's development possibilities and the needs of lumber production, recreation and erosion protection.

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* Perspectives de l'agriculture irriguée en l'an 2000.

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TABLE I

Actual land resources balance

(Unit in thousand ha)

Land category	*Land resources*		*Agriculture*	*Pastures*	*Forests*	*Settlements and Industry*	*Barren areas*
	Area	*Per cent*					
Flat	3,940	29·9	2,170	390	290	390	700
Semi-mountainous	3,580	27·1	970	590	720	230	1,070
Mountainous	5,670	43·0	770	1,020	1,730	320	1,830
Total	13,190	100·0	3,910	2,000	2,740	940	3,600
Per cent	100·0	—	29·7	15·2	20·8	7·0	27·3

1.2 LAND RESOURCES BALANCE IN 2000 A.D.

In view of the above mentioned disadvantages and the present tendencies in the use of land resources, their repartition till 2000 A.D. is foreseen as follows :

(1) From the 3·9 million ha of land available for agriculture, the area available after the next 25 years is expected to be limited only to 2·5 million ha, of which 2·0 million ha will be flat areas. The concentration of agriculture mainly in the plains is an acute necessity because only by this way a high competitivity will be reached in agriculture. The concentration of agriculture in flat areas of a high productivity facilitates irrigation, the application of methods of mechanical cultivation and the creation of a number of great agricultural exploitations. Following the above repartition, the percentage of land resources available for agriculture is decreased from 29·9 per cent to 19 per cent (approx.) in 2000 A.D., but their qualitative composition is improved markedly as most of these lands are flat ones.

(2) The remaining 1·4 million ha of cultivated farm land, mountainous or semi-mountainous, is assumed to be transformed into pastures of a medium to high pasture capacity for the development of cattle-breeding production. So, the participation of cattle-breeding lands is expected to increase from about 15·2 per cent to day to 26·8 per-cent in 2000 A.D.

(3) The forest lands are expected to increase from 2·74 million ha (20·8 per cent) at present to 3·54 million ha (26·8 per cent) in 2000 A.D. The extension of forests is imposed not only for economic reasons, but also for many other reasons related to environmental protection, public health, etc.

(4) The growing tourism along the coasts and in the island departments will cover an appreciable area of land resources of Greece. During the next 25 years touristic activity is expected to cover 0·4 million ha.

(5) The accelerated urbanization and the development of industry will require significant land resources for settlements and industrial zones. The need of the zone for settlements and industries is expected to be approximately doubled during the next 25 years.

(6) Another basic objective is the reclamation of barren lands of Greece in the best possible way. For the above aim a considerable part of the present barren lands (3·6 million ha) will be used within the next 25 years for the creation of pastures and forests development.

(7) Table II figures the land resources repartition in Greece for the year 2000.

2. WATER RESOURCES

2.1 AVAILABLE WATER RESOURCES AND THEIR USE TILL 2000 A.D.

Greece's water supply comes from two basic resources : surface water and ground water. In both cases water originates from precipitations and

TABLE II

Land resources repartition for 2000 A.D.

(Unit in thousand ha)

Land category	*Area*	*Per cent*	*Land use*					
			Agriculture	*Pastures*	*Forests*	*Settlements and industry*	*Tourism*	*Barren lands*
Plain	3,940	29 9	2,000	700	490	750	—	—
Semi-mountainous	3,580	27·1	400	1,400	750	300	300	430
Mountainous	5,670	43·0	100	1,300	2,300	300	100	1,570
Total	13,190	100·0	2,500	3,400	3,540	1,350	400	2,000
Per cent	100	—	19	25·8	26·8	10·2	3·0	15·2

what is left after the losses from runoff and evapotranspiration. In spite of what is generally believed that Greece's water resources are amply sufficient because of the relatively rich rainfall, the landscape of the country, the geological structure, the runoff characteristics and the climatic conditions sensibly diminish the really available water quantities and render difficult their valorization. Moreover, a problem of unequal distribution of rainfall over Greece is experienced owing to its greatest part falling in the western part of the country.

The estimated total annual available water potential is over 64,000 million m^3, of which 61,500 million m^3 correspond to surface water and 2,500 million m^3 to the exploitable potential of ground water.

The existing reserves of ground water surely should be greater. Their estimation needs the assessment of performance of the more extended surveys of the ground-water aquifers.

Of the 61,500 million m^3 of surface water, 14 million m^3 originate from the waters of international rivers flowing through Western Greece (Axios, Strymon, Nestos, Evros Rivers), i.e., they originate from catchment basins of rivers having their springs in adjacent countries, influencing not only the volume but also the quality of their waters.

The utilized quantity of water during 1975 was estimated at 4,276 million m^3 or 6·7 per cent of the available water potential of Greece. It is evident that there is an ample margin in water resources and consequently the country does not face a problem of insufficiency in water. It is noted from the water volume used, that 3,576 million m^3 were used by agriculture for irrigation purposes, 585 million m^3 were used for domestic uses and 115 million m^3 for industrial and power production purposes. Agriculture is the major water consumer (83·6 per cent).

As the yearly water potential offer exceeds 64,000 million m^3, the balance of the water resources in Greece will be established by the water demand in the future from the different partial water use sectors and the possibility of covering it by the construction of necessary hydraulic projects. The water demand during the next 25 years in all sectors will be very active. Agriculture will need great quantities of water, given that only 45 per cent of irrigable plain areas are irrigated at present and more than a double amount of water will be needed for their further irrigation till 2000 A.D.

A great water demand will also result from urban use for water supply needs in settlements. It is assumed that till 2000 A.D., the present low per capita daily water consumption will rise sensibly, due also to the increase of the population. So, the total quantity of utilized water is expected to rise from 585 million m^3 in 1975 to 2,100 million m^3 (approx.) in 2000 A.D.

From development of tourism will also result a significant increase in water resources demand. As this demand will occur in the same time with the peak of the home demand during summer months, problems will arise of seasonal regulation of water yield in the great urban centres and tourist resorts.

The assumed industrialization of the country will also put a high demand on water resources. So, the actual industrial water demand level (present: 75x10⁶ m³) will be about five times higher till the year 2000 A.D.

A significant amount of water will also be utilized for hydropower production as the construction of important new hydroelectric projects is planned for the next 25 years. The quantities of water used for the operation of the hydropower projects is expected to be about doubled till the year 2000 A.D.

From the available 64,000 million m^3 of the water resources, the aggregate utilization till the year 2000 A.D. is expected to reach 10,070 million m^3. Following the above estimation it is expected that the exploitation percentage of the total available water resources in Greece will rise from 6·7 per cent in 1975 to 15·7 per cent in 2000 A.D. Table III shows the country's water resources balance for the years 1975 and 2000 A.D.

TABLE III

Balance of water resources for the years 1975 and 2000 A.D.
in million m^3

Category of water resources	*Available quantity*	*Demand of water*	*year* 1975	*year* 2000
Surface water	61,500	Agricultnre	3,576	7,550
Ground water	2,500	Industry	75	360
		Water supply	585	2,090
		Power	40	70
			4,276	10,070
		Excess (unused)	59,724	53,930
Total	64,000		64,000	64,000

2.2 PROBLEMS OF LONG-RANGE WATER POLICY

The basic problems which will be encountered in the entitled sectors during the coming 25 years are the following:

—Execution of the necessary works for the development of water resources (irrigation projects, water supply projects for urban centres and industrial areas, hydroelectric projects).

—Protection of water resources from pollution.

—Securing of national water interests in international rivers by contracting international agreements with neighbouring countries.

In conclusion, from the examination of water resources balance it is borne out that water resources will not be a limiting factor for the development of the country during the coming 25 years.

As water resources belong to the class of renewable natural resources (by rainfall), their relative scarceness or shortage depend upon the works to be constructed for securing the necessary water amounts. The most serious problem of water resources in Greece will be their protection from water pollution. The continuous and correct monitoring of water quality, the institution of appropriate specifications concerning the installation of industrial units and the treatment of effluents and the imposition of penalties on those causing pollution are some protection measures, the application of which is urgent.

3. POPULATION TRENDS

The population of Greece is at present 9·1 million and represents 3·5 per cent of E.E.C. population and 9 per cent of Balkans population. The everage population density of Greece (65 persons per square kilometre) is about the same as that of other Balkan countries, but is lower than the Western Europe. On the other hand, country's population from the view point of age longivity approaches the advanced level of W. Europe populations with a 12 per cent participation of the age group of over 65 years, while it is considerably distant from the population level of Balkan countries, some of which are still to the mature population level. The natural population increase in Greece (0·7 per cent yearly) is slightly higher than that of W. Europe, but lower than the Balkan countries.

The future evolution of population in Greece mainly depends on the changes in the reproduction level. With the actual data, the margin for a further improvement of the expected life span at the time of birth appear as relatively limited and it is estimated that during the next ten years it will be covered. The expected life span will increase mainly owing to the decrease of infant mortality.

Following the population trends in Greece, the population development rate in the future will not be different from that assumed for the E.E.C. countries. Namely, the population increase is expected to be nil at about the middle of first ten years of the 21st century. For Greece, however, certain geopolitical reasons impose the reversion of these tendencies. For that reason a timely adoption of a "restrained" retention policy for these tendencies is under study. It is expected that the population increase rate will reach a zero value during the second decade of the 21st century, when the population will be around 11 million. This evolution secures a more sound age pyramid and strengthens the effort of completion of the the economic and social development of the country, both at national and regional levels.

4. AGRICULTURE

4.1 ASSUMED EVOLUTION TILL 2000 A.D.

The most important of the assumed developments in Greek agriculture till the year 2000 A.D. are the following:

—Increase in yield of the crops per unit area and of the cattle grown.

—Significant decrease of cultivated mountainous and semi-mountainous lands.

—Significant decrease in active agricultural population of Greece.

—Increase in fixed capital of the agricultural field.

The expected increase in the yields will result from the application of an improved technology and the extension of irrigation mainly in plain lands.

On the other hand, many mountainous and semi-mountainous areas will not be cultivated any more and thus the area of agricultural land in 2000 A.D. is estimated to be limited to 2·5 million ha, against 3·9 million ha in 1975, including fallows.

The development of the non-agricultural sector of our economy will render necessary, the decrease, and also possible to a significant extent, of the active agricultural population of Greece in the year 2000 A.D. The manpower thus made available will be absorbed gradually by non-agricultural sectors, of higher productivity.

The further renovation of agriculture will require the investment of significant amounts in fixed farm capital. In addition to the significant investment requirements of land reclamation works, increased capital will be also needed for mechanical equipment, buildings cattle-breeding, greenhouses, etc. Parallelly, a significant increase of the utilized circulating capital is foreseen due to the specialization of production and its organization on an exploitation basis with marketing orientation.

4.2 AGRICULTURE AND DEVELOPMENT

In spite of the assumed decrease of contribution of agriculture to occupation and income due to the above mentioned evolution, its importance for economic development and the welfare of the population will however not decrease. Indeed, in addition to the direct contribution of agriculture to the increse of the country's gross national product, agriculture will also contribute indirectly to the overall economic development :

—by securing increased currency resources,

—by offering increased quantities of good quality raw materials for further development of Greek agricultural industries,

—by contributing to the achievement of the goals of regional development owing to the distinguished position which agriculture holds in the economy of regions situated outside great urban centres.

—by liberating certain production factors (labour, soil) and their use for the development of other fields of economy (industry, tourism).

Important will also be the role of agriculture for the conservation of a sound *ekistics* and population structure, as well as the conservation of natural environment.

4.3 ASSUMED EVOLUTION OF PLANT PRODUCTION

In plant production, an increase is assumed of the specialization degree of farm exploitations and of the various agricultural regions, according to their respective comparative advantages. From the above there would result re-arrangements of agro-production structures in each region. The following evolutions are expected in the field of agricultural production:

—A further production increase of certain crops, as most of forage gramineae and leguminosae (barley, corn, lucerne, etc.), cotton, sugar beets, certain horticultural crops, fresh fruits, dry fruits, table olives, etc.

—A relatively low increase or stagnation in the production of certain other products, as raisins, olive oil, tobacco, etc.

—Production decrease for some products, as wheat and pulses.

—Introduction of new crops and varieties, more productive and sought for in the market, either not cultivated or not covering Greek demand and exports to any extent.

4.4 BASIC PROBLEMS OF AGRICULTURE

The basic problems of agriculture, the resolution of which is sought according to priority, are the following:

—*The improvement of the size and structure of agricultural exploitations*

The small size of farm holdings and their fragmentation constitute a limiting factor for the modernization and the organization, on a profitable basis, of agricultural production. Most of the farm holdings (80 per cent) have an area smaller than 5 ha and each exploitation consists many times of 5 or more plots.

—*The development of group cultivation*

It is the free union of small agricultural undertakings for the creation of big and competitive ones, capable to compete against those of Western Europe. The advantages from the formation and operation of group exploitations will be important for the Greek agriculture, i.e., for:

—the possibility of full utilization of modern methods and means,

—the obtaining of competitive production cost, which will allow a broader introduction of Greek products into foreign markets,

—the development of new crops favoured by climatic conditions in Greece but needing other forms of farming than the traditional, familiar one with a fragmentated farm property.

—*The extension of irrigation*—See the following para 5.-

5. IRRIGATED AGRICULTURE

5.1 IRRIGATION AND AGRICULTURAL DEVELOPMENT

Among the works that may contribute substantially to the improvement of the conditions of Greek agriculture, the most important are those related to irrigation.

First of all, irrigation increases three times, on an average, the gross agricultural revenue and the agricultural income by restructuring the crops pattern and the better use of other production factors. Following the statistical data of the past years, the cropped produce from irrigated areas of the country cover about 70 per cent of the value of all the cropped produce, while they are produced by only 24 per cent of the cultivated land. This means that each irrigated hectare corresponds, on an average, to three dry-farmed hectares, as far as the value of the obtained produce is concerned. This comparison, although it presents only one side of the obtained benefit, is insufficient to demonstrate the importance of irrigation for the development of Greek agriculture. Secondly, they enable not to follow the orientation in crops imposed by environment and to widen substantially the grown crops, preferring those which give higher income and correspond better to the market demand.

On the other hand irrigation makes possible, in many cases, the planning of crops throughout the year by means of the differentiation of vegetative periods and the use of appropriate plant varieties which, in the past, were determined exclusively by the rainfall regimen.

Irrigation, at last, is a primordial land improvement measure for the planning of agricultural production, which is undoubtedly the main aim of modern agriculture because it will allow:

—to control agricultural and stock-breeding production,

— to organize rationally the marketing of the crops and the export policy,

—to secure, for agricultural industries, their regular supply with raw materials of suitable quality and sufficient quantity,

—to stabilize to a great extent the net income of agricultural population of the country.

Recognising the importance of irrigations for the progress of Greek economy and agriculture, their extension, as much as possible, is one of the main objectives of the effort of the State within the framework of the general programme for the country's development.

5.2 PRESENT SITUATION

Following the official statistical data of the State, the total irrigated area amounts to 844,000 ha (1975), 24 per cent of the total area of cultivated land in Greece (3,525,000 ha). The area irrigated by Government-built irrigation projects amounts to 222,000 ha, while the irrigable area is 326,000 ha.

The representation of the actually irrigated area as percentage of irrigable area shows the degree or index of valorization and it works out to 68·5 per cent for the year 1975.

Surface irrigation methods, i.e., by borders, furrows or flooding, etc., are applied on 502, 000 ha (59 per cent), while sprinkler irrigation is used on the remaining area of 342,000 ha (41 per cent).

The crops grown on irrigated lands are the following: tilled crops (cotton, corn, etc.) 68 per cent, orchards 18 per cent, horticulture 11 per cent, vineyards 3 per cent. In the areas served by State irrigation projects, the main crops are: cotton (21 per cent), trees (20 per cent), lucerne (17 per cent), corn (12 per cent), rice (9 per cent) sugar beets (5 per cent) and horticultural crops (4 per cent).

The waters used for State irrigation projects come mainly from summer runnoffs of rivers (58 per cent), springs (19 per cent) and secondly from reservoirs (10 per cent), natural lakes (7·5 per cent) and ground-water aquifers (5·5 per cent).

Till the end of 1975, in the State irrigation projects with surface irrigation, an area of 105,000 ha was levelled. The rate of increase of levelled areas is of the order of 8,000-10,000 ha yearly. From a technical point of view, the main features of modern irrigation systems in Greece are summarized as follows:

Surface irrigation projects

(*a*) Construction of integrated projects including, in addition to infrastructure features, the networks extending to the plots, as well as the land levelling works and the compulsory farm consolidation in order to adapt the plots to the layout of the hydraulic works.

(*b*) Application of a rectilinear and parallel layout of irrigation canals, lined totally with concrete or flumes with a correspondent layout of drainage ditches and operating roads.

(*c*) Equipment of irrigation networks by automatic level regulators and siphons for diverting irrigation water from tertiary canals to the plots.

Sprinkler irrigation systems

(*a*) Construction of complete irrigation networks for the conveyance of water under pressure through underground pipes, the distribution of water to the users "à la demande", the determination of the price per cubic metre and sprinkler irrigation.

(*b*) The application of sprinkler irrigation by low pressure (2-2·5 Kp/cm^2) rotary sprinklers installed on portable pipings.

(*c*) Equipment of the irrigation networks with special hydrants with a water metre, pressure regulator and discharge controller, as well as with automatic operation equipment for pumping stations.

5.3 PERSPECTIVES FOR 2000 A.D.

5.3.1 Expansion of irrigation

The expansion of irrigation is considered as a basic necessity of first priority for the developement of agriculture. The cultivated area actually amounts to 3,525,000 ha, as stated before, for a population of about 9,000,000. Consequently, the cultivated area corresponding to each inhabitant is about 0·4 ha. Under the condition that agriculture will be limited during the next 25 years to about 2,500,000 ha and that the population of Greece will then be of the order of 10,500,000, the cultivated area per inhabitant will decrease to 0·24 ha. It is obvious that the intensification of agriculture by the developement of water resources will allow to face the challenge of the increasing demand of Greece.

The competent State Services, after estimation of the possibility of developing irrigation in Greece, believed that the total irrigated area may be increased during the next 25 years from 844,000 ha at present to 1,600,000 ha, covering 64 per cent of 2,500,000 ha being the cultivated area to be in 2000 A.D. This result is expected to be achieved by the irrigation of 830,000 ha with river and spring waters, 370,000 ha by ground waters, 350,000 ha by reservoirs and 50,000 ha by natural lakes.

The necessary total volume of water to cover the demand of the above 1,600,000 ha was estimated at 7,550 million m^3. For the determination of the above value, the irrigation efficiency was taken as 80 per cent, which is expected to be obtained by the application of improved irrigation methods and better use of irrigation water.

This volume of water which has to be secured requires the drawing up and the implementation of a plan for a full mobilisation of all water supply sources, taking into consideration also the non-agricultural needs of water. The agricultural needs of water in Greece are limited to a relatively short period, from May to September, when the discharge of rivers and other sources is the lowest and the total volume of water does not cover, during that period, the needs of agriculture.

In some cases the distribution of water needs in Greece does not coincide with that of the supply sources. Only the construction of storage dams, sometimes combined with the transfer of available water to other catchment basins, as well as the increase of exploitable ground-water potential may secure the necessary water resources for the expected expansion of irrigation.

5.3.2 Evolution of technology

In view of the further assumed significant increase of the irrigated area of the country till the year 2000 A.D. and the concomitant reduction of the total agricultural land and of the active agricultural population, the problem of the right and economical use of water resources and of active agricultural population will become more acute. The efforts, without doubt, will be directed to the improvement of irrigation methods and to the drawing up of regional irrigation programmes for the best possible use of irrigation water.

The progress that took place, during the last 15 years, in irrigation technique is important, but it does not respond to all the actual needs. A possible substantial improvement in irrigation methods might be the localised irrigation. This method is sufficiently spread at present among farmers and there is a net tendency for its expansion. The main reasons for the interest in that method are economy in water obtained by the use of small flows of water corresponding to the evapotranspiration, the possibility to use low discharges of water and the automatization of irrigation to a great extent, having as a result a decrease of necessary work and expenses.

On the other hand, the irrigation programmes are expected to play a considerable role during the next 25 years in the right use of irrigation waters, aiming finally at increasing the yields, reducing irrigation cost or limiting the unfavourable indirect effects of irrigation.

For obtaining the above goal a complete knowledge will be needed of the complex system crop-soil-atmosphere for each irrigation region, so that water may be given in convenient quantities, when exactly needed, and on the basis of scientific and experimental research data, instead of the traditional or arbitrary rules.

TEHRAN SPECIAL SESSION 1977

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R. 14

LIKELY IRRIGATED AGRICULTURE OF 2000 A.D.

CONTRIBUTION PROBABLE A PARTIR DE L'IRRIGATION, DU DRAINAGE ET DE LA MAITRISE DES CRUES, POUR FAIRE FACE AUX BESOINS DE LA PRODUCTION AGRICOLE VERS L'AN 2000. ROLE ET ACTIVITE DE L'ICID ET DE SES COMITES NATIONAUX

par

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1. PLANIFICATION A LONG-TERME DE LA MISE EN VALEUR DES RESSOURCES HYDRAULIQUES ET DE L'UTILISATION DES EAUX POUR L'EXPANSION DE LA PRODUCTION AGRICOLE

1.1. EVALUATION DE LA DEMANDE POUR L'EXPANSION HORIZONTALE ET VERTICALE DE L'IRRIGATION ET DU DRAINAGE

1.1.1-Disposition actuelle des utilisations des terres et le rôle actuel de l'irrigation et du drainage

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* Probable contribution from irrigation, drainage and flood control to meet the requirements of agricultural production towards the year 2000—Role and activities of ICID and its National Committees.

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1.1.1-1. Surface (chiffres relatifs à l'année 1974)

1.1.1-1.1 Surface totale cultivée, (non compris des étendues de terrain réservé au pâturage extensif).

$$S_1 = 4.833.998 \text{ ha}$$

1.1.1-1.2 Surface totale de l'étendue destinée au pâturage extensif

$$S_2 = 222.150 \text{ ha}$$

1.1.1-1.3 Surface totale munie des facilités d'arrosage

$$S_3 = 684.508 \text{ ha}$$

1.1.1-1.4 Surface totale munie des dispositifs de drainage

Seuls les travaux de drainage effectués par l'Etat sont ici référés. On fait la distinction des aires mises en valeur uniquement avec des oeuvres de drainage, de celles qui, en plus, ont été munies de moyens d'irrigation.

On a:

$$S_4^1 = 18.400 \text{ ha}$$

$$S_4^2 = 45.255 \text{ ha}$$

1.1.1-1.5 Surface ayant des facilités d'irrigation et du drainage

$$S_5 = 684.508 + 18.400 = 702.908 \text{ ha}$$

1.1.1-1.6 La surface couverte aux points 1.1.1-1.3 à 1.1.1-1.5, destinée au pâturage permanent n'est pas assez importante. Elle est de 18.000 ha, à peu près.

1.1.1-1.7 D'une manière générale, toutes les aires exposées aux crues n'ont d'utilisation agricole qu'à des époques limitées, le printemps et l'été, surtout. Mais il y a toujours, malgré cela, des risques de grandes pertes dues aux crues printanières tardives ou automnales précoces. Dans des conditions pareilles se trouvent aussi les sols des plaines alluviales de beaucoup des cours d'eau du Portugal. On estime à près de 80.000 ha le total.

1.1.1-2. Zones d'irrigation

1.1.1-2.1 L'irrigation et le drainage sont, plus ou moins, prévus d'une façon uniforme dans tout le pays.

1.1.1-2.2 Le climat du Portugal continental est caractérisé par l'existence d'une saison sèche qui va de mai à septembre, dans laquelle le déficit hydrique atteint des valeurs élevées surtout aux mois de juillet et d'août. Le déficit est plus remarquable dans le sud du pays et dans le nord-est de Tras os Montes.

Pour les cultures printanières-estivales, l'irrigation est indispensable pour tout le pays, bien que sa valeur devienne plus grande lorsque le déficit hydrique augmente aussi.

Grosso modo on peut répartir le pays en trois régions naturelles d'irrigation et du drainage: le Nord atlantique, le Nord de Tras os Montes et le Sud méditerranéen.

La région du Nord atlantique est la plus pluvieuse et sa faiblesse hydrique estivale est peu marquée. C'est la région où les problèmes de défense et d'assèchement ont plus d'acuité. Au contraire, la pratique de l'irrigation est beaucoup facilitée par l'existence de débits permanents dans les cours d'eau, par la plus grande hauteur des niveaux phréatiques et par des besoins en eau d'arrosage bien moindres.

Aux régions du Nord de Tras os Montes et du Sud méditerranéen, la précipitation est faible et très concentrée à la saison des pluies. Les nécessités en eau pour l'arrosage sont très élevées et les ressources hydriques estivales superficielles ou souterraines sont fort faibles. L'irrigation dans ces régions, gagne son importance la plus élevée et exige toujours des infrastructures destinées à la rétention et à la retenue des eaux, pour la régularisation annuelle des ressources disponibles à la saison des pluies. Le drainage est encore un problème à cause de la concentration des pluies dans des périodes plutôt brèves et aussi à cause de la topographie plane de ces régions, facteurs rendus plus graves par l'imparfait drainage interne des sols.

1.1.1-2.3 Rapport des surfaces cultivées région/pays

(*a*) Surface d'utilisation agricole totale

Région Nord atlantique	32 pour cent
Région Nord de Tras os Montes	13 pour cent
Région Sud méditérranéen	55 pour cent

(*b*) Surface ayant des facilités d'arrosage

Région Nord atlantique	71 pour cent
Région Nord de Tras os Montes	8 pour cent
Région Sud méditérranéen	21 pour cent

1.1.1-3. Rendements agricoles

Les tableaux suivants donnent quelques unes des principales cultures du continent portugais ainsi que les respectives superficies moyennes annuelles cultivées et ses rendements unitaires correspondants, pour la décennie 1965/1974 (tableau N°. 1) et pour l'an 1975 (tableau N°. 2).

On ne peut faire deux cultures annuelles, ou davantage, que dans les aires irriguées, sauf des rares exceptions, ce qui ne signifie pas, cela va sans dire, que telle pratique soit une constante. Des facteurs, tels que l'indisponibilité de variétés culturelles de cycle réduit, la technologie peu évoluée, la petite ou nulle diversification culturelle et d'autres conditions, déterminent une seule culture annuelle, en général culture estivale irriguée, dans des surfaces considérables. En contrepartie, dans d'autres régions, et c'est le cas de l'Algarve, l'intensification culturelle est très élevée. Y faire trois cultures annuelles est commun.

TABLEAU I

Cultures	*Surfaces (ha)*			*Rendements (T/ha)*	
	Cultures à sec	*Cultures irriguées*	*Total*	*Cultures à sec*	*Cultures irriguées*
Blé*	531.000	—	531.000	1,1	—
Seigle	241.000	—	241.000	0,7	—
Riz	—	37.000	37.000	—	4,3
Maïs			419.000	1,3	4,5
Avoine	196.000	—	196.000	0,5	—
Orge	104.000	—	104.000	0,7	—
Pomme de terre			109.000	10,1	20,0
Tomate		20.132	20.132	—	40,0
Haricot			356.000	0,2	0,8

Le recours à des cultures de valeur commerciale élevée, telles que les cultures horticoles et les cultures fruitières, dépend de l'existence de facilités d'irrigation.

1.1.1-4. Il y a près de vingt années que la méthode de l'irrigation par aspersion a commencé à être adoptée au Portugal. Dans les premiers temps, elle ne fut employée que dans des petits aménagements privés et seulement très récemment elle fut introduite dans des grands aménagements hydro-agricoles réliasés par l'Etat.

Maintenant, on estime à 15.000 ha l'aire équipée et irriguée par aspersion, soit près de 2 pour cent de la surface totale irriguée, au Portugal. Près d'être achevés, il y a des plans d'aménagements hydro-agricoles de l'Etat, où l'on n'aura que de l'irrigation par aspersion et que, dans un bref délai, l'aire irriguée par aspersion sera agrandie jusqu' à près de 60.000 ha.

L'irrigation goutte à goutte est encore à sa phase expérimentale, n'ayant d'intérêt que pour des petits vergers et quelques serres de production horticole et des fleurs.

On peut donc conclure qu'à l'heure actuelle, on n'utilise, dans presque la

* Voir renvoi en bas de page Tableau II.

TABLEAU II

Cultures	*Surfaces (ha)*			*Rendements (T/ha)*	
	Cultures à sec	*Cultures irriguées*	*Total*	*Cultures à sec*	*Cultures irriguées*
Blé*	462.000	—	462.000	1,3	—
Seigle	210.000	—	210.000	0,7	—
Riz	—	30.000	30.000	—	4,4
Maïs	—	—	368.000	1,3	4,5
Avoine	207.000	—	207.000	0,6	—
Orge	101.000	—	101.000	0,9	—
Pomme de terre	—	—	107.000	9,5	20,2
Tomate	—	18.000	18.000	—	48,0
Haricot	—	—	304.000	0,2	0,8

* Les cultures spécifiques du régime des cultures à sec, tel le blé, sont capables de produire plus largement si on les insère à l'assolement des terrains arrosés, tirant parti de l'amélioration de la fertilité et de la possibilité de l'utilisation d'arrosages complémentaires. Le blé, par exemple, donne fréquemment, dans des conditions pareilles, des rendements de l'ordre de 4 t/ha.

totalité du périmètre irrigué, que des techniques d'irrigation d'écoulement en surface par débordement et par sillons, avec ou sans l'aide de syphons.

Quant à l'origine de l'eau pour l'irrigation, une évaluation basée sur des nombres avec des réserves, nous montre la distribution suivante :

—Dérivation de cours d'eau 27 pour cent

—Utilisation de retenue au moyen de barrages 14 pour cent

—Eaux souterraines (puits, sources, galeries) 59 pour cent

La garantie de l'irrigation à la période estivale est étroitement associée à l'hydraulicité de l'année hydrologique. Dans les aménagements avec barrage il y a, en général, une garantie d'irrigation dans 80 pour cent des années; dans les cultures irriguées utilisant des eaux souterraines, la garantie d'irrigation est plusieurs fois supérieure à 80 pour cent. Dans les cultures irriguées avec dérivation de cours d'eau, la garantie d'irrigation est évidemment moindre et l'agriculture estivale est très aléatoire, ce qui montre nettement la forte irrégularité du régime hydrologique général des rivières portugaises.

Les prix de revient des projets de mise en valeur hydrologique, hors sa variation d'après le type de l'aménagement, sont très influençables par les conditions particulières de chaque projet.

En moyenne, les coûts plus récemment pratiqués sont ceux qui figurent au tableau suivant:

TABLEAU III

Coût des ouvrages d'irrigation en 10^3 escudos/ha

Type d'aménagement	*Système d'irrigation*	
	Surface	*Aspersion*
Avec barrage de retenue	80–100	100–120
Avec dérivation de cours d'eau ou aménagement d'eaux souterraines	20–30	40–50

Quant à la compétence des irrigants dans l'utilisation de l'eau, on constate que seulement aux zones des cultures traditionnellement irrigués existe une technique d'irrigation acceptable, transmise et perfectionnée tout au long de beaucoup de générations successives. Dans les autres zones, les difficultés d'adaptation aux cultures irriguées sont, parfois, appréciables. Les services officiels y ont une tâche de la plus haute importance, l'expérimentation et la divulgation des techniques d'irrigation les plus convenables.

En général, le drainage des sols agricoles a, au Portugal, une grande importance, surtout dans la période pluvieuse, dû aux excédents des précipitations qui s'accumulent aux horizons superficiels des sols, à cause de la perméabilité interne imparfaite et de la topographie défavorable. C'est le cas le plus généralisé où la pratique du drainage superficiel, au moyen de fossés peu profonds, vise surtout à améliorer ou maintenir le niveau de la production des sols.

Des problèmes appartenant particulièrement au drainage des sols toujours détrempés et impropres pour être cultivés sont peu fréquents. Au niveau global, ils ne concernent que des surfaces insignifiantes. Ce sont des situations qu'imposent le recours à des solutions plus complexes, avec l'utilisation des fossés collecteurs et, à moindre degré, des drains souterrains, aussi bien que l'élévation mécanique de l'eau drainée.

Comme nous avons déjà référé, la défense des crues a une importance spéciale dans les plaines marginales des tronçons inférieurs des vallées, des plus importantes rivières portugaises. C'est le cas des vallées des fleuves Vouga, Mondego, Tage et Sado, où plusieurs dizaines de milliers d'hectares sont exposés à des crues, très fréquentes. qui demandent des travaux spécifiques de régularisation et de défense. Ces travaux ont des caractéristiques particulières aux zones des estuaires, où les problèmes de salinité demandent des ouvrages supplétifs de mise à profit des sols.

1.1.1-5. Brève évaluation

1.1.1-5.1 Il n'y a pas de données statistiques suffisant pour définir, au niveau national, le pourcentage de valeur de la production agricole qui résulte des aires irriguées, d'autres aires mises en valeur ou des surfaces protégées contre les crues. Pour les aires irriguées, d'accord avec les résultats économiques prévus pour les périmètres irrigués et en oeuvre, la culture irriguée donne des rendements bruts de l'ordre de 3 à 6 fois plus que ceux qu'on peut obtenir avec la culture à sec. Par exemple, au cas concret de l'Aménagement hydro-agricole de Vigia (2.100 ha), on prévoit, pour le produit brut d'origine végétal, une augmentation de 4 fois et de, à peu près, 9 fois pour le produit brut animal. Pour les aires défendues des crues, des études économiques plus récentes, estiment une augmentation du rendement brut supérieur à 100 pour cent.

1.1.1-5.2 Quant à la population rurale des zones englobées dans les cultures irriguées, on ne dispose pas d'éléments statistiques qui donnent une réponse concrète. On peut dire uniquement que la population rurale se concentre dans les zones où les cultures sont plus intenses et où les petits aménagements sont la majorité.

1.1.1-5.3 La mise en valeur hydro-agricole, en général est, au Portugal, un instrument basilaire de la politique de développement économique et social, soit à niveau régional, soit à niveau national. Comme il a été dit précédemment cette mise en valeur amène toujours un remarquable essor d'intensité culturale qui peut s'appuyer sur des cultures de haut rendement, destinées à l'exportation, en nature ou après transformation industrielle, ou se baser sur des cultures d'exclusif intérêt du ravitaillement national, en concourant de cette manière pour réduire les déficits des balances, commercial et alimentaire.

En liaison avec cette face du problème, il faut considérer encore la création de nouveaux postes de travail et l'amélioration du niveau de vie des populations du secteur agricole, des zones de montant producteurs de facteurs, et de jusant, de transformation et commercialisation agricole.

1.1.2 Tendances vers les changements dans les utilisations des terres

1.1.2-0. Explosion démographique prévue, pouvant affecter les tendances actuelles

La population du continent portugais était, en 1970, de $8590{,}5 \times 10^3$ habitants appartenant au secteur rural $6393{,}7 \times 10^3$ habitants et au secteur urbain $2196{,}8 \times 10^3$ habitants.

D'après la prévision de croissance de la population du continent, elle atteindra, en l'an 2000, le total de $9442{,}9 \times 10^3$, répartis par le secteur rural avec $6375{,}9 \times 10^3$ et avec $3067{,}0 \times 10^3$ par le secteur urbain.

1.1.2-1. Nécessité et politique de l'expansion de la production agricole

1.1.2-1.1 Il faut que la politique de l'expansion agricole portugaise va, avec décision, vers l'augmentation progressive des productions agricoles, de manière à suppléer ou amoindrir les hauts déficits de la balance commerciale et de la balance alimentaire, et à répondre aux nécessités croissantes

TABLEAU IV

Projections de la consommation humaine de quelques produits alimentaires

Produits	Prévision	Projections	
	1975	1980	1985
1. Viande, en général	366	435	575
2. Lait complet, liquide	614	854	1.087
3. Fromage	30	36	42
4. Beurre	6	9	12
5. Pommes de terre	835	820	806
6. Haricot sec	57	55	53
7. Maïs	203	178	150
8. Riz	134	141	148
9. Produits horticoles frais	1.270	1.200	1.150
10. Fruits frais	947	1.062	1.178

TABLEAU V

Exploitation de produits agricoles en comparaison avec l'exportation totale

Année	Exportation totale de produits agricoles		pour cent de l'exportation de produits agricoles par rapport au total exporté	
	En 10^3	En 10^3 milliers de escudos	Quantitè	Valeur
1970	1.667	7.964	38	29
1971	1.542	8.263	37	27
1972	1.479	8.538	35	24
1973	1.707	10.740	38	24
1974	1.852	15.801	39	27

d'une population dont les conditions de vie devront tendre vers des niveaux toujours plus hauts.

En ce qui concerne la balance commerciale, des productions agricoles qui ont contribué davantage, en 1947, pour son déséquilibre, ont été:

Maïs	$3{,}75 \times 10^3$ escudos
Sucre	$2{,}95 \times 10^3$ escudos
Viande de bovins	$1{,}29 \times 10^3$ escudos
Coton	$2{,}96 \times 10^3$ escudos
Oléagineuses	$1{,}57 \times 10^3$ escudos
Tabac	$0{,}45 \times 10^3$ escudos
Blé	$1{,}85 \times 10^3$ escudos

La suppression intégrale de ces déficits maintenant augmentés à cause de la croissance de la consommation, ne paraît pas viable. On croît, néanmoins, qu'ils pourront être réduits de manière considérable et dans un

TABLEAU VI

Exportations principales de l'agriculture

Produits	*Exportation totale*	
	En 10^3	*En 10^3 milliers de escudos*
Liège	86,7	1.132,6
Vins et eau de vie	184,8	3.768,6
Bois	606,5	1.733,5
Extraits de résine	109,8	1.542,1
Fruits	14,3	402,0
Huiles et graisses de provenance végétale	7,4	294,6
Produits de provenance animale	6,7	306,2
Pâte de papier	363,3	2.517,3
Produits horticoles préparés (dont 90 pour cent sont de conserve de tomate)	99,6	1.977,6

délai moyen, avec une planification convenable de la production, beaucoup d'intensification agricole et introduction de nouvelles cultures.

Quant à la consommation de produits alimentaires, des études récentes ont permis d'établir les projections de la consommation globale qu'on peut voir au tableau N.° 4, établi pour quelques produits alimentaires des plus importants.

Les valeurs de ce tableau nous montrent bien l'intensité de l'effort de production qu'il faut faire dans les années futures, surtout dans le domaine de l'élevage et de la production fruitière.

Dans le commerce avec l'extérieur, l'agriculture maintient son influence traditionnelle, avec une petite tendance à la croissance, ce qui peut se voir au tableau N°. 5:

En faisant l'analyse des exportations provenant des secteurs agricole, de l'élevage et forestier, on voit que sa diversification est plutôt petite. Les produits dont la position parmi les exportations est la plus haute, on peut les trouver, en valeurs de 1974, dans le tableau N°. 6, suivant.

1.1.2-1.2 L'augmentation de la demande de produits agricoles a, évidemment, grande incidence dans la politique du gouvernement, soit à moyen soit à long délai, surtout en ce qui concerne l'expansion des cultures irriguées et son intensification, et à la bonification des cultures à sec existantes, par l'inclusion de nouvelles cultures et leurs techniques. On tente, de cette manière d'améliorer l'approvisionnement interne en denrées alimentaires, augmenter les exportations et créer de nouveaux emplois.

1.1.2-2. Tendances en changement de l'utilisation des terres

1.1.2-2.1 En ce qui concerne l'intensification de la production des sols cultivées à présent, la tendance générale est vers une augmentation progressive du degré d'intensité au moyen de l'inclusion de nouvelles cultures, d'un plus grand emploi d'engrais, de l'adoption de techniques plus adéquates et la définition d'une favorable politique de restructuraction agraire.

Quant aux nouvelles cultures, l'orientation dernièrement suivie c'est l'incrément des cultures fourragères en vue de l'augmentation substantielle de la production de viande et du lait, bien comme de la betterave, des oléagineuses, du tabac et du coton, pour suppléer les importations qu'on faisait traditionnellement des colonies et encore les céréales et produits horticoles essentiels.

Sur l'emploi des engrais au Portugal, les indices respectifs, comparés à ceux qu'on connaît à niveau européen, sont très bas. En moyenne, ils sont:

N	17,0 kg/ha
PO_4	16,4 kg/ha
K	2,7 kg/ha

Quant à la mécanisation, elle a son plus grand essor au sud méditerranéen, où la topographie et la structure foncière et les types culturels offrent les meilleures conditions de rentabilité.

1.1.2-2.2 Bien que, au Portugal, tous les sols potentiellement productifs soient explorés, le type d'utilisation choisi ne s'ajuste toujours à son aptitude culturelle. Au fait, il y a beaucoup de grands périmètres avec utilisation agricole, dont la vraie aptitude est évidemment forestière.

Ce problème est de la plus haute importance et, selon des études récentes il occasionnera, dans un bref délai, une reconversion d'utilisation de, à peu près, 2×10^6 ha d'exploitation agricole en exploitation forestière ou agro-forestière.

1.1.2-2.3 Ayant en vue l'augmentation de la production agricole référée au 1.1.2-2.1, le Gouvernement a, en phase d'étude, un projet de restructuration du Ministère de l'Agriculture qui, avec d'autres mesures, vise à l'établissement d'un département national d'extension et d'assistance technique.

Pour hâter la reconversion citée au 1.1.2-2.2, on a créé, intégré au Secrétariat d'Etat des Ressources Forestières, un département spécifique.

1.1.2-3. Basé sur les valeurs de la demande de produits agricoles de haut intérêt estimés pour 1985 (voir tableau N°. 4), et considérant le taux moyen de croissance de la population et des capitations de ces produits, on peut estimer sa demande à l'an 2.000 (tableau N°. 7).

Comme nous avons déjà dit, la politique agricole du Gouvernement a toujours visé à l'intensification de la production agricole à travers la

TABLEAU VII

Demande prévue des produits agricoles à l'an 2000

Production	*Quantité* (10^3 *t*)
1. Viande, en général	1.048
2. Lait liquide complet	2.242
3. Fromage	67
4. Beurre	28
5. Pommes de terre	765
6. Haricots secs	47
7. Maïs	90
8. Riz	171
9. Produits horticoles frais	1.012
10. Fruits frais	1.608

valorisation de cultures à sec et de l'augmentation progressive des aires irriguées. Les objectifs de cette valorisation sont, foncièrement, d'une part, satisfaire lourds déficits de la balance alimentaire et de la balance commerciale et, d'autre part, contribuer, avec célérité, à la création d'emplois pour élever le niveau de vie et développer harmonieusement tout le pays, au point de vue économique et social.

1.1.3 Demande de mise en valeur hydraulique et d'utilisation des eaux

1.1.3-1. Expansion de l'irrigation et du drainage

1.1.3-1.1 L'expansion horizontale de la mise en valeur hydro-agricole (irrigation et drainage) est, pour l'agriculture portugaise, sinon le seul moyen, au moins le plus important pour la croissance de la production agricole, vu les conditions du pays.

D'après des études récemment effectuées, destinées à définir la projection des superficies à irriguer, l'an 2000, on a constaté que les limitations des ressources hydriques et des sols aptes à l'irrigation, iront restreindre l'expansion des aires irrigables et la limiter à un niveau inférieur au nécessaire pour couvrir tous les déficits des balances alimentaire et commerciale.

Pour les niveaux actuels de l'intensification culturale, on croit que pour satisfaire la demande de produits agricoles qu'on peut prévoir pour l'an 2000, il faudrait élargir l'irrigation de, encore 700.000 ha. Pourtant, les dernières estimations pour les périmètres potentiellement irrigables sont de l'ordre de 375.000 ha, un peu plus que 50 pour cent de l'aire totale qu'on juge nécessaire.

Sur le drainage, nous avons déja vu que le problème ne peut se séparer, en général, de l'irrigation, sans que toutefois il prenne une forte expression, sauf à de situations très spéciales, mais peu étendues en superficie, de zones particulièrement peu favorisées à cause des conditions de débordements saisonniers, permanents ou presque.

A l'an 2000, en espère que toute la superficie ayant des potentialités de mise en irrigation soit déjà mise en valeur. Dans le tableau N°. 9 se trouve sa distribution en trois grandes régions d'irrigation. On peut y voir, aussi, pour chaque région, la superficie totale irriguée qu'on peut prévoir, l'an 2000.

1.1.3-1.2 La tendance, aujourd'hui, est pour la rapide croissance de l'aire irriguée, à la demande des mêmes agriculteurs, au cas des petits aménagements et par l'initiative du Gouvernement, au cas des grands aménagements hydro-agricoles.

Les demandes d'exécution de petits aménagements se vérifient dans tout le pays mais elles sont particulièrement nombreuses dans la région Sud méditerranéen, surtout dans les "Unités Collectives de Production" dans la zone d'intervention de la Réforme Agraire.

Les demandes d'études et d'exécution de petits aménagements intéressent des aires de l'ordre de 80.000 ha destinés surtout aux cultures de maïs, tomate, riz et tabac, qui sont encore en phase expérimentale.

TABLEAU VIII

Prévision des superficies irriguées l'an 2000

Région	Aires irriguées, en ha		
	Actuel	Augmentation de l'aire irriguée jusqu'à l'an 2000	Prévision pour l'an 2000
Nord Atlantique	486.000	62.440	548.440
Nord de Tras os Montes	54.760	67.200	121.960
Sud méditerranéen	143.748	246.202	389.950

1.1.3-1.3 Le Gouvernement, aux demandes d'exécution de petits aménagements donne un appui très effectif soit financier, soit d'élaboration de projets. Cet appui est, pourtant, limité aux moyens techniques et financiers dont l'administration peut disposer.

1.1.3-2. Expansion verticale de l'irrigation et du drainage

L'intensification de la production des sols irrigués est, au Portugal, une préoccupation très aigue dans les grands aménagements hydro-agricoles.

Les problèmes relevant directement des aménagements d'irrigation sont d'une grande diversité; on citera, notamment, ceux du drainage de nombreux terrains à irriguer, l'adoption de techniques culturales permettant d'assurer aux sols une teneur raisonnable en matières organiques, la défense du sol et la lutte contre l'érosion des bassins versants qu'alimentent les lacs de barrage, voir les terres à irriguer, le nivellement du sol et la défense contre le vent, notamment le long du littoral.

Le périmètre d'Idanha où l'irrigation n'a atteint que 37 pour cent de la surface irrigable vingt-et-un ans après la fin des travaux, illustre bien un problème grave, posé par la nature du sol. En fait, les projets étant conçus pour l'irrigation par gravité, l'existence de vastes étendues de sol agricole très mince sur une couche imperméable argileuse rend les travaux de nivellement nécessaires à la bonne maîtrise de l'eau très difficile et très onéreuse. L'installation de l'irrigation par aspersion au niveau des exploitations obligerait les agriculteurs à des investissements très difficilement rentables avec les cultures actuelles.

D'autres problèmes surgissent dans le domaine des communications, dans celui du bien-être rural du fait de la création de nouvelles agglomérations et de l'amélioration des anciennes, ainsi que du ravitaillement en énergie électrique, sans cesse plus généralisé.

Afin de parvenir à une efficacité accrue de l'exploitation des aménagements hydro-agricoles, la mise en valeur du capital humain, soit grâce à l'instruction générale ou la formation de main-d'oeuvre spécialisée, soit par la préparation des entrepreneurs agricoles aux nouvelles tâches découlant de la transformation des sols par l'irrigation, est sûrement de la plus grande importance.

D'autres problèmes découlent des superstructures concernant l'industrialisation et la commercialisation des produits de la terre ou ceux qui sont nécessaires aux exploitations agricoles.

L'expansion verticale des aires irriguées contribuera foncièrement à la compensation des déficits des balances alimentaire et commerciale, complémentant l'action des nouvelles aires qui, sur ces entrefaites, sont peu à peu mises en irrigation. Sur ce sujet, il faut expliciter son action supplétive dans l'adoucissement des restrictions déjà référées résultant des limitations des sols et des ressources hydriques.

Pour les cultures irriguées de l'Etat, l'expansion verticale pourra avoir des effets similaires à une augmentation de la superficie irriguée de l'ordre de 15.500 ha; pour les petites cultures irriguées, presque toujours de l'initiative des particuliers, on croit qu'elle pourra causer des profits équivalents à ceux de l'irrigation d'une superficie supérieure à 100.000 ha.

La tendance actuelle est pour la modernisation des cultures irriguées traditionnelles, tâche que le Gouvernement a prise en mains en l'adossant aux Services.

Cette activité s'est avérée du plus grand intérêt économique-social et est en train de conduire à des résultats véritablement fructueux avec des répercussions sur les bienfaits de l'exploitation agricole et sur les conditions de vie de beaucoup de milliers de familles rurales, en élevant son niveau de vie et contribuant pour les fixer.

1.1.3-3. Diverses mesures de mise en valeur

En ce qui concerne la mise en valeur des marécages, l'intensification de l'exploitation de quelques périmètres déjà récupérés, basée sur une adéquate expérimentation agricole pourra apporter à l'agriculture intensive une superficie de 10.000 ha à peu près. Les possibilités de récupération des autres marécages qui exigent d'autres travaux pourront, dans un futur plus ou moins éloigné, embrasser encore 8 à 10.000.

Ces travaux sont en train d'être étudiés et faits par les services officiels qui, pour appuyer ses représentations, ont commencé des études expérimentales sur la récupération de salés dans la Lezíria Grande de Vila Franca de Xira (Bassin inférieur du Tage).

1.1.3-4. Brève évaluation

D'après le programme des nouvelles cultures irriguées, on prévoit à court délai la mise en valeur d'une superficie de 50.000 ha. à peu près, ce qui correspond à une augmentation de près de $1.000 \times 10^6 m^3$ d'eau déjà retenue pour des fins agricoles, dont on peut disposer actuellement $5.600 \times 10^6 m^3$.

Les motifs de la croissance de la demande d'eau pour l'agriculture ont été déjà largement référées. Ils sont, surtout, l'urgence d'augmenter les productions agricoles et créer de nouveaux emplois.

1.2. EVALUATION DU POTENTIEL POUR L'EXPANSION HORIZONTALE ET VERTICALE

1.2.1 Potentiel connu pour accroître l'irrigation

Tous les projets de mise en valeur hydro-agricole déjà sanctionnés pour être exécutés et ceux qui, probablement, le seront futurement, englobent des barrages de captation et de retenue. Le tableau N°. 9 nous donne une liste de ses noms avec la région d'irrigation et la superficie à mettre en valeur.

TABLEAU IX

Nom de l'aménagement	*Région*	*Aire à mettre en valeur ha*
Alqueva (Plan d'irrigation de l'Alentejo)	Sud méditerranéen	124.000*
Crato	Sud méditerranéen	6.300
Ribeira S. Domingos	Sud méditerranéen	650
Minutos	Sud méditerranéen	3.100
Marvao	Sud méditerranéen	600
Vigia	Sud méditerranéen	1.210
Lucefecit	Sud méditerranéen	1.300
Mondego	Nord Atlantique	15.000
Cova da Beira	Nord Atlantique	17.000
Nordeste Transmontano	Nord de Tras-os-Montes	23.300
Algarve	Sud méditerranéen	10.000
Lima	Nord Atlantique	5.800
Vouga	Nord Atlantique	48.300
Total		256.560

* C'est un projet dont les bénéfices—l'irrigation, l'énergie et l'approvisionnement en eau aux populations et à l'industrie, à moyen-long délai—ne seront obtenus qu'à partir de 1983.

Pour chaque projet est adopté le système d'aspersion sauf quelques exceptions d'aires aptes à la culture du riz ou avec des conditions pour l'irrigation par gravité.

1.2.2 Potentiel pour accroître l'intensité

Il y a, encore, de bonnes possibilités d'agrandir la productivité des terres irriguées, soit avec une mise en irrigation des sols les plus adéquats, soit à travers l'adoption de technologies plus évoluées, parfaitement adaptées.

Avec la mise en irrigation la plus adéquate, on peut faire une appréciable économie d'eau et une baisse marquée des coûts de la production. Au Portugal, généralement, l'efficacité de l'irrigation par gravité est plutôt petite. Elle descend jusqu'à des valeurs de l'ordre des 30 à 40 pour cent surtout à cause du mauvais apprêt des terrains, dimensionnement incorrect des éléments d'irrigation et, dans certains cas, à la déficiente préparation professionnelle des irrigants.

Le prix de la mise en irrigation est variable avec la topographie et la nature du sol. Il va de 10.000$00/ha à 20.000$00/ha.

Ce prix, si haut, surtout dans les cas les plus défavorables, a eu une appréciable influence sur la tendance à la généralisation du système d'irrigation par aspersion. Le coût d'une installation d'irrigation par aspersion, réseaux fixe et mobile, et stations de pompage, approche les 45.000$00/ha.

Le recours au drainage souterrain pour rabaisser le niveau phréatique et contrôler la salinité des sols, est aussi une technique qui peut augmenter la productivité de certains terrains irrigués. C'est le cas de la "Lezíria Grande de Vila Franca de Xira" et d'autres marécages dont la mise en valeur est en cours. Ce sont des travaux dispendieux dont le prix, aux conditions courantes est de 20.000$00/ha, à peu près.

1.2.3 Capacité de développer le potentiel

Le potentiel de croissance d'intensité de l'utilisation de l'eau, on peut le dire franchement favorable: pourtant on ne peut l'utiliser entièrement à cause de restrictions diverses parmi lesquelles on peut citer le manque de fonds et l'exiguité des moyens, techniques nécessaires, soit pour élaborer, soit pour exécuter des projets. Le rythme de développement des cultures irriguées au Portugal, fut, jusqu'ici, lent, 30 pour cent la première année, 60 pour cent la cinquième et 80 pour cent, à peu près, vingtième. Pour rendre meilleure, cette situation, on devra bien projeter et surtout, financer convenablement l'oeuvre d'irrigation et aussi l'irrigant, bien comme les Services d'extension et d'appui technique et les écoles de formation professionnelle. En phase de sanctionnement par le Gouvernement, il y a déjà un programme bien ambitieux dont l'objectif est la satisfaction des nécessités référées. Des données suffisantes nous font défaut pour une évaluation des coûts.

1.2.4 Plans pour l'évaluation finale

La planification de l'emploi des ressources hydrauliques est commise à la "Direcção-Geral dos Recursos e Aproveitamentos Hidráulicos", département de la "Secretaria de Estado dos Recursos Hídricos e do Soneamento Básico". Le rapport de ce département avec le secteur de l'assainissement basilaire est du type horizontal et beaucoup facilité parce que les deux secteurs sont intégrés dans le même Secrétariat d'Etat. Avec les secteurs de l'Energie et de l'Agriculture, les liaisons sont établies par des Comités spécifiques interministériaux.

Les liaisons avec la planification économique nationale se font à travers des organes soumis au Ministère du Plan et au Ministère des Finances à qui appartient l'orientation et l'approbation des plans d'aménagement des ressources hydrauliques.

2. CONTRIBUTIONS PROBABLES DES TECHNOLOGIES MODERNES ET DE LA GESTION DES EAUX

La croissance des productions nécessaires soit au marché interne soit à l'exportation impose l'intégrale mise à profit des ressources du sol, notamment des aires soumises et à soumetre à la mise en irrigation. Donc, le recours aux technologies modernes devra être équationné à deux niveaux:

(*a*) Dans l'intensification des cultures irriguées déjà existantes par l'introduction de nouvelles méthodes d'arrosage, en conduisant à une plus grande efficacité et permettant que la distribution de l'eau pour irriguer soit faite d'accord avec les nécessités des cultures. Cette intensification impose aussi le recours à des variétés ou à des cultures adéquates, à schèmes variés d'engraissement et d'amendement et aussi d'une convenable technologie du sol.

Tous ces aspects imposent expérimentation adéquate, insuffisante parmi nous, et la possibilité de divulgation et d'utilisation des cultures irriguées par un service convenable d'extension et d'assistance technique.

(*b*) Dans l'élaboration des projets d'irrigation, qu'on devra faire d'accord avec les objectifs indiqués en (*a*) et dans le sens d'obtenir la plus grande souplesse et de la facilité d'adaptation à des conditions qui peuvent se modifier très rapidement. Donc, on doit abandonner le système de commande par montant, existant dans la plupart des cultures irriguées actuelles, en faveur de la commande par jusant et toujours, si possible, où projeteront les réseaux de manière à laisser à l'irrigant la liberté d'option par l'irrigation par gravité, par aspersion ou par le système goutte à goutte.

De cet exposé, on peut aisément conclure l'urgente nécessité de l'investigation aux domaines du génie rural et des cultures arrosées parce qu'il faut, doter, avec des structures adéquates à des vastes surfaces irriguées ou irrigables et y faire une agriculture rationnelle et évoluée.

L'expérience des pays où de tels problèmes sont déjà résolus nous sera très utile, n'oubliant toutefois les aspects particuliers imposés par les conditions de notre milieu.

3. CONTRAINTES ET PROBLEMES ESCOMPTES

Nous croyons pouvoir affirmer que les restrictions physiques dans les 25 années prochaines n'auront une influence décisive sur le développement et l'utilisation de l'irrigation et le drainage et défenses des crues, vu que les recours hydriques et les sols encore disponibles ne constituent un facteur limitatif à l'exécution des plans de développement pour les futures vingt-cinq années.

Les plus grandes restrictions au rapide développement de l'utilisation des cultures irriguées et du drainage et défense des crues, sont dues, sans doute, au faible niveau de l'instruction et à la déficiente formation professionnelle. Ces aspects constituant aujourd'hui une grande préoccupation, on va établir des départements d'extension et de formation professionnelle au niveau du Ministère de l'Agriculture et des Pêches.

En ce qui concerne les restrictions au delà des limitations des moyens financiers, les problèmes de commercialisation et des prix et du crédit agricole, sont les plus importants à référer.

Une des plus fortes limitations de toute activité agricole se rallie aux aspects de la commercialisation et des prix. L'intervention de l'Etat fut fréquente soit en fixant des prix (blé, riz, huile d'olives...), soit en fixant des limitations (viande, vin, pommes de terre...), soit encore en garantissant des prix.

Pourtant, les prix d'une grande partie des produits sont libres, surtout en ce qui concerne les produits horto-fruitiers.

La politique interventionniste de l'Etat a, pour l'agriculteur, en règle, plus d'intérêt quant à la garantie des prix et de l'écoulement des produits qu'en ce qui concerne le niveau des profits. Ce type d'intervention présuppose logiquement une politique agricole bien définie, ce qui n'a été le cas, parmi nous.

Avec des prix se formant sans contrainte, le rôle des intermédiaires a été très onéreux, en absorbant, quelquefois, une partie indispensable pour couvrir les coûts de la production. Il faut, donc, accélérer le virage en ce qui concerne les circuits de commercialisation, en réduisant le nombre de participants. C'est la politique des prix.

Tout d'abord il faut accélérer la création d'unités de conservation et de magasinage, dûment étudiées, dimensionnées et localisées, afin d'améliorer les produits, d'adapter l'offre à la demande et de réduire le montant des intermédiaires. Tous ces aspects évidents et mis en lumière depuis beaucoup de temps sont cruciaux pour le développement des cultures irriguées parmi nous.

En ce qui concerne la politique de formation de prix, il faut signaler que, pendant beaucoup d'années, on a pratiqué une politique de stagnation des prix des produits agricoles, afin d'assurer à l'industrie naissante une bonne marge de profits. L'essor industriel fut basé sur des salaires bas et ceux-ci dans le bas prix des denrées alimentaires, ce qui a déterminé le congèlement et la fixation des prix agricoles qui, maintenus au long des années, ont aidé à amoindrir le secteur, en décourageant les investissements. Il y aura, aussi, à assurer, dans une politique agraire globale bien définie, le placement des produits et l'assurance de prix flexibles et compensateurs.

Un autre facteur d'étranglement, noté depuis beaucoup d'années, c'est le manque de crédit dans ses diverses modalités—bref, moyen et long délai. En disposer, c'est une nécessité urgente. Sans obvier à cette grave lacune, on ne pourra pas dynamiser tout le procès économique de l'activité agro-pécuaire.

En ce qui concerne la production et la productivité, c'est clair qu'il faudra marcher vers l'utilisation rationnelle des aptitudes des sols et chercher à obtenir, dans les plus divers secteurs, des prix pouvant concurrencer dans les marchés internationaux.

C'est inutile, dans cet aspect, montrer l'intérêt d'employer de la semence et des plantes sélectionnées, d'introduire et d'obtenir de nouvelles cultures, ce qui sera décisif surtout aux deux secteurs, le viticole et le fruitier. Maintenant l'emploi de la semence sélectionnée est surtout fait avec le blé et l'orge (en culture sèche) et avec le riz et le maïs (en culture irriguée). L'emploi des engrais, est en chemin d'agrandir, mais il est encore loin des niveaux européens. La mécanisation faite rationnellement et progressivement sera un autre facteur de développement à avoir en considération.

Les lois sur terres, eaux et ambiant, viennent d'être beaucoup modifiées dû aux transformations politiques dernièrement survenues. Donc, les déficientes structures rurales du pays doivent être corrigées à travers un procès de Réforme Agraire, en exécution, ayant été déjà nationalisées les terres appartenant aux cultures irriguées de l'Etat. Inclus aussi dans ce procès, la structure des zones de latifundia du sud du pays qui se transforme vers une intensité de cultures plus grande, en assurant une augmentation des emplois et une plus juste répartition des bénéfices.

Dans les autres régions, notamment au Nord, les restrictions du développement à cause des minifundia, devront être amoindries par le recours à l'associativisme agricole.

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COMITE NATIONAL IRANIEN DE L'ICID

SESSION SPECIALE DE TEHERAN 1977

R. 15

LIKELY IRRIGATED AGRICULTURE OF 2000 A.D.

LAND RECLAMATION FOR THE ENHANCEMENT OF AGRICULTURAL PRODUCTION IN THE USSR*

USSR National Committee, ICID

The Guidelines for the Development of the National Economy of the USSR for 1976 – 1980 approved by the 25th Congress of the Communist Party of the Soviet Union, state the main objective of agriculture for the given period to consist of ensuring further growth and stabilization of agricultural production, its comprehensive intensification and efficiency enhancement as a means of better meeting the demands of population for food and those of industry for raw materials, as a way of providing the required state reserves of agricultural produce.

The volume of agricultural production is largely conditioned by the area and productivity of agricultural lands, plowlands in particular.

In 1950 – 1961, the plowland area in the USSR grew to reach 224 million hectares mainly at the expense of plowing the wild and abandoned lands. Plowlands might be further expanded primarily through land reclamation involving drainage of bogs, irrigation of deserts and other developments.

Another way of increasing the output of agricultural produce, consisting of raising the productivity of agricultural lands, is also related to land reclamation including irrigation, drainage, water-erosion and flood control, pasture water supply, removal of brush, hillocks, stones, etc.

Nearly 80 per cent of the USSR agricultural lands are situated in the moisture-deficient zone. Two-thirds of commodity grain are produced in such arid regions as the South Ukraine, Povolzhiye, the North Caucasus and Kazakhstan.

The conditions found in the USSR permit raising such valuable heat-loving crops as rice, cotton, etc., on irrigated lands. Irrigation of agricultural crops and perennial plantings, of meadows and pastures both in the

* Mise en valeur des terres pour l'accroissement de la production agricole en URSS.

arid and moisture-deficient zones, increases the yields 1·5 – 2 times and more.

Lands under reclamation cover about 8 per cent of plowlands and plantations (15 million ha under irrigation and 10 million ha under drainage) and yield approximately 25 per cent of all plant-growing produce in terms of money. In the recent years, the irrigated and drained lands have accounted for about half the increment of the gross agricultural produce.

Lands under irrigation and drainage supply 100 per cent of the gross output of cotton and rice, 65 per cent of vegetables and cucurbits, some one-fourth of fruit, over one-third of grapes.

Fodder from reclaimed lands and watered pastures provides two-thirds of wool, almost all Karakul, much milk, meat and other products of animal husbandry. The cost of the agricultural produce obtained from lands under reclamation exceeds 9 billion roubles.

Construction of irrigation and drainage systems calls for substantial initial capital investments (1–5 thousand roubles/hectare). These expenditures, however, are repaid in 5–7 years, which testifies to their high economic effectiveness. The value of the produce obtained per hectare of irrigated lands is three times as much, and that of drained lands 1·5 – 2 times as much as the output of dry farming.

Alongside chemicalization, mechanization and selection, land reclamation is one of the main trends of scientific and technological progress in agriculture, one of the principal ways of intensifying agricultural production, and an indispensable condition for its steady and accelerated development.

Work in land reclamation has gained a great swing since May 1966 when the CPSU Central Committee approved a realistic, science-based long-term program for extensive land reclamation.

Implementation of this program has been made possible by the very course of the economic development, and is based upon the increased economic and technological power of the country.

Another stride will be made in improving agricultural lands in the current Five-Year Plan period. The area of lands under reclamation will grow from 25 to 35 million ha. Additional 37·6 million ha of pastures will be irrigated.

About 40 billion roubles will be allocated to the reclamation and agricultural development of lands (170 billion roubles allotted to the development of agriculture by and large): this equals the amount total for the preceding 10 years.

In order to set up large zones of secured grain production, work will be hastened on land irrigation in dry Povolzhiye, the North Caucasus and South Ukraine, as well as in the drained areas of the Baltic republics, Byelorussia, the Ukraine, the RSFSR Non-chernozem zone and in other regions. The total annual production of grain on lands under reclamation will make up 20 million tons by the end of the Five-Year Plan period.

By the same time, rice production will rise close to the level of three million tons (two million tons were harvested in 1975 with the yield of

40 metric centners per hectare). In the Kuban lower reaches alone, annual rice output will reach to one million ton due to the expanson of rice plantations in the abandoned floodplain and the construction of the Krasnodar reservoir. Rice growing will continue advancing in Kazakhstan, the Far East, in the Amudarya and Volga lower reaches.

The production of corn grain on irrigated lands will be doubled.

By 1980, the gross output of vegetables on irrigated lands will be brought to 17·3 million tons by way of completing the construction of irrigation systems for specialized vegetable-growing farms in the zones of big cities and industrial centres, and extending the commodity production of early and heat-loving vegetables in the southern regions of the country.

By the end of the Five-Year period, the output of raw cotton will exceed 9 million tons (8·4 million tons were harvested in 1974 with the average yield of 28·8 metric centners per hectare). The cotton-sown areas will be expanded and the yield raised, involving primarily the fine-fibrous varieties on the irrigated lands put into service in the Karshi Steppe and the zone of the Karakum Canal which delivers water from the Amudarya River for 900 km.

Irrigation will permit increasing the production of sugar beet both in the old and new regions of irrigated beet-growing. It is planned to embark on setting up big irrigation-based agro-industrial complexes for sugar production.

The Far East is the principal soya-producing region in the USSR. Alongwith raising the production of soya on the drained lands of the Far East, soya is envisaged to be grown on irrigated lands in the RSFSR and Ukraine southern regions, in Moldavia and the Transcaucasian Republics. Irrigated soya yields 2 tons per hectare in the southern regions.

Reclamation operations are to ensure a gain in the production of flax, tea, tobacco, sorghum, in the output of ethereal and medicinal plants, fruit, berries, grapes and other valuable produce of crop growing.

Particular importance is attached to land reclamation in further enhancement of animal husbandry which will be gradually provided with an industrial basis. A task posed herein is to establish a stable fodder base for big animal-raising complexes on lands under reclamation. This involves solving a complicated problem of utilizing waste water from animal farms for fertilizer irrigation. All this will permit saving a great quantity of fertilizers and improving soil fertility on the one hand, and effectively protecting water bodies from pollution on the other.

Land reclamation and development in Polesiye allows for setting up a large base for meat and milk production in the region.

Provision of irrigated haylands and pastures, and improvement of natural fodder lands will be carried out on a large scale, at high rates.

Specialized seed-growing farms will be created on reclaimed lands to secure the production of commodity seeds of perennial grasses, alfalfa included.

Land reclamation will gain a prodigious swing in the RSFSR non-chernozem zone to further the progress of crop farming and animal husbandry.

The task to be accomplished consists of both obtaining high, steady yield of agricultural crops on lands under reclamation and enhancing the quality of agricultural produce (the content of protein in grain and soya, that of sugar in grapes and sugar beet, etc.). This calls for abiding by an advanced general field management implying the application of appropriate fertilizer amounts, timely and effective accomplishment of all field operations and irrigations.

Since the total increment of agricultural produce in the current Five-Year Plan period will result from the increase of labour efficiency, one of the key objectives will involve drastically enhancing the mechanization of irrigation in the existing and, what is still more important, in the new irrigation systems to be put into service.

The fleet of sprinkler machinery will be replenished with 136 thousand machines and installations. The significance of this manifests itself in the fact that in 1975 sprinkling covered quite over 4·4 million ha, or nearly one-third of all lands under irrigation. "Dnepr", new sprinkler sideroll machine, will come to irrigated fields alongwith such highly productive machines as "Fregat" and "Volzhanka" mastered by the industry. The machine has an operation range of 450 m which permits feeding it from a subsurface network with pipes spaced at 900 m. It waters 2 ha of crops from one position. Construction of piped irrigation systems admits of saving land and water, provides conditions for the mechanization and automation of irrigation, for a sharp increase in labour efficiency. Much work will be done on mechanizing the methods of surface water application.

The construction of double-acting systems allowing both drainage and irrigation wll be further promoted in the drainage zone.

Subsurface tile drainage will be built on 70 per cent of the drained lands to be put into use in the current Five-Year Plan period.

It is planned to improve the technical condition of irrigation systems in operation. Improvement of soil conditions, enhancement of water availability and fundamental levelling of irrigated lands will be carried out on the total area of 4·4 million ha., and reconstruction of drainage systems will cover about one million ha.

The construction of new reclamation systems, renovation of the existing ones and land-levelling operations will encompass an area exceeding 23 million ha. Besides more than 37 million ha of pastures will be water-supplied. Thus, during the current Five-Year Plan period, reclamationists will drastically improve 10 per cent more of the country's agricultural lands.

Common structures (including pumping stations) in reclamation systems are built of precast reinforced concrete, which permits complete industrialization of their construction. By 1980, the output capacity of plants belonging to the USSR Ministry of Land Reclamation and Water Management (Minvodkhoz SSSR) will exceed 10 million m^3 of precast reinforced concrete per year.

Constructing organizations will be consolidated and equipped with high-efficiency machinery. Those under the Minvodkhoz SSSR carryout earthwork of over 6·2 billion m^3 per year. Industrial ministries have introduced earth-excavating machines of continuous action, which produce finished canals requiring no additional work. Sets of concrete-placing machines have been devised to perform uniterrupted mechanized lining of canal bottom and slopes with concrete.

Special attention will be paid to providing an industrial basis for the operation of reclamation systems, and to completing the process of turning over the maintenance of on-farm systems to state operation-and-maintenance organizations.

To speed up the development of reclaimed lands, irrigation and drainage systems should be brought into service together with appropriate dwellings, cultural, public-service and industrial buildings and communications including roads, power transmission lines, water mains, etc. Proceeding from the experience gained in the Golodnaya Steppe, the construction of reclamation systems in unpopulated areas will be integrated with providing the infrastructure of state farms (sovkhozes). As compared to the previous five-year plan period, the investments in land reclamation will be augmented 1·5 times during the current one, while those in sovkhoz construction will grow three times. Apart from the Golodnaya Steppe, integrated construction of reclamation and agricultural projects will be carried out widely in the Karshi and Dzhizak Steppes, in the Far East, Povolzhiye, Polesiye and some other regions.

Alongside the construction of reclamation systems specialized state farms are set up in undeveloped desert regions. During the first years, the development of these lands is carried out by a main contractor organization until the planned yield of agricultural crops is attained and the farms are completed with personnel and machinery. Reclaimed lands are presently under development in the new 100 big cotton–, rice–growing and animal –raising sovkhozes in the Golodnaya Steppe, the Syrdarya and Amudarya lower reaches, in Polesiye and Povolzhiye. After land development, the sovkhozes organized therein will be turned over to agricultural agencies.

Huge land and water resources are available in the USSR for further advance of land reclamation.

Analysis of potentialities for further increase of the agricultural production in the USSR, shows the reserves for expanding plowlands and areas under fodder crops without drastic reclamation to be practically exhausted. Land reclamation potential, implying the area of lands requiring and suitable for irrigation and drainage, is assessed at 150 million ha.

The long-term forecast-plan of land reclamation development for 1985, approved by the Government, envisages bringing the area of lands under reclamation up to 48 million ha. As a result, the reclaimed lands (or the fodder obtained therefrom) will yield—47 million tons of grain, 10 million tons of raw cotton, 28 million tons of vegetables and cucurbits, 7·5 million tons of meat, 48 million tons of milk and above 500 thousand tons of wool.

Mean annual river flow makes up 4,714 km^3 in the USSR. However, the distribution of water resources over the country territory is extremely uneven.

The high rates of development in industry and agriculture, the improvement of water supply for the growing population of the country, have brought about a sharp rise in water consumption which increased more than threefold in the last 25 years and exceeded 300 km^3 per year.

Much work was done during the years of the Soviet power in the plan-based use of water resources to the interests of all branches of the national economy There have been built large water resources systems, cascades of multi-purpose headworks on the Volga and Dnieper, on the rivers of Central Asia, the Transcaucasia, Siberia and other regions of the country.

Despite this, even now during some dry years, water supply is reduced for a number of branches of the national economy in the most developed southern regions encompassing the main industrial potential, almost all the areas under irrigation and such unique fishery water bodies as the Caspian and Azov seas.

At present, irrigation accounts for about 45 per cent of the total water consumption and about 70 per cent of the irretrievable consumption. Water resources become deficient already in a number of important irrigated regions. Therefore, great work will be carried out during the current Five-Year Plan period on the reconstruction of the existing irrigation systems, accompanied by the implementation of technical and organizational undertakings, which will make possible economical use of water resources.

The following reservoirs will be constructed to incorporate unique buttress dams: the Andizhan reservoir in Uzbekistan, the dam being 115 m high and the volume of concrete used amounting to 3·8 million m^3, the Kirov reservoir in Kirghizia; the Krasnodar reservoir will be put into operation to its full capacity (3 billion m^3); the Tyuyamuyun reservoir (on the Amudarya River) will be commissioned to store 5·3 billion m^3 at the first construction stage. Provision of the Talimardzhan reservoir will permit expanding the irrigated areas in the Karshi Steppe almost two times and improving the reliability of water supply. Flow regulation for the irrigation needs will be started at the following multipurpose headworks: the Charvak headworks on the Chirchik River, the Toktogul headworks on the Naryn River in the Kirghiz SSR, the Nurek headworks on the Vakhsh River (the Amudarya tributary). Construction operations will be launched at several major multipurpose headworks, one of them being the Rogun headworks on the Vakhsh River.

Further social and economic progress demands that speeding up the accomplishment of extensive undertakings for prudent use of water resources and pollution control, and scientifically planning the development of water-consuming branches of the national economy, large-scale work should be started in good time to radically solve the problem of supplying high-quality water to the developing industry, agriculture and population.

In order to achieve the major long-term economic objectives for the water supply of the southern regions, the USSR Ministry of Land Reclamation and Water Management has been charged to work out the technico-economic justification for transferring part of the flow of the northern and Siberian rivers, and to draw up projects for the construction required for diverting part of the northern river's flow to the Volga River basin.

These tremendous plans are unprecedented in the world practice of hydraulic engineering.

Thus, the first stage of Siberian flow transfer envisages supplying 25 km^3 of water from the Ob River to the Syrdarya and Amudarya lower reaches. The total length of the canal makes up 2·3 thousand km. Water will be delivered by four pumping stations to a height of about 70 m. The installed capacity of the pumping stations is 1·4 million kW. The same flow amount is planned to be transferred from the northern rivers to the Volga. The Volga will supply water to the Don and farther on to irrigate the lands in the Rostov District, in the Stavropol and Krasnodar Territories. Feeding the Volga and the Don with the water of the northern rivers will permit not only preserving but further increasing the fish resources of the Caspian and Azov seas, particularly those of sturgeons. Projects are elaborated for the regulation of the flow from the Caspian Sea to the Kara-Bogaz-Gol Bay and the construction of a special headworks in the Kerch Strait to maintain optimal biological and salt regimes in the Azov Sea.

Effecting such large-scale developments in territorial redistribution of flow brings about great expenditures of finances and resources, and is liable to tell on the natural conditions of a number of regions and inland seas.

Wide comprehensive research will be carried out to provide scientific justifications for the priority and volumes of operations involved in the territorial redistribution of water resources, with due regard to the effect on the ecological, physiographical and socio-economic processes.

Further large-scale advance of irrigation involves the implementation of big projects for the regulation of river flow and its interbasin redistribution.

The volume and rates of land-reclamation operations can be reliably determined for a remote future with the availability of dependable forecasts for the yields of agricultural crops on the rainfed and reclaimed lands.

TEHRAN SPECIAL SESSION 1977

IRANIAN NATIONAL COMMITTEE OF ICID

COMITE NATIONAL IRANIEN DE L'ICID

SESSION SPECIALE DE TEHERAN 1977

R. 16

LIKELY IRRIGATED AGRICULTURE OF 2000 A.D.*

CONTRIBUTION PROBABLE DE L'AMENAGEMENT HYDROAGRICOLE POUR FAIRE FACE AUX BESOINS DE LA PRODUCTION AGRICOLE VERS L'AN 2000

RAPPORT DU COMITE NATIONAL MAROCAIN DE L'ICID

RESUME

Le Maroc prévoit d'ici l'an 2000 d'irriguer une superficie de 1.080.000 ha qui constitue la superficie maximum irrigable compte tenu des ressources en eau. Actuellement près de 500.000 ha sont irrigués.

Cet aménagement hydro-agricole devrait contribuer à satisfaire d'ici l'an 2000 les besoins du pays en sucre alors qu'actuellement on ne produit que 55 pour cent de nos besoins et aussi à diminuer l'écart entre production et besoins pour les céréales, le lait, la viande et l'huile. On prévoit pour l'an 2000 un déficit de 2.000.000 T de céréales, 700.000 T de viande, 600.000 T d'huile et 1/3 millions de litres de lait.

Seulement, ces objectifs ne peuvent être atteints sans une mise en valeur effective des terres qui seront équipées.

Cette mise en valeur dépend:

1. de l'évolution et de l'adaptation des techniques modernes aux conditions locales d'où la nécessité d'une collaboration internationale pour une meilleure maîtrise et connaissance de ces techniques et aussi la création de centre d'expérimentation et de recherche.
2. de la préparation des agriculteurs à recevoir et à utiliser ces techniques. Car si dans les pays développés les questions techniques dominent les débats, chez nous et dans d'autres pays en voie de développement, ce sont les questions socio-économiques qui sont les plus préoccupantes.

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* Likely irrigated agriculture of 2000 A.D. Role of ICID and its National Committees to meet the situation.

SUMMARY

In the year 2000 Morocco will have an irrigated area of 1,080,000 ha which is the maximum irrigable area, considering the available water resources. Just now about 500,000 ha are irrigated.

This hydro-agricultural project will help to satisfy in the year 2.000 the needs of the country in sugar whereas at present only 55 per cent of our requirements are produced. This will also enable to reduce the gap between production and requirements in cereals, milk, meat, and oil. In the year 2000 there will be a deficit of 2,000,C00 tons of cereals, 700,000 tons of meat, 600,000 tons of oil and 1/3 million of litres of milk.

But, these objectives can not be attained without an efficient development of land which will be equipped.

This development depends on—

1. Evolution and adaptation of modern techniques to local conditions. Therefore it is necessary to have an interntional collaboration for a better management and knowledge of these techniques and to create a centre for experimentation and research.
2. Training of farmers to understand and to utilize these techniques. When these questions dominate the discussions in developed countries, in our county as well as in other developing countries, we are more concerned about social and economic problems.

INTRODUCTION

Le monde doit se préparer à nourrir dans l'avenir une population en croissance constante et dont l'alimentation devra être mieux assurée, car les moyens dont nous disposons nous font un devoir de faire disparaître les grandes famines et de pallier les conséquences des catastrophes naturelles, dont la terrible sécheresse qui règne depuis plusieurs années sur une partie de notre globe constitue un funeste exemple.

Pour tenir ce pari, qu'il faut gagner à tout prix, l'homme dispose heureusement de moyens techniques qui s'affirment tout en prenant de l'ampleur. C'est une course essentielle qui est engagée entre la pénurie d'une part et l'imagination, et la capacité d'organisation des hommes d'autre part.

Le Maroc est un pays très divers où les cîmes émergées de l'Atlas sont proches des étendues désertiques. Mais l'ensemble du pays est situé en zone semi-aride. Le développement de la production agricole y est impératif. Or il passe nécessairement par la maîtrise de l'eau sous toutes ses formes; le bilan des ressources en eau peut être ainsi dressé.

Les ressources renouvelables sont de l'ordre de 25.10^9 m^3 par an (pluie utile) alors que les précipitations apportent quelque 150.10^9 m^3. L'évapotranspiration consomme 84 pour cent des précipitations, soit 125.10^9 m^3.

9.10^9 m^3 sont actuellement irrécupérables (crues exceptionnelles, ou survenant sur des oueds sans site de stockage favorable, eaux salées etc.). Il reste donc 16 10^9 m^3 mobilisables.

Sur ce total 8.10^9 m^3, soit 50 pour cent étaient exploitées en 1972. On estime à 12.10^9 m^3, les mobilisations prévues en l'an 2000, la récupération des pertes actuelles provenant de l'exploitation des nappes pour 1.10^9 m^3, le reste soit 3.10^9 m^3 étant à stocker dans des barrages à construire.

L'agriculture utilise actuellemet 7,5 10^9 m^3 sa part passera à 10.10^9 m^3 en l'an 1992.

La surface des terres utilisées directement par l'agriculture représenterait entre 7 à 8 millions d'ha alors que le territoire marocain s'étale sur plus de 50 millions d'ha.

L'utilisation agricole se répartit comme suit:

60 pour cent culture céréalière

25 pour cent jachère temporaire

5 pour cent plantation fruitière

10 pour cent autres cultures.

Environ 16 millions d'ha n'ont qu'une valeur de forêts et de parcours.

Ces données font apparaître le caractère extensif de l'agriculture marocaine fondée essentiellement sur la monoculture céréalière.

La céréaliculture occupe les plaines et les plateaux qui s'étendent entre les montagnes et l'Atlantique et qui reçoivent une pluviométrie suffisante. C'est dans ces régions que l'on trouve l'esentiel des autres cultures annuelles et des plantations fruitières.

Le reste du territoire constitué par le Sud, l'Oriental et l'intérieur du pays qui sont des régions au relief accidenté ou à faible pluviométrie se consacrent principalement soit à l'élevage, soit à l'agriculture irriguée, soit aux deux spéculations à la fois.

L'irrigation dont la progression est déterminante pour ces régions, représentant la plus grande partie du territoire national occupe une place privilégiée dans la politique agricole Marocaine.

L'objectif à long terme est l'irrigation de près d'un million d'ha. Ce million d'ha se répartit entre, d'une part 9 périmètres de grande hydraulique totalisant environ 700.000 ha et une multitude de petits périmètres de petite et moyenne hydraulique environ 300.000 ha.

La réalisation de ce programme nécessite la construction de près de 20 barrages dont 12 sont en service dominant une superficie de près de 400.000 ha.

Les superficies irriguées seront occupées par les cultures suivantes:

25 pour cent céréales

25 pour cent cultures industrielles (betteraves à sucre, canne à sucre, coton)

25 pour cent cultures fourragères

25 pour cent maraichages, arboriculture

La politique agricole du Maroc vise les objectifs suivants:

—réduire l'écart entre la production et les besoins en denrées alimentaires de base (céréales, sucre, oléagineux, lait, viande)

—améliorer le niveau de vie de la population rurale (+65 pour cent de la population totale)

—augmenter la participation du secteur agricole par l'exportation de produits agricoles (agrumes, primeurs, coton).

La question que l'on est amené à se poser et qui fait l'objet de ce rapport c'est : quelle est la contribution de l'irrigation et du drainage pour faire face aux besoins de la production agricole vers l'an 2000?

1. PARTICIPATION ACTUELLE DE L'AMENAGEMENT HYDROAGRICOLE A LA PRODUCTION AGRICOLE

1.1 PLACE DE L'AGRICULTURE DANS L'ECONOMIE GENERALE

L'agriculture a été considérée comme secteur prioritaire dans les trois plans de développement que connut le Maroc depuis son indépendance.

La part des investissements publics et semi-publics consacrés à l'agriculture s'est élevée à environ 30 pour cent au cours des deux premiers plans et à 45 pour cent au cours du plan 1968-1972, si on inclue dans les crédits alloués à l'agriculture sensu stricto ceux affectés à la construction des barrages dont l'agriculture est la principale bénéficiaire sinon la seule.

Au sein de ce secteur prioritaire, l'agriculture en irrigué constitue une autre priorité: bien qu'elle couvre moins de 10 pour cent de la SAU totale, celle-ci a bénéficié au cours du dernier plan de 62 pour cent des crédits affectés à l'agriculture (barrages compris). Près de 80 pour cent de ces crédits sont consacrés aux opérations d'aménagements hydroagricoles. A noter également que la quasitotalité des crédits d'équipements est affectée à la grande hydraulique.

1.2 SITUATION ACTUELLE ET DEVELOPPEMENT DE L'AMENAGEMENT HYDROAGRICOLE ET DE LA PRODUCTION AGRICOLE

Le Maroc prévoit d'ici l'an 2000 d'irriguer une superficie d'un peu plus de 1 million d'hectares dont à peu près 700.000 ha seront irrigués par des eaux retenues par les grands barrages ou par pompage c'est ce qu'on désigne par grande hydraulique (GH), ces 700.000 ha se trouvent dans des périmètres dont la superficie est supérieure à 5000 ha, les 300.000 autre font partie d'un ensemble désigné par petite et moyenne hydraulique (PMH) et se trouvent disséminés à travers tout le pays. Les périmètres de petite et moyenne hydraulique seront amenés à jouer un grand rôle dans l'équilibre économique régional du pays car en général ils se trouvent dans les zones sèches du pays (bours).

En 1975 la superficie totale irriguée par la grande hydraulique est d'environ 325.000 ha, les tableaux I et II donnent l'évolution des superficies irriguées.

TABLEAU I

Evolution de l'équipement réalisé par l'Etat de 1950 à 2000
(Grande Hydraulique)

(en ha nets)

Offices	*1950*	*1960*	*1970*	*1975*	*2000*
Moulouya	—	10.000	33.500	44.500	61.000
Gharb	11.000	22.000	29.000	65.500	230.000
Doukkala	—	6.500	21.000	26.700	90.000
Haouz	8.500	8.500	12.000	33.700	129.000
Tadla	18.000	51.000	78.000	93.000	117.000
Tafilalet	—	—	12.000	23.600	41.000
Draa	—	—	—	20.000	28.000
Souss	—	—	—	—	82.000
Massa	—	—	—	18.000	20.000
Loukkos	—	—	—	—	36.000
Total	37.500	98.000	186.000	325.000	834.000

TABLEAU II

Situation en 1975 des équipements en petite et moyenne hydraulique

Eau pérenne	*200.000 ha (dont 90.000 de façon moderne)*
Eau d'hiver	110.000 ha
Eau de crue	150.000 ha

Les superficies irriguées en PMH ne sont pas connues avec la même précision vu leur dispersion et l'absence d'inventaire précis.

La plus grande partie des superficies actuellement équipées est irriguée, mais la mise en valeur n'atteint pas le niveau d'intensité souhaité; les céréales irriguées extensivement occupent, par exemple, une trop grande place, tandis que d'autres cultures de plus grand rapport restent insuffisamment développées.

Le tableau III donne la composition des cultures irriguées au début et à la fin du précédent plan quinquennal ainsi que celle attendue à la fin du plan actuel (73-77) et en régime de croisière au stade final des aménagements. Ces dernières valeurs ne sont données qu'à titre indicaif, vu le terme lointain de ce stade final.

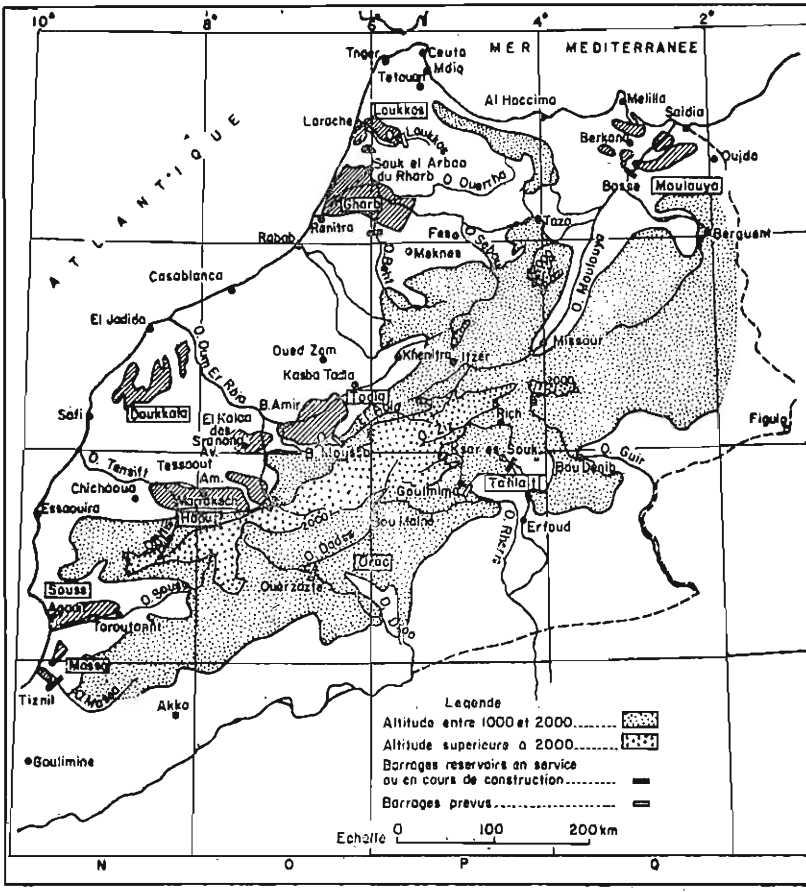

FIGURE 1 : Grands périmètres d' irrigation moderne

On remarque dans ce tableau que 2 cultures ont pris un grand développement: les agrumes et la betterave sucrière.

Le Maroc est actuellement le troisième exportateur d'agrumes parmi les pays producteurs du Bassin Méditerranéen. Le verger en 1972 couvrait 66.000 ha.* Il a produit 1.012.000 T pendant la campagne 1972-1973 et il correspond à une production de 1.500.000 T en 1980-81; l'abaissement de la rentabilité de cette production a conduit à adopter un plan de reconversion variétale par arrachage ou surgreffage des variétés s'exportant mal (variétés à pépins, fines et doubles fines, 17.000 ha environ) au profit des variétés de qualité très demandée (clémentines, navets et variétés de demi saison Washington sanguines et salutianas).

Une extension importante du verger semble encore possible, surtout si les marchés de l'Europe de l'Est se développent.

TABLEAU III

Importance et répartition des cultures irriguées

	1968 ou 1968/1969		*1972 ou 1971/1972*		*1977 ou 1976/1977*		*Fin d'aménagement des périmètres d'irrigation*	
	Superficie (ha)	*Product P(T)*	*S(ha)*	*P(T)*	*S(ha)*	*P(T)*	*S(ha)*	*P(T)*
Agrumes	60.000	726.000	66.000	876.000	86.000	1.150.000	115.000	2.500.000
Coton	13.200	18.800	16.200	26.400	34.000	59.000	94.000	193.000
Betterave (irriguée) (1)	12.700	67.000	32.000	136.000	35.000	170.000	68.000	345.000
Canne à sucre (1)	—	—	500	—	11.600	31.700	112.000	646.300
Riz	7.200	43.000	2.300	12.000	10.000	50.000	37.000	180.000
Céréales (irriguées) (2)	—	—	482.000	510.000	465.000	590.000	300.000	630.000
Fourrages (irrigués)	—	—	75.000	—	115.000	—	366.000	—
Maraichage	—	—	100.000	—	140.000	—	190.000	—
Oliviers (irrigués)	—	—	77.000	167.000	82.000	190.000	132.000	490.000

Observations:

(1) Pour la betterave et la canne à sucre, les surfaces et les productions de sucre en 1977 et en stade final de mise en valeur sont les objectifs fixés dans le plan sucrier.

(2) Le sixième environ des céréales irriguées est cultivé de façon intensive en 1972—le pourcentagesera porté au quart en 1977. Ces superficies ne comprennent pas les céréales irriguées par eaux de crue.

Les cultures sucrières vont prendre un essort considérable.

La culture de la betterave à sucre a commencé en 1962 et a connu depuis un brillant développement. En 1972-73, elle a été pratiquée sur 50.300 ha (220.000 T de sucre).

L'augmentation des prix du sucre sur les marchés mondiaux et leur flambée en 1974 a conduit le Gouvernement à refaire le plan sucrier. Alors que la production nationale était limitée à 66 pour cent des besoins, afin de bénéficier des prix extérieurs faibles, les nouveaux programmes ont pour objet de couvrir la totalité de ces besoins et même de créer, au moins temporairement, des excédents exportables. Ils réorientent de manière décisive les plans de développement de certains périmètres.

La superficie en betterave doit atteindre en 1976-77 65.000 ha (dont 30.000 environ en bour) et en stade final d'aménagement et de mise en valeur des périmètres, c'est-à-dire aux environs de 1990, 85.000 ha (dont 18.000 ha en bour).

La culture de la canne à sucre prendra une très grande importance dans le Gharb et le Loukkos où elle couvrira près de la moitié des surfaces irriguées; son importance sera moindre dans la Basse Moulouya. En 1977, la superficie de canne doit atteindre 11.500 ha (Gh : 8.320; L: 400, M:2.750) et 135.000 ha (Gh: 110.000; L:19.000; M: 5.600) en stade final.

La production de sucre doit être de 325.000 T en 1977 (taux de couverture 62,5 pour cent). A partir de 1984, année où l'équilibre doit se produire (650.000 T) la production devient excédentaire, jusqu'aux environs de l'an 2000 (tableau IV).

TABLEAU IV

Evolution de la production en sucre

(millier de tonnes)

	1975	*1980*	*1985*	*1990*	*1992*
Production	248	472	783	1102	1107
Consommation	519	600	696	806	855
Excédent ou Déficit	−271	−128	+87	+296	+252

La culture du coton connaît actuellement une certaine stagnation (16.200 ha en 1973 dont 13.200 dans le Tadla). L'augmentation des cours sur les marchés mondiaux en permettant un accroissement des prix d'achat à la production (prix concernant 80 pour cent de la production en 1973: 1,60 DH/kg; en 1974: 2,15 DH/kg) devrait entraîner une reprise.

Avec la complète mise en service dès 1977 du périmètre du Massa au Sud d'Agadir dans lesquels près de 6.000 ha devront être cultivés annuellement en maraichage primeurs, le Maroc affirme sa volonté de s'octroyer une part très importante du marché européen correspondant.

1.3 LA LEGISLATION SUR LA MISE EN VALEUR. LE CODE DES INVESTISSEMENTS AGRICOLES. L'INTERVENTION DE L'ETAT

Pour pouvoir atteindre les objectifs qu'il s'est fixé, l'Etat a adopté en matière de mise en valeur agricole et plus particulièrement hydroagricole une politique que l'on peut considérer de type contractuel, si l'on pense que les agriculteurs réclament unanimement l'irrigation pour laquelle seul l'Etat est en mesure de réaliser les investissements nécessaires. Cette politique peut se résumer ainsi en matière d'aménagements hydroagricoles: l'Etat fournit aux agriculteurs des périmètres la totalité des équipements hydrauliques et une aide importante, financière ou sous forme de prestations de service pour la mise en valeur. En contrepartie, ils sont tenus de mettre en valeur leurs terres suivant des normes précises. Cette politique est définie et les mesures d'application précisées dans une série de textes législatifs promulgués en 1969 et formant le "Code des investissements agricoles". Cette obligation de mise en valeur se trouve justifiée par le fait que les bénéfices des efforts consentis par la puissance publique doivent s'étendre au-delà des seuls agriculteurs des périmètres qui n'ont donc pas le droit de nuire à la collectivité par leur défaillance.

Les principales dispositions de ce code relatives aux périmètres irrigués dont l'application doit avoir un effet déterminant pour le développement de l'agriculture sont les suivantes:

L'Etat réalise l'ensemble des équipements d'irrigation et d'assainissement c'est-à-dire les équipements internes: séguias, colatures et améliorations foncières (remembrement, drainage, planage, épierrage, matériel mobile d'aspersion.)

L'Etat fabrique donc pour l'agriculteur un outil complètement achevé: il en assure la plus grande partie du financement (60 pour cent), la contribution des propriétaires bénéficiaires se limitant au paiement;

—d'une redevance annuelle et permanente pour l'usage de l'eau d'irrigation; cette redevance couvrant une partie de l'amortissement et des dépenses d'exploitation et d'entretien du réseau externe. Le prix du m^3 d'eau varie de 0,0225 DH à 0,0290 DH. Une majoration sera appliquée pour les eaux pompées.

—d'une participation directe des propriétaires à la valorisation des terres irriguées dont sont exonérés pour la tranche de 0 à 5 ha ceux possédant le périmètre. Cette participation est fixée actuellement à 1.500 DH/ha et des facilités de paiement sont prévues.

"L'Etat réalise l'ensemble des équipements d'irrigation et d'assainissement".

Les bénéficiaires de l'aide publique sont tenus sous peine d'être expropriés, de mettre en valeur leurs terres suivant les normes fixées suivant les conditions locales concernant:

—les plans d'assolements

—les techniques culturales

—la règlementation des modes d'irrigation et la discipline de l'utilisation de l'eau

—l'introduction d'une spéculation animale.

1.4 MODE D'IRRIGATION—CONCEPTION EQUIPEMENTS

On n'utilise presque exclusivement au Maroc que l'irrigation gravitaire. L'irrigation par aspersion n'a été adoptée jusqu'à ce jour que lorsque l'irrigation gravitaire n'était techniquement pas possible (sols légers, micro-reliefs...)

Ce maintien de l'irrigation gravitaire s'explique par le fait que jusqu'à présent les avantages de l'aspersion ne justifient souvent pas les investissements de départ et les dépenses en devises plus élevés qu'elle réclame, surtout dans les conditions socio-économiques existantes.

La contrainte d'économie de l'eau généralement intervient peu dans le choix du mode d'irrigation, soit que les quantités d'eau mobilisables dans des conditions économiques sont suffisantes, soit que les infiltrations peuvent être réutilisées par exploitation des nappes qu'elles alimentent ex: Haouz, Souss) ou dérivation à l'aval des débits des Oueds qu'elles soutiennent (ex: Bassin de l'Oum Er R'Bia).

Par ailleurs, il existe une tradition d'irrigation au Maroc et les aménagements hydrauliques internes étant réalisés par la puissance publique avant toute mise en eau, le démarrage de la mise en valeur devrait se faire rapidement et même sans délai en appliquant la nouvelle législation.

Les réseaux d'irrigation gravitaire sont bétonnés jusqu'aux prises quaternaires et, exception faite des canaux principaux adducteurs, sont en éléments précontraints et portés. Le régulation est assurée par des vannes à niveau amont ou aval constant et par des modules.

Il est souhaité de voir adapter par les agriculteurs l'irrigation à la raie et en calant à deux débits (d'attaque et d'entretien) au moyen de siphons tubulaires. Mais ceux qui pratiquaient l'irrigation avant l'introduction des équipements modernes abandonnent difficilement leurs techniques et se contentent bien souvent de simplement les améliorer (robtas ou billons doubles bassins).

Cependant, les espoirs de voir rapidement les agriculteurs utiliser convenablement les techniques modernes d'irrigation gravitaire étant souvent déçus, il sera sans doute accordé dans le choix du mode d'irrigation de plus en plus d'importance à la garantie d'une bonne utilisation de l'eau qu'apporte l'irrigation par aspersion (tableau V).

Dans l'optique actuelle, on estime que sur les 790.000 ha de grande hydraulique 240.000 ha environ seront irrigués par aspersion.

Le drainage souterrain, jusqu'à présent, ne s'est avéré indispensable que dans les terres lourdes (tirs) du périmètre du Gharb où sur les 300.000 ha de la plaine, il sera réalisé sur 200.000 ha environ. Les drains aspirateurs sont des tubes en P.V.C. annelés, de e intérieur 58mm, posés mécaniquement. La remontée de la nappe par les irrigations le rend nécessaire aussi dans d'autres périmètres (Loukkos, Tadla...)

TABLEAU V

Evolution des superficies irriguées par aspersion

Périmètre	*Réalisés en ha*	*En cours*	*En projet*	*Total*
Haouz central	280	—	20 000	20 280
Loukkos	—	1 500	38 400	39 900
Massa-Souss	19 000	6 300	8 900	34 200
Doukkala	1 220	16 000	16 600	33 820
Moulouya	—	—	13 500	13 500
Gharb	—	2 600	94 000	96 600
Total	20 500	26 400	191 400	238 300

2. DEVELOPPEMENT DE L'AGRICULTURE IRRIGUEE

2.1 EVOLUTION DEMOGRAPHIQUE ET BESOINS AGRICOLES

A la veille du futur plan quinquennal (1978-1982), la situation de l'agriculture marocaine se caractérise par:

—une forte inégalité dans la répartition de la propriété foncière environ

+87 pour cent des foyers ruraux possèdent entre 0 et 4 ha et se partagent moins de 35 pour cent de la superficie cultivable

+10 pour cent des foyers ruraux possèdent entre 4 et 10 ha et se partagent 32 pour cent de la superficie cultivable

+3 pour cent des foyers ruraux possèdent plus de 10 ha et se partagent 33 pour cent de la superficie.

—68 pour cent des exploitations utilisent uniquement de la main-d'oeuvre familiale

—52 pour cent des exploitations emploient l'énergie "animale" seulement

—35 pour cent déclarent n'ayant pas commercialisé de production (autoconsommation)

—un faible taux de croissance annuel de l'agriculture (3,6 pour cent) et une faible part de cette dernière dans la production intérieure brute.

—déficit chronique en produits alimentaires de première nécessité (céréales, viande, huiles, produits laitiers et sucre). Ces produits représentaient en 1975 plus de 20 pour cent de nos importations. Le tableau donne entre 1955 et 1975 l'évolution de la production et des besoins.

Evolution de la population

En 1977 18.500.000 habitants

Pour un taux de croissance démographique de 2,5 pour cent, les estimations de la population future sont:

1982–22.000.000

1992–30.000.000

2000–37.000.000 (40.000.000)

Cette croissance posera des problèmes énormes en particulier de nourriture. Nourrir cette population s'avère difficile sinon impossible.

Céréales, huiles, lait, vainde, sucre—à peine 80 pour cent des besoins sont couverts (tableau VI).

TABLEAU VI

Principales productions végétales et les pourcentages de couverture des besoins nationaux (1974)

Sucre	270 000 T	54,5% des besoins
Huiles	33 500 T	26% ,,
Céréales	4 800 000 T	89% ,,
Agrumes	943 000 T	589% ,,
Légumes	1 700 000 T	119% ,,

Une étude comparative entre 1955 et 1975 nous permettrait de faire une estimation sur les futures productions et besoins Tableau VII et VIII.

Besoins en céréales ont augmenté de 3 pour cent, alors que la production augmente de 1, 7 pour cent

Besoins en lait ont augmenté de 2 pour cent, alors que la production augmente de 1, 9 pour cent

Besoins en huile ont augmenté de 9, 2 pour cent, alors que la production augmente de 2, 6 pour cent

TABLEAU VII

Evolution de la production et des besoins agricoles entre 1955 et 1975

	1955		*1975*		*Taux de croissance annuel %*	
	Product.	*Besoins*	*Product.*	*Besoins*	*Product.*	*Besoins*
Céréales (1000 T)	2 882	1 946	4 015	3 482	1.7	3.0
Produits laitiers (106 L)	375	450	550	675	1.9	2.0
Huile d'olive (1000 T)		17	10	88		8.6
Viande (1000 T)	130	131	216	220	2.6	2.6
Sucre (1000 T)		333	251	500		2.0

Si on prendra en compte la croissance normale des besoins et une meilleure nutrition, les besoins futurs sont estimés à :

TABLEAU VIII

Evolution future des besoins

	1977	*1982*	*2000*
Céréales	3.947.000 T	4.562.000	7.361.000 T
Viandes	265.000 T	357.000	1.035.000
Produits laitiers	731.000 T	929.000	2.197.000
Huiles	155.000 T	225.000	861.000

Les prévisions pour l'an 2000 tabulent sur une évolution du niveau de vie et une amélioration de la consommation individuelle sauf pour les céréales. Les déficits seraient les suivants :

Céréales	2.000.000 T
Viandes	700.000 T
Huiles	600.000 T
Lait	1,3 millions de litres

ces chiffres reflètent l'ampleur des problèmes qui risquent de se poser à l'économie marocaine dans le futur.

2.2 EVOLUTION DE L'AMENAGEMENT HYDROAGRICOLE

Le potentiel des terres irrigables est estimé à l'heure actuelle à 1.080.000 ha dont près 835.000 ha situés dans les zones d'action des Offices Régionaux de Mise en Valeur Agricole. Au terme du plan 1973-1977 520.000 ha seront équipés (162.000 par pompage et 358.000 par eaux de barrages). La surface des terres restant à mettre en eau s'élèvera donc à 315.000 ha).

Actuellement l'ensemble des barrages existants (12) dominent une superficie de 410.000 ha. Les équipements des zones dominées couvriront fin 1977, 358.000 ha il subsistera donc un décalage de 52.000 ha.

Il est prévu de mettre en service avant l'année 1982, 8 barrages qui domineront une superficie d'environ 261.000 ha ce qui amènera la superficie à équiper entre 1977 et 1982 à 313.000 ha.

D'autre part conformément au plan sucrier les superficies dont il faut réaliser l'équipement à la fin de 1982 s'élèvent à 201.000 ha.

Rythme d'équipement

1967	6.000 ha/an
1970	22.000 ha/an
1975	43.000 ha/an

Compte tenu des potentialités des sociétés d'études et des entreprises de travaux, les rythmes d'équipements envisagés sont par année en ha:

1978	*1979*	*1980*	*1981*	*1982*	*Total*
16 500	39 150	52 600	57 650	59 700	225 600

On voit que même si ces prévisions sont réalisées, il subsistera un décalage entre zones dominées et zones équipées de 87.400 ha nettement supérieur au décalage actuel.

3. CONTRIBUTION DES TECHNIQUES AVANCEES A L'AMENAGEMENT HYDROAGRICOLE

La rentabilisation des investissements consentis en matière d'aménagement hydroagricole ne peut se faire sans une maîtrise totale des techniques d'irrigation, de drainage et de gestion des eaux.

Les techniques avancées ayant fait leur preuves dans d'autres pays ont à être testées voire adaptées aux conditions des pays où elles sont introduites.

D'autre part pour un pays comme le Maroc, le facteur limitant étant l'eau, un effort considérable devrait être entrepris pour l'économiser et ne fournir à la plante que ce dont elle a besoin.

Les techniques d'irrigation localisée ou microirrigation apparaissent très timidement, de même que les techniques de recharge artificielle de nappe etc....

Pour mieux s'imprégner de la contribution probable des techniques modernes, nous donnons ci-après un constat de situation pour ressortir les principaux axes des futures études et recherches.

3.1 UN ESSAI DE CONSTAT

3.1.1 La mobilisation de l'eau en tête du périmètre

—Les équipements de stockage ou de mobilisation de l'eau ont atteint à ce jour un développement considérable: témoin le nombre de barrages et le volume stocké correspondant, les stations de pompage, etc. La maîtrise de ces problèmes est satisfaisante, et les volumes qu'il conviendrait de mobiliser encore pour satisfaire l'ensemble des besoins agricoles ressortissent plus aux problèmes de disponibilités et de politique agricole (au niveau des coûts et des priorités) qu'aux problèmes "techniques".

—Par contre, au niveau de l'estimation des besoins, la relative abondance en eau "disponible" par rapport à la superficie équipé cache notre méconnaissance profonde. Il n'est que de comparer les résultats "variés" obtenus par l'application des diverses formules de calcul de l'ETP pour se pénétrer de l'arbitraire qui préside au choix des besoins de telle ou telle culture, et de l'imprécision (compréhensible sur le plan scientifique) des formules proposées et élaborées outre méditerranéen, voire outre Atlantique.

Cette imprécision (obligée) de nos outils scientifiques, trop souvent perdue de vue, conduit à des illogismes étonnants; il n'est que de constater avec quelle âpreté chaque projecteur défend, à la dizaine de m^3 près, "ses" besoins en eau et la facilité (apparente) avec laquelle il adoptera un coefficient de pertes en eau (à la parcelle et dans le réseau). D'un côté une "formule", même si elle est approximative, voire peu représentative, de l'autre côté des "indications" répétées d'un manuel à l'autre.

On reviendra plus loin sur ce problème fondamental (et bientôt d'actualité pour des périmètres aux ressources en eau limitées comme le Tadla, le Haouz, les Doukkalas) de la connaissance des besoins réels des plantes, et plus encore de la réduction de l'ETP.

3.1.2 Les réseaux d'irrigation

L'équipement de la plupart des nouveaux périmètres est conçu et réalisé selon des bases quasi intangibles: la trame B, le canal porté en béton, la distribution d'une main d'eau de 30 L/s.

La trame d'irrigation

Comme toute trame d'irrigation, celle-ci va plus loin que la simple redistribution géométrique des propriétés, et implique une forme spécifique de mise en valeur: planification autoritaire des assolements, exécution collective des grands travaux agricoles, de l'irrigation, etc. A ce niveau, il est nécessaire de faire la part des difficultés obligatoires, inhérentes à la mise en place d'une structure moderne modifiant profondément les structures traditionnelles et spécifiques de chaque périmètre.

Le canal horté en béton

On est en droit de s'interroger sur l'opportunité du réseau gravitaire en canaux portés en béton, quelles que soient les caractéristiques physiques et agricoles du périmètre (topographie, nature des sols, spéculation actuelle) et le type de mise en valeur projetée (intensification de l'assolement). Toutes choses égales par ailleurs, le canal porté est-il par exemple la solution la plus appropriée à l'irrigation des zones plantées (traditionnelles ou non), la plus économique pour des zones destinées à la céréaliculture?

Le calibrage à partir d'une main d'eau de 30 L/s

Bien que ce problème se situe théoriquement au niveau de l'irrigation à la parcelle (technicité des agriculteurs, système d'arrosage, etc.), il convient cependant de relever ses conséquences sur le réseau: une fois arrêtée la valeur de la main d'eau, le calibrage des canaux, le type de prise (TOR), etc, sont également fixés. Autrement dit, si ce débit est trop fort ou trop faible, c'est le réseau lui-même qui n'est alors plus adapté, et qui réduit d'autant l'efficacité de l'irrigation sur l'ensemble du périmètre.

On constate aujourd' hui que la valeur de la main d'eau uniformément arrêtée à 30 L/s est trop forte pour un certain nombre de périmètres, soit à cause de l'inexpérience des agriculteurs nouvellement installés en irrigué, soit à cause de l'emploi des méthodes d'irrigation traditionnelles adaptées à un débit de l'ordre de 10 L/s. Il conviendrait peut-être, cas par cas, d'analyser la situation afin, soit d'accélérer la mise en oeuvre de méthodes d'irrigation permettant l'emploi de ces 30 L/s, soit d'adapter le réseau aux conditions spécifiques de tel ou tel secteur.

3.1.3 L'irrigation à la parcelle

Au niveau des méthodes d'irrigation à la parcelle, force est de constater que les méthodes traditionnelles (essentiellement le robta) ou traditionnelles améliorées (billons brofonds de 20 à 40 m de long), sont encore les plus répandues; cet état de choses, normal dans les secteurs non aménagés l'est beaucoup moins dans des périmètres "modernes" ou conjointement à l'installation de la trame B étaient prévues des méthodes d'irrigation adaptées (raies, calant, corrugation, emploi généralisé des siphons) procurant l'efficacité maximum admissible en irrigation gravitaire. Devant cette situation, on est en droit de se poser les deux questions fondamentales:

(*a*) pourquoi la "modernisation" de l'irrigation s'est-elle arrêtée "aux portes" de la parcelle?

(*b*) cette situation est-elle préjudiciable à l'intensification de la production agricole?

(*a*) A la première question, on peut apporter 2 éléments de réponse:

(1) Le nombre et la diversité des tâches auxquelles avaient à répondre les techniciens jusqu'à présent, en regard de leur effectif limité, expliquent que les améliorations aient d'abord concerné les problèmes amont: régularisation de l'eau (barrage) et distribution (réseau).

(2) La diffusion de nouvelles méthodes d'irrigation relève plus de la vulgarisation que de la technique proprement dite: elle exige des expérimentations préalables, des techniciens et vulgarisateurs confirmés, une "durée" de mise en place sans rapport avec les délais de construction ou de conception

d'un réseau. En bref, il faut bien reconnaître une désaffection de la plupart des agriculteurs pour les méthodes modernes d'irrigation.

(*b*) La réponse à la seconde question est beaucoup plus délicate et complexe. Si l'on analyse en détail le principe de la trame B, on se rend compte qu'il dépasse largement le cadre d'un réseau d'irrigation ou d'une remodélisation du parcellaire, mais qu'il exprime en fait une "idée", pour ne pas dire une "philosophie" de l'aménagement.

3.2 OBJECTIFS D'UN CENTRE D'EXPERIMENTATION ET D'ADAPTATION

3.2.1 Les objectifs souhaitables de ce centre

Au moyen de recherches théoriques ou appliquées, d'expérimentation d'études, d'enquêtes, ce centre pluridisciplinaire aurait pour mission:

—d'affiner et de préciser les "outils" scientifiques utilisés au niveau de la conception et de la réalisation des projets d'aménagement et de mise en valeur;

—d'apporter un soutien scientifique et technique aux techniciens "de terrain",

—de mettre au point et diffuser les méthodes modernes de calcul et de traitement de l'information;

—de collecter, éventuellement de tester, puis de diffuser les techniques d'aménagement mises au point dans d'autres pays soit similaires au niveau des problèmes de la mise en valeur, soit de technologie avancée.

3.2.2 Des thèmes de recherches possibles

(*a*) Les besoins en eau

—Détermination des besoins en eau des plantes "in situ"

—Besoins globaux (au niveau d'un cycle végétatif);

—Besoins décadaires, mensuels et de pointe

—Réduction des besoins en eau en fonction des stades de développement et des périodes critiques (recherche de l'optimum apport en eau—rendement).

—Relations sol—eau—plante.

(*b*) La dose d'irrigation

Recherche et expérimentation sur:

—la notion et la détermination pratique de la R.U. en fonction des sols et des plantes;

—la notion et la détermination éventuelle de la R.F.U. ou d'un équivalent de "sécurité".

(*c*) Les besoins en eau—la dose d'irrigation

Recherches et expérimentation sur la mise au point d'un tour d'eau spécifique et d'efficacité optimale.

Au niveau d'un périmètre, concevoir les méthodes:

(1) d'information continue sur l'importance et la nature des cultures en place, les besoins en eau, l'état d'humidité du sol;

(2) de traitement synthétique de ces informations;

(3) d'organisation du tour d'eau:

Déclenchement et répartition optima des arrosages dans l'optique:

—d'une diminution des pertes en réseau,

—d'une réduction du personnel salarié affecté à la gestion

—d'une irrigation efficace à l'échelle du périmètre.

(*d*) Les méthodes d'irrigation et l'aménagement des sols

(1) Inventaire des méthodes d'irrigation "traditionnelle"

—les dispositifs et leurs dimensions

—les débits utilisés et utilisables

—les pertes en eau et en superficie cultivable

—les résultats agronomiques

—les caractéristiques d'utilisation (temps, personnel)

—les moyens nécessaires et les coûts d'installation

(2) Analyse comparée des méthodes d'irrigation "traditionnelles "en regard des contraintes rencontrées (relief, nature du sol, type de culture, parcellaire, valeur du débit disponible, etc.)

Ceci dans le double but:

—de metrre au point leurs améliorations éventuelles en tenant compte des contraintes "irréductibles" et des contraintes "réductibles",

—de connaître leur possibilité d'emploi et leur validité dans certains cas spécifiques.

(3) Etude et expérimentation sur les méthodes "modernes" d'irrigation gravitaire et l'aménagement des sols correspondant:

(4) Information, expérimentation sur les méthodes d'irrigation "de pointe" pratiquées pour des cultures et sous des climats similaires: aspersion goutte à goutte...)

—les conditions d'utilisation,

—les résultats agroéconomiques,

—les coûts correspondants d'exécution et d'entretien,

—les problèmes de vulgarisation,

—etc.

(5) Homologation des matériels d'irrigation (notamment d'aspersion) disponibles sur le marché.

(*e*) Les techniques du drainage

(*f*) Les techniques du lessivage des sols.

4. CONTRAINTES ET PROBLEMES

L'aménagement hydroagricole, pour être efficace, ne doit pas être conçu sans précautions essentielles, la plus importante étant de tenir compte des hommes qui le feront vivre et qu'il faut préparer à le recevoir. D'où la nécessité de la prévulgarisation, de l'organisation des hommes, de leur participation à la gestion. En particulier les structures de gestion, qui sont souvent des organismes concessionnaires sous tutelle de la puissance publique doivent limiter leur rôle aux ouvrages principaux, laissant à des organisations coopératives dont elles auront suscité la création de gérer les réseaux dérivés.

La participation de l'agriculture a été limitée par le technicien; celui-ci dans certains cas ne se voit responsable que de l'irrigation (culture de canne à sucre au Maroc), la puissance publique ayant aménagé se donne le choix de pratiquer les principales façons culturales pour rentabiliser son investissement. L'agriculteur devient un simple exécutant.

Or la réussite ou l'échec, le rythme de mise en valeur à l'irrigation dépendent essentiellement des hommes.

La rapidité et l'efficacité de la mise en valeur des périmètres à l'irrigation dépendent de l'organisation de la vulgarisation et de la formation technique et professionnelle dans les domaines de la maîtrise de l'eau et des productions à l'irrigation.

Les prévisions de resorption ou de limitation du déficit de production faites sur l'an 2000 ne peuvent se faire que si effectivement les taux de croissance de la production escomptés se réalisent. Or ceci ne peut se faire que s'il y a mise en valeur effective donc que si le décalage entre zones équipées et zones mises en valeur est resorbé.

Il en résulte que si dans les pays développés les questions techniques dominent les débats, chez nous et dans d'autres pays en voie de développement ce sont les questions socio-économiques qui, en tant que problèmes majeurs de la mise en valeur, paraissent les plus préoccupantes. Ceci nous amène à faire deux suggestions: la première est que dans les manifestations de l'ICID et ses publications, les questions à caractères socio-économiques figurent en bonne position à côté des questions techniques. La seconde est que, les problèmes n'étant pas universels, mais pouvant (tout au plus) être communs à des pays géographiquement voisins ou dont les niveaux de développement sont équivalents, l'ICID devrait organiser (ou aider à organiser) des conférences ou journées d'études régionales en liaison avec le groupe de pays concernés.

CONCLUSION

Le Maroc entreprend un programme important d'irrigation qui consiste à irriguer d'ici la fin du siècle 1.080.000 ha de façon moderne.

Des aménagements importants pour protéger la plaine du Gharb contre les inondations seront réalisés prochainement.

Les difficultés rencontrées dans la réalisation de ce programme tiennent surtout au régime foncier (exiguité et morcellement des exploitations, modes de faire valoir archaïques). On a tenté de résoudre ces difficultés par la mise au point d'une trame hydraulique et de voierie rationnelle et certaines dispositions législatives sur l'obligation de la mise en valeur et l'application de normes de cultures rationnelles mais le succès est partiel. La réforme agraire demeure une nécessité vitale.

La contribution de l'ICID et de son Comité National Marocain (l'ANAFID) à la réalisation de ce programme est indirecte et limitée: participation de techniciens Marocains aux manifestations nationales et internationales organisées par l'ICID et l'ANAFID. Lecture des publications de ces deux organisations. Participation aux groupes de travaux.

Le Comité National Marocain souhaite que l'ICID organise en collaboration avec les Comités Nationaux des journées d'études régionales sur des thèmes intéressants plus particulièrement les pays de certaines régions— bassins méditerranéens, Afrique, Moyen Orient etc... ou les pays en voie de développement. De même, il souhaite que les questions à caractère économique et social (notamment dans les pays en voie de développement) figurent en bonne place à côté des questions techniques dans les manifestations de l'ICID.

TEHRAN SPECIAL SESSION 1977

IRANIAN NATIONAL COMMITTEE OF ICID

COMITE NATIONAL IRANIEN DE L'ICID

SESSION SPECIALE DE TEHERAN 1977

R. 17

LIKELY IRRIGATED AGRICULTURE OF 2000 A.D.

PROBABLE CONTRIBUTION FROM IRRIGATION, DRAINAGE, AND FLOOD CONTROL TO MEET THE REQUIREMENTS OF AGRICULTURAL PRODUCTION TOWARDS THE YEAR 2000—ROLE AND ACTIVITIES OF THE ICID AND ITS NATIONAL COMMITTEES

G.D.R. National Committee, ICID

0. INTRODUCTION

Agriculture and food industry of the G.D.R. have according to the vote of the IXth Congress of the Socialist Unity Party significant orders: Their most important contribution is to guarantee the healthy nourishment of the people with high value food and the industry supply with raw material by own agricultural production in a growing scale.

The needed increase of the agricultural production, the increase and stabilization of the yields per ha, the further improvement of the quality of products and the production structure can in the long run only be maintained by a further increase of soil fertility and the formation of large production units.

The agricultural production in the G.D.R. becomes more and more intensive on the line of co-operation and is step by step developed to an industry-like production of crops and animals. These large production units distinguish themselves by a high degree of specialization, concentration as well as by horizontal and vertical co-operative relations.

That enables the complex use of all the measures for the intensification of production and an effective introduction of the scientific-technical progress as the main factor of that.

* Contribution probable à partir de l'irrigation, du drainage et de la maîtrise des crues pour faire face aux besoins de la production agricole vers l'an 2000. Rôle et activité de l'ICID et de ses Comités Nationaux.

In the socialist agriculture of the G.D.R. the further intensification has the priority because it decisively influences the increase of the level of production, the productivity and efficiency of livestock-farming, and of the whole agriculture and food industry.

The efforts are particularly done towards a permanent increase of the soil fertility and the further improvement of the soil culture, for

—the soil as the main production means of agriculture in the G.D.R. is one of the most important sources of social wealth. Its fertility can not only be maintained but also improved by additional expenditures.

—the cultivated area in the G.D.R. is limited and not expansible apart from reclamations after mining. The necessary increase and stabilization of yields can be guaranteed by a high soil culture and an intensive exploitation of the cultivated area only.

The large-area reclamation especially irrigation and drainage together with chemicalization and mechanization are more and more decisive means for the increase of yields.

According to the vote of the IXth Congress of the Socialist Unity Party especially the irrigation of crops has to be expanded in order to control the soil water regime and to make the agricultural production more independent on the atmospheric conditions.

These measures guarantee increasing supply to our people with main foodstuffs by own production. Moreover the G.D.R. contributes to the solution of the world food problem supplying further agricultural, especially animal products for export.

Following the scope:

I. LONG-TERM PLANNING OF WATER DEVELOPMENT AND WATER USE FOR THE EXPANSION OF AGRICULTURAL PRODUCTION

1.1 ASSESSMENT OF DEMAND FOR HORIZONTAL AND EXPANSION OF IRRIGATION AND DRAINAGE IN THE G.D.R.

1.1.1. Present land use and present use of irrigation and drainage

1.1.1-1. *Area (ha) for* 1975

1.1.1-1.1	Total cultivated area:	6,295,460 ha
	among them arable land	4,698,989 ha
	among them grassland	1,358,660 ha
	among them meadow	692,389 ha
	intensively used pasture	600,421 ha
1.1.1-1.2	waste land	75,061 ha
	land not suitable for any use	142,866 ha
1.1.1-1.3	Total irrigation area	610,000 ha
	among them sprinkler irrigation	310,000 ha
1.1.1-1.4	Total drainage area	1,220,000 ha
	among them subsurface drainage approx.	800,000 ha

11.1–1.5 Area of–1.3. and–1.4. which is provided with both 400,000 to 450,000 ha

1.1.1–1.6 Area of–1.3. to–1.5. which is permanent pasture, approx 500,000 ha

1.1.1–1.7 Area without flood protection measures: no
Area with flood protection measures approx. 850,000 ha

1.2.1–2. *Irrigation region*

1.1.1–2.1 Irrigation and drainage regions are not uniformly spread all over the G.D.R. and are concentrated in certain ecological zones.

The preferred irrigation areas (=100 per cent) are at time:

(*a*) light soils with low running ground water in the central and northern districts of the G.D.R. (30 per cent)

Predominant reasons for irrigation: Increase and stabilization of yields

(*b*) intensively cropped loess and loam sites in the southern central and southern districts of the G.D.R. (20 per cent)

Predominant reason: Increase of yields and stabilization

(*c*) Lowlands of the central and northern districts of the G.D.R., which are affected by ground water (40 per cent)

Predominant reason: Increase of yields and stabilization

(*d*) Waste water and liquid manure application regions near to cities and community and livestock-farming centres (10 per cent)

Predominant reasons: Effective utilization of these liquids and increase of yields and stabilization

The preferred drainage sites (=100 per cent) within the irrigation regions are at time:

(*a*) Lowlands of the central and northern districts of the G.D.R. affected by the ground water (70 per cent)

Predominant reasons: Qualification for cultivation, increase of yields

(*b*) Waste water and liquid manure application regions (10 per cent)

Predominant reasons: Qualification for cultivation, increase of yields

(*c*) Loess and loam sites endangered by waterlogging (20 per cent)

Predominant reasons: Qualification for cultivation, increase of yields

1.1.1–3. *Crop yields* (*a*) *with and* (*b*) *without irrigation* (*1971–75*)

1.1.1–3.1

		a	*b*
sugar-beets	*t/ha*	35·8	27·9
potatoes	*t/ha*	24·0	17·1

wheat	*t/ha*	4·9	4·1
grass in rotation	*t/ha*	62·2	43·3
grassland	*t/ha*	63·1	48·5

These yields are means from selected farms and refer to standard areas with clear water irrigation. With the application of waste water and liquid manure the yields of grass in rotation and sugar-beets are higher by 12 to 16 per cent.

1.1.1–3.2 Cropping intensity for 1.1.1–3.1 (*a*) 1975 and (*b*) the G.D.R.–mean

	Sprinkler irrigation mm/year	*fertilization kg/ha*	
		N P_2O_5	K_2O
(*a*) *1975*			
Sugar-beets	109	200...240	according to results of the agro-chemical service every 4 years as "normally supplied"
potatoes	81	190	
wheat	65	120...160	
grass in rotation	195	350...400	
grassland	180	200...350	
(*b*) G.D.R. mean with and without irrigation	104	72	113

1.1.1–3.3 The importance of the irrigation for crop production in the G.D.R

The irrigation becomes an ever more important factor in the increase and stabilization of the yields in crop production on the way to an industry-like agriculture. It enables an essential more intensive exploitation of the soil and increases the efficiency of the intensification factors *e.g.*, chemicalization, mechanization and technical drying.

The irrigation causes a better exploitation of the yield potential of new high yield varieties and makes especially the agricultural production independent of the weather.

The irrigation provides preconditions for a repeated exploitation of the same area during one year also in the G.D.R. Examples for that are:

- —1 to 2 more cuts for fodder
- —winter-intercropping—potatoes
- —winter-intercropping—maize for silage
- —cereals—summer-intercropping
- —early potatoes—late vegetables
- —early vegetables—late vegetables

1.1.1–4. *Complementary information*

1.1.1–4.1 Irrigation methods

According to 1.1.1–1.3 about 52 per cent of the total irrigation area is sprinkler irrigation and nearly 48 per cent are different systems

From all the sprinkler irrigation methods (=100 per cent) in the G.D.R. the semi-portable sprinkler methods and among them at time still the side-roll type system (>60 per cent) dominate. The portable sprinkler method has still the second place (>30 per cent).

Centre-pivot systems of the FREGAT-type (USSR) have had an increase (at present 4 per cent) since 1974,. In the coming years the portion of FREGAT-systems will increase essentially. The permanent sprinkler method has at present a portion of one per cent only.

Micro-irrigation methods are not spread yet.

From the different irrigation methods the subsurface irrigation by simple method gains in point in the coming stages of 5-year-plans. It is based as a new technique on the combination of large-volume subsurface drainage or cross-subsurface drainage (small or mole drains combined with large-volume drains) with open ditches in larger spaces (800—1,000 m). It is an especially suitable irrigation method for ground water affected nearly even bottom lands with very permeable sand and peat soils.

Surface-flooding, flood irrigation, and furrow irrigation are nearly not existing in the G.D.R. 70 per cent of the irrigation systems use clear water only, predominant from surface water and only a small portion from ground-water. The portion of waste water and liquid manure irrigation systems is at present 15 per cent in each case. Among them it is relatively a small portion of industrial and open-cast waste water. Brackish water is not used for irrigation in a larger extent at this time. The other irrrigation methods take 80 per cent ground water near the surface or water from open ditches in ground water provinces. The remaining portion consists of still existing older waste-water-flooding facilities.

Whereas the reliability of a continuous water supply is 90 to 95 per cent for ground water, waste water and liquid manure it is only about 80 per cent for surface water utilization. A special field of irrigation besides waste water and liquid manure sprinkler irrigation (organic irrigation; in each case 15 per cent) is the ferti-irrigation. Blanketing and plant protective irrigation are nearly not used in the G.D.R. The annual rate of the utilization of irrigation facilities by the socialist farms has increased during recent years and has reached a level of 90 to 95per cent. That shows the technically and technologically involved increase of the operating safety on the one hand and the growing skill of the users in operating the irrigation facilities on the other hand. The operating input could systematically decreased from 3 to 5 hands/100 ha with portable sprinkler methods to 1·2 to 2·0 hands with side roll type systems. For centre pivot irrigation systems (FREGAT) only 0·8 to 1·0 hand/100 ha and for permanent sprinkler irrigation systems with the G.D.R. made REGNOMAT-system 0·3-0·5 hand/100 ha are needed.

With the subsurface irrigation by simple method the operating input is according to the type of the facility and the degree of automation 0.2 to 0·5 hand/100 ha.

1.1.1–4.2 The importance of drainage in the G.D.R.

There are three techniques for soil water regulation and drainage at present suitable for soil water control and drainage on the agricultural sites of G.D.R.

Ground-water control on very well to moderately permeable bottom land with no or poor slope and what in its natural state is dominated by ground water. Its hydro-technical control-system can mutually be used for drainage and irrigation as well.

A *combination of techniques* of deep loosening, liming and tile drainage on waterlogging soils with low ground-water level, where sole drainage only shows no good results.

Drainage measures on the other waterlogged sites with no conditions or necessity for water control or the combination of techniques and where temporary or permanent waterlogging requires a partial drainage or where no other solution for an industry-like crop production is possible. The greatest part is drained by tile drainage (53 per cent). New techniques with plastic drains reached a growing part during the past decade.

The ground water control also serves as large-area improvement of the growth conditions for crops and of the technological soil-qualification for industry-like crop production.

The selection, design, and construction follow the obligatory G.D.R.—standards (*TGL*). There are the following principles:

—great yield-efficiency

—high technical efficiency

—operating safety

—improvement of the technologic soil qualities for industry-like large-area production

—small input for construction and maintenance

1.1.1–4.3 The importance of other reclamation measures in the G.D.R.

The construction of polders and dykes is nearly finished in the G.D.R. Today we only reconstruct existing facilities or improve their protection efficiency. There are no possibilities for land reclamation in the G.D.R. except the reclamation of temporary mining areas. The area of lignite mining has extended from 49,000 ha to 78,000 ha during the past two decades. The annual reclamation for agricultural use has reached 3,000 to 5,000 ha.

1.1.1–4.4 Areas affected by erosion

In the G.D.R. 800,000 to 900,000 ha are affected by water or wind erosion. The main part has the water erosion. By arrangements of water regulation, treatment of ground and others the water erosion is effectively controlled. The annual damages by wind erosion are limited by rows of trees and shrubs and agronomic practices and permanent degradation is avoided.

1.1.1–5 *Summary assessment of the present exploitation of the soil and role of irrigation and drainage*

1.1.1–5.1

(*a*) The irrigation area of the G.D.R. takes at present 10·5 per cent of the the cultivated area. On an average 20 *dt GE* more (*GE*=grain unit) per ha are harvested by irrigation, that is an increase of about 50 per cent as compared to the yields without irrigation.

(*b*) The drainage area of the G.D.R. is 19·5per cent of the cultivated area. According to site conditions, preconditions and practices 8 to 13 *dt GE* more per ha are harvested by drainage. It is however more important that the drainage measures make the supposition for a mechanisation of crop production and improve the technological qualification of the soils for an industry-like large-area crop production. Cultivated areas reclaimed by other measures are relatively small. Each year 3,000 to 5,000 ha of lignite mining areas are reclaimed. This results in yields of about 40 *GE*/ha.

(*c*) In the G.D.R. about 850,000 ha are flood protected. That means the protection of the annual total or partial crop of 20 to 50 *dt GE*/ha.

1.1.1–5.2 Percentage of rural population living in such areas

A division of the rural population according to the individual measures (1.1.1–5·1 and others) is at present impossible because of the above mentioned (1.1.1–2·1) unequal distribution of the G.D.R. into the ecologic zones.

1.1.2 Trends towards changes in land use

1.1.2–1. *Demand and policies for the expansion of agricultural production*

The politico-economic importance of the expansion of amelioration measures especially the irrigation is mentioned in the Introduction already. The increasing self-sufficiency of the population with regard to the high value food and the industry supply with raw material take a leading part in it. That requires an intensification of crop production and the cooperation of all the intensification factors (chemicalization, mechanization, amelioration, technical drying, breeding, schooling). The main intensification factor is the utilization of the scientific-technical progress in economy in order to fulfil or to overfulfil the targets of the development plans.

1.1.2–1.1 Expected increase or decrease of the demand

The social political development in the G.D.R. and the social political measures will result in increase of the standard of living and also in a permanent increase of the food-demand. The demand for agricultural raw materials for industries will also increase and has to be met by agriculture in parts.

The stock-farming production has always increased with the rising yields of crop production and will increase further.

Production of important agricultural products (dt/ha)

Year	In cropped area			In cultivated area	
	Cereals	*Potatoes*	*Sugar-beets*	*Animal for slaughter*	*Milk*
1955	24 8	132·8	265·9	134·9	765
1965	29·2	177·2	263·1	216·0	1,002
1974	39·7	210·9	296·9	336·1	1,284
1980	41·0	225·0	380·0	366·1	1,300

Moreover the irrigation for fruits and vegetables will increase by 25 to 30 per cent.

1.1.2–1.2 Long-term policies for attaining of these development tendencies

It is planned especially to develop the irrigation as a supposition for these targets as follows:

	1975	*1980*
total irrigation	610,000 ha	1,130,000 ha
sprinkler irrigation	310,000 ha	630,000 ha

From these areas of the G.D.R. which are in want of drainage (2,370,000 ha=38 per cent of the cultivated area) 1,850,000 ha will be drained by 1980 and the remaining part by 1990/95. The further development of irrigation will follow a long term and complex plan. For the 5-year plans from 1981 to 1985 and 1986 to 1990 a similar growth in irrigation area is planned as from 1976 to 1980.

60 to 80 per cent of the drainage will be tile drainage and its combination with mole drainage, deep soil loosening, and a larger-spaced pipe—and ditch-system. Particularly the above mentioned targets 1.1.1–4.2 will be reached with regard to an up-to-date industry-like large-scale production.

1.1.2–1.3 Development in the five year plan 1976-80 and 1.1.1–2.

An increase of the irrigated area by 520,000 ha in the present five-year plan was decided by the government. Among them are 320,000 ha of sprinkler irrigation area. Precedently irrigation is used for vegetables, fruits, early potatoes, sugar-beets, and fodder.

Cereals in irrigated rotations are included into the irrigation. Beside the rationalization of existing irrigation facilities new techniques and technologies for the construction and the control are developed. They will result in an increase of productivity, great yield-efficiency, and material economy.

Simultaneously the fertilizer and plant-protective agent input will increase relatively to the use in the past:

	1975/76	*1976/80*
N kg/ha	114·3	154·0
P (P_2O_5) kg/ha	79·4	84·1
K (K_2O) kg/ha	112·7	103·2
plant-protective agent M/ha	49·7	67·9

Fertilizers and plant-protective agents are applied in irrigation areas by preference in order to get the optimum combined effect.

That means it is necessary to provide fertilizer rates from about 10 per cent more for cereals, 25 per cent more for sugar-beets, and 70-100 per cent more for fodder crops than on areas without irrigation.

1.1.2–3 *Summary assessment of changes of tendencies*

Starting from the yield increase of important agronomic products by 60-70 per cent and more than a doubling of the meat-production during the past two decades an important increase of the main food production is expected by 1990-2000. Because this development will take place on nearly the same cultivated area like today the above mentioned measures can be successful only by the co-operation of all the intensification factors.

1.1.3 Demands for water development and use

All the important data are given below (1.1.2–1)

1.1.3–1.1 Horizontal expansion of irrigation and drainage

It is planned to irrigate 100 per cent of vegetables in 1977 yet and increasing a larger part of fruits, early potatoes, sugar beets, and fodder-crops. Beside that the large part of the other potato-areas as well as the large part of the cereals growing areas in irrigation-rotations will be irrigated. Simultaneously with the construction of drainage facilities the grassland in the lowlands and other areas according to 1.1.1–2.1 are opened.

1.1.3–1.2 Present trends to expand irrigation and drainage

1.1.3–4. All the necessary data are reported under 1.1.2

1.2 ASSESSMENT OF THE POSSIBILITIES TO EXPAND IRRIGATION AND DRAINAGE HORIZONTALLY AND VERTICALLY

1.2.1 The known potential for the expansion of irrigation, and

1.2.2 The potential to increase the intensity water use in agriculture

The main crops for irrigation until 1980 are vegetables, fruits, early potatoes, sugar-beets, and fodder-crops, where simultaneously an efficient utilization of waste water and liquid manure is planned. Beside that the expansion will occur on the areas reported in 1.1.1–2.1. The techniques and facilities reported in section 1.1.1–4.2 and 1.1.1–4.2 will be used. The largest expansion of irrigated areas will result from the employment of the Soviet sprinkler irrigation system FREGAT.

Surface water is predominantly used as water resource (see 1.1.1–4.1). The problems connected with that will be found under 1.1.1–3.3. The planned irrigation techniques are expected not to need much water. The specific water demand per product is to be decreased by 10 to 30 per cent by the optimum combination of fertilization, irrigation, and cropping system. Water saving sprinkler irrigation techniques and the new technique of the mutual ground-water control developed in the G.D.R. are used for that. Further work is done for their improvement.

1.2.3 The capacity to develop the potential

The measures necessary for the expansion of amelioration were voted by the government of the G.D.R. and are part of the five-year plan for the development of the G.D.R.—economy from 1976 to 1980. That also refers to the tasks of water resources management, architecture, mechanical engineering, and the matter producing industry.

1.2.4 Plans for final assessment

The development of irrigation and drainage will follow a long-term and complex plan, which still has to be framed precisely. All the necessary sectors of economy are united in it. An addition of 520,000 ha irrigated area is voted for the period upto 1980. A similar addition is planned for the following five-year plans. The selection and development of techniques for irrigation and drainage follow these principles:

1. Great yield-efficiency (increase and stabilization of high value crop production at the time fixed)
2. Great technical efficiency (good material-economy, small specific energy demand, great control effect according to the required parameters).
3. Permanent operating safety (system operating without disturbances and small need for maintenance; balanced parameters and sub-systems)
4. Improvement of the technological soil-qualification for an industry like large-area production (rational cultivation procedures according to the need, large fields without obstacles)
5. Small specific inputs for construction and maintenance (small demand for material, hands, power, finances and easy maintenance in longer intervals of time).

The investment input is according to tbe techniques and site conditions—5,500 to 15,000 M/ha for sprinkler irrigation and 2,000 to 10,000 M/ha for the subsurface irrigation by simple methods. One third of that gets the irrigation facility itself; one third the necessary sub-area drainage, soil, relief, and land-amelioration; and one third the water resources management for power and other performances.

The annual technological costs are 400 to 700 M/ha and 150 to 200 M/ha for sprinkler irrigation and subsurface irrigation by simple methods respectively.

2. CONTRIBUTIONS EXPECTED FROM ADVANCED TECHNOLOGIES AND IMPROVED WATER MANAGEMENT

(*a*) Efficiency-increase by improved technology

Some technical-technological aspects had already been reported in previous sections. Sprinkler irrigation methods with an operation need smaller than 1 hand/100 ha and if possible 0·5 hand/100 ha are most important for the G.D.R. to improve the tendency of the yield efficiency/hand which was 60 per cent greater in the past two years than in the time before. The hands available for crop production will decrease in future. New irrigation techniques have to be suitable for a three-shift operation by a high degree of automation. Semi-portable facilities with electric motors, lateral steering, hydro-switching circuit of sprinklers or groups of sprinklers, great handiness and movability will increase essentially. In future these demands will be met by improved centre-pivot sprinkler systems and straight roll-move sprinkler lateral systems.

The efficiency of the mutual ground-water control is increased by the development and quick introduction of a deep ploughing the surface with sand overlaying tillage technique and of the micro-and mesorelief-amelioration. The horizontal and vertical permeability of the soil, the accessibility and the water and heat-regime of peat soils are improved by a special deep ploughing tillage method where one part sand and one part peat are slantingly arranged and covered by sand. The uniformity and efficiency of the ground water control and the accessibility are improved and partial waterlogging and dry ground are prevented by a fine subgrade. Altogether the further automation of pumping stations and distribution plants in irrigation regions will result in a decrease of the operating input and of idle time and in an improvement of the needed extra water supply.

(*b*) The increase of the efficiency of extra water is reached by:

—an optimum plant density of potatoes and sugar-beets as well as by an exact temporal and spatial distribution of N-fertilizers on cereals and fodder-crops

—a better temporal distribution of water applications according to the need. Therefore the sprinkler irrigation rota has to be shortened from more than 10 days to 5 to 7 days, especially on soils with low water capacity.

—a decisive improvement of the agronomic and farm-technological parameters, the sprinkler irrigation intervals, the application rate and rain intensity

—optimum irrigation crop rotations in order to improve the successive distribution of the sprinkler irrigation water on single crops

—storage sprinkler irrigation on good waterholding or such sites with empty soil water storage at low usable water capacity during periods of time when the capacities and water resources are used very little

—utilization of irrigation facilities for liquid manure, waste water slurry, fertilizers, and plant-protective agents. This will not only result in some important advantages but also in a great yield efficiency (e.g. late N-fertilization).

—permanent and indirect determination of the usable water capacity according to the data processing model and the computer programme for the sprinkler irrigation advisory service of the G.D.R. on the basis of evapotranspiration, rainfall, application rates, and other meteorologic and agronomic parameters

—the utilization of new high-yield varieties which have a poor specific water need/product.

(*c*) In order to solve all these problems it is important to watch the latest know-how with regard to usable water resources, engineering, technology, techniques, and agronomic parameters as well as to take mutual advantage. The ICID gives some opportunities for that and requires the proportional co-operation of all the members. In the G.D.R. we work at the solution of the new problems. We shall report the results in adequate form and in time.

3. EXPECTED CONSTRAINTS AND PROBLEMS

There are still some problems in the G.D.R. which have to be solved at the arrangement of the large-area irrigation in high effective crop production. The present useful water resources are not sufficient. Therefore new resources have to be opened. The largest part of the irrigation water will always come from surface water, the second-place part will come from new opened ground-water supplies. All the waste water and liquid manure will be included in the irrigation completely. New ways of obtaining, introduction, and storage are necessary for the utilization of the water resources in question inclusive of brackish water.

The comparison of the politico-economical inputs for irrigation with the returns by increase and stabilization of the yields shows an amortization time of 15-18 years. Beside that there are some other social advantages with regard to the water resources management, environment protection, land improvement, and infrastructure. These and the following problems have to be solved or improved:

—optimizing the agronomic parameters

—improvement of the agrarian quality of the technical and chemical treatments on the irrigation areas

—better adaption of irrigation to the agronomic requirements

—development of present rational high-effective engineering, technology, and techniques with a high degree of automation, solid operating safety, a small need for hands, and great productivity.

These tasks require new technological principles of organisation what the ICID can essentially contribute to.

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