APPLICATION OF MASSCOT METHODOLOGY IN DEZ IRRIGATION AND DRAINAGE SYSTEM

MISE EN ŒUVRE DE LA METHODOLOGIE MASSCOT DANS LE SYSTEME D'IRRIGATION ET DE DRAINAGE DE DEZ

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ABSTRACT

Irrigation and drainage networks have been built in Iran by financing from public budgets during last decades in order to improve irrigation services and increase water productivity. Investigations have shown that the current situation of irrigation and drainage networks is far from the ideal and needs reform in management, operation, and maintenance. Improving performance of irrigation systems needs proper diagnosis of the problems and a systematic approach towards modernization. One such methodology that has recently been used and recommended by FAO is MASSCOTE (Mapping System and Services for Canal Operation Techniques) methodology. This approach is a stepwise revolving frame that includes rapid assessment of the performance of an irrigation system including system's capacity and sensitivity, perturbation, water supply, operation and maintenance costs, etc. In this article the results of using this methodology for performance assessment of Dez irrigation system will be presented. This project is located in south west of Iran with a coverage area of 96000 hectares. The MASSCOTE application contained two phases, first the field investigations from headwork to quaternary canals, and second preparation of Modernization plan based on field investigation and further analysis. The results of analysis showed that water supply to the system is abundant, and the maintenance and operation of DEZ irrigation network is good, but the irrigation efficiency and the accuracy of measurement devices is low. Several immediate, mid-term and long term recommendations were proposed for managerial, operational and institutional improvement. It was recommended to prepare a management information system for collecting and analyzing all information about operation and maintenance of the system to accelerate and optimize our decision making process based on this system. Calibration of the flumes that deliver water to tertiary canals

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was considered necessary. For the mid-term improvements, improving the crops variety to adapt with local climate towards higher production which are more tolerant to high temperatures and water stress was considered advisable.

Key words: *Irrigation and Drainage Networks, Masscote, Rapid Appraisal Procedure, Perturbation.*

RESUME ET CONCLUSIONS

Les réseaux d''irrigation et de drainage ont été construits en Iran au cours des dernières décennies afin d'améliorer les services d'irrigation et la productivité de l'eau augmente, par le financement des budgets nationaux. Au fil du temps, une sensibilisation accrue des agriculteurs a entraîné une hausse des attentes locales pour les services d'irrigation plus performantes. En fait, les agriculteurs veulent que le système d'irrigation pour assurer une certaine souplesse, équitable et fiable des services de distribution d'eau. Ils sont également intéressés à jouer un rôle plus important dans la gestion du système d'irrigation. Des enquêtes ont montré que la situation actuelle des réseaux d'irrigation et de drainage est loin de l'idéal et a besoin de réformes dans la gestion, l'exploitation et l'entretien de ces systèmes. Des améliorations sont également essentiels à la ferme des réseaux d'irrigation niveaux. Améliorer la performance des systèmes d'irrigation a besoin d'un bon diagnostic des problèmes et une approche systématique pour élaborer des plans d'amélioration. Une telle méthodologie qui a récemment été utilisée et a recommandé par la FAO est la méthodologie MASSCOTE que représente le Système de cartographie et de services pour Canal Opération Techniques. Cette approche par étapes est un cadre de roulement qui comprend l'évaluation rapide de la performance d'un système d'irrigation, y compris la capacité du système et de la sensibilité, la perturbation, l'opération d'approvisionnement en eau et les coûts de maintenance, etc. Cette méthodologie devrait être effectuée étape par étape afin de décomposer la complexité de l'évaluation dans les secteurs et les éléments simples, et dans chacune de ces étapes nous préciser et consigner les résultats. Dans cet article nous allons voir les résultats de cette méthodologie pour l'évaluation des performances de l'irrigation Dez et réseau de drainage qui est situé dans le sud-ouest de l'Iran avec une zone de couverture de 96000 hectares. L'enquête a conduit par l'équipe de la FAO afin de proposer des recommandations pour améliorer les conditions actuelles. L'application contient deux phases MASSCOTE, la première enquête sur le terrain de headwork des canaux quaternaires, et la préparation deuxième plan de modernisation fondée sur l'enquête de terrain et une analyse plus approfondie. Les résultats des analyses ont montré que l'approvisionnement en eau du système est abondante, et l'entretien et l'exploitation du réseau d'irrigation DEZ est bon, mais la précision à faible efficacité de l'irrigation, et des appareils de mesure est plutôt faible. Plusieurs immédiats, à moyen terme et à long terme des recommandations ont été proposées pour l'amélioration de gestion, opérationnel et institutionnel. Le nouveau rôle des usagers de l'eau au moment et à l'exploitation et la gestion de ce réseau a été proposé d'être redéfini. Il a été recommandé d'établir un système d'information de gestion pour recueillir et analyser toutes les informations sur le fonctionnement et la maintenance du système pour accélérer et optimiser notre processus de décision basée sur ce système. Etalonnage de l'canaux qui fournissent l'eau à canaux tertiaires a été jugé nécessaire. Également les performances des stations de pompage devraient être explorés et pour contrôler les souches sur l'environnement des sorties de drain devrait être mieux contrôlée. Pour les améliorations à mi-parcours, a été jugé opportun d'améliorer la variété des cultures

à s'adapter au climat local vers une production plus élevée, plus tolérer à Des températures élevées et le stress hydrique.

Mots clés: *Réseaux d'irrigation et de drainage, Masscote, évaluation rapide de la performance, perturbation.*

(Traduction française telle que fournie par les auteurs)

1. INTRODUCTION

Population growth and consequently existing issues such as lack of food security has created some challenges. Irrigation and drainage networks play a major role in mitigating these challenges. A huge public budget has been invested in Iran during the last thirty years in order to ensure food security. An optimal operation of the infrastructures needs continuous supervision, applying new technology and techniques and also providing the required funds to implement programs, which are proposed. Existing physical development attitude in irrigation is one of the major challenges and in most cases; the social conditions and traditional operation systems are ignored. Consequently, the developed systems have some weaknesses, which cause problems in optimal operation of irrigation networks. These lead to failure in achieving expected goals of high yield at the farm level and, hence, at the national level. Low water distribution efficiency, fragmentation of agricultural land, lack of empowerment of farmers, lack of proper irrigation practices, inappropriate crop pattern and density of cultivation and inappropriate water tariffs are the most important reasons for low productivity at the farm level. Therefore the infrastructure of operation, maintenance and management should be diagnosed in order to improve the current situation.

Dez system is the largest irrigation network of Iran which covers 96,000 ha and is located in southwestern part of Iran in the Khuzestan province. Investigations have shown that despite large investments, its performance is far from the optimal in comparison with other systems. It is also more obvious in drought periods. One of the methods of evaluation that have been recently used and recommended by FAO is the Masscote (Mapping System and Services for Canal Operation Techniques) methodology. This approach includes a multi-step process such as rapid appraisal, mapping the system capacity and sensitivity, perturbation, water supply operation and maintenance costs etc. By implementing this method in a step by step manner the complexity of working through the elements would become simpler and the results of each step would be documented in the conclusion. By using Masscote methodology the performance evaluation of Dez irrigation system was done. Detailed description of this method and the results of investigation have been discussed here.

2. PROJECT DESCRIPTION

The Dez irrigation and drainage system is one of the largest surface irrigation network under operation since 1978 in north of Khuzestan province in south of Iran consisting of a gross command area of about 125,000 ha and a net command area of about 96,000 ha (Figure1). It supplies water to a vast variety of croplands which are cultivated with a well equipment system. It irrigates a wide-ranging land size having different land tenure system, all of which compete for a cash crop market. The supply resource of this irrigation system is a reservoir

which is located about 30 km north of Dezful having a nominal capacity of about 3.4 billion cubic meter. A regulating dam is constructed about 28km downstream of this structure that incorporates 7 sluice gates and a discharge capacity of about 6000 cubic meter per second. A diversion dam is also constructed about 5 km downstream of the regulating dam at a height of 4m having a concrete spillway structure with the length of 394 m and 8 sluice gates on the right bank to flush out the sediment and further 2 intake structures at the right and left banks feeding two canals of 157 and 94 cubic meter per second, respectively. It is diverted on the average 2500 billion cubic meters every year to the Dez irrigation system. The measurement system in the entrance of tertiary canals is parshall flumes. The main crops which are cultivated in the regions are cash crops and sugar cane. Dez irrigation system has also 1287 km service road, 1070 irrigation gates, 632 km drainage and 2 large bridges. The main characteristics of Dez Irrigation Scheme are illustrated in table 1.

Table 1. Main Characteristics of Dez Irrigation Scheme (Principales caractéristiques du système d'irrigation Dez)

Region	command area (ha)	Irrigated area (ha)	Canal Capacity (m^3/sec)	Length of Main Canals (km)	Length of Secondary Canals (km)
West	74000	57000	157	109	246
East	43500	33000	92	132.5	267
Sabili pomp station	7500	6000	12.5		
Total	125,000	96,000	-		

Application of Masscot in irrigation modernization

MASSCOT has been developed by the Land and Water Division (AGLW) of FAO on the basis of its experience in modernizing irrigation management in Asia. Masscot comprises tools such as the rapid appraisal procedure (RAP) and benchmarking to enable a complete sequencing of diagnosis of external and internal performance indicators and the design of practical solutions for improved management and operation of the canal. Canal operation is a complex task involving key activities of irrigation management, which implies numerous aspects that have to be combined in a consistent manner. These aspects are:

- Services to users;
- Cost of providing the services;
- Performance monitoring and evaluation (M&E);
- Constraints and opportunities in water resources management; and
- Constraints and opportunities of the physical systems.

Masscot aims to organize project development into a stepwise revolving frame. The steps of this approach are mentioned in Table 2 also the description and the results of each step one by one based on the table framework mentioned as follows.

Table 2. The Ten Steps of MASSCOTE (Les dix étapes de MASSCOTE)

Mapping....	Phase A – baseline information
1. The performance (RAP)	Initial rapid system diagnosis and performance assessment through the RAP. The primary objective of the RAP is to allow qualified personnel to determine systematically and quickly key indicators of the system in order to identify and prioritize modernization improvements. The second objective is to start mobilizing the energy of the actors (managers and Users) for modernization. The third objective is to generate a baseline Assessment, against which progress can be measured.
2. The capacity and sensitivity of the system	The assessment of the physical capacity of irrigation structures to Perform their function of conveyance, control, measurement, etc. The assessment of the sensitivity of irrigation structures (off takes and cross-regulators), identification of singular points. Mapping the Sensitivity of the system.
3. The perturbations	Perturbations analysis: causes, magnitudes, frequency and options for Coping.
4. The networks and water balances	This step consists of assessing the hierarchical structure and the main features of the irrigation and drainage networks, on the basis of which Water balances at system and subsystem levels can be determined. Surface water and groundwater mapping of the opportunities and Constraints.
5. The cost of O&M	Mapping the costs associated with current operational techniques and resulting services, disaggregating the different cost elements; cost analysis of options for various levels of services with current techniques and with improved techniques.
Mapping....	Phase B – Vision of SOM & modernization of canal operation
6. The service to users	Mapping and economic analysis of the potential range of services to be Provided to users.
7. The management units	The irrigation system and the service area should be divided into subunits (subsystems and/or unit areas for service) that are uniform And/or separate from one another with well-defined boundaries.
8. The demand for operation	Assessing the resources, opportunities and demand for improved canal Operation. A spatial analysis of the entire service area, with preliminary Identification of subsystem units (management, service, O&M, etc.).
9. The options for canal operation improvements / units	Identifying improvement options (service and economic feasibility) for each management unit for: (i) water management, (ii) water control, and (iii) Canal operation.
10. The integration of SOM options	Integration of the preferred options at the system level, and functional Cohesiveness check. Consolidation and design of an overall information management system For supporting operation.
11. A vision and a plan for modernization and M&E	Consolidating a vision for the Irrigation scheme. Finalizing a modernization strategy and progressive capacity development. Selecting/choosing/ deciding/phasing the options for improvements. A plan for M&E of the project inputs and outcomes.

Source: FAO

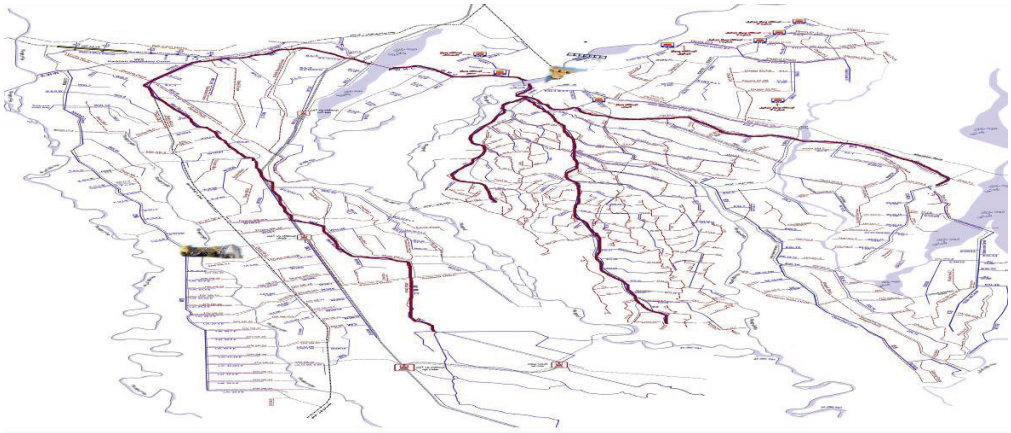

Fig. 1. The layout map of the Dez irrigation system (La carte disposition du système d'irrigation Dez)

The First Step: Rapid Appraisal Procedure (RAP) has been implemented in the Dez irrigation system as the first phase of Masscote application. The RAP consists of a systematic set of procedures for diagnosing the limits of performance within an irrigation and drainage network it contains two types of indicators, internal and external indicators. The RAP could provide sufficient information to target key action items for modernization in a very short period of time. It therefore serves as a valuable tool for managers to prioritize specific actions within individual irrigation projects. The RAP for Dez Irrigation system was applied to obtain data for both the internal indicators and the external indicators. External performance indicators characterize the inputs and outputs of irrigation projects, including water, yield and economics. The internal indicators are related to operational procedures, management and institutional set-up, hardware, water delivery service and other processes in the scheme provide insight into what to be done to improve water delivery service and overall performance.

The study in Dez Irrigation system based on applying rapid appraisal process to diagnosis weakness and strengthens of water delivery service quality, system capacity and sensitivity, perturbation, cost, efficiencies, and others main factors in order to make a better decision on improving of irrigation management and approaching to modernization of irrigation system. The investigations and field visit have shown that the current status of Dez irrigation system is favorable according to the external and internal indicators. The RAP contains many questions about all different parts of the system that should be completed. Consequently, based on this step some scores have calculated for the defined indicators both internal and external indicators. These indicators helped the researchers to analyze the current status of the Dez irrigation network. According to the output this study the income of Dez irrigation system per hectare has been calculated 3169 US$/ha and income per unit of water supplied measured 0.09 US$/$m^3$. Therefore average income per hectare in Dez project is quite higher than other project in that region. But because of low efficiency of system and huge water consumption of mentioned project income per unit of water supplied is very low. Results for the indicators within the social order and services to farmers and service in the main channel showed that the scores were 3.3, 2.2 and 3.1 respectively. As it is defined the upper limit of the indicators

is 4. Therefore, the results are fairly good and also the status of the system has improved in comparison with an investigation that had been done in 1999 which it represents that the situation is progressed. Some internal indicator results are shown in table 3.

The Second Step: The capacity & sensitivity of the system is the second step of Masscote. Application of this phase is shown that there is no serious problem with the supply system and it is completely reliable. But there is no buffer reservoir in the system and the conveyance efficiency seems good at all levels. On the other side, Sabili zone which handle by pump station maintenance in poor condition. The measurement of main, secondary and tertiary canals of East and West zone are good, fair to good and poor to fair, respectively. It should be mentioned that no enough information available on headwork of structures to judge about the sensitivity. So the findings about this step are as follows:

- The sensitivity of offtake is low (<1) when canals operate at full scale depth.
- Some cross regulators seem to be highly sensitive (head > 1 meter).
- A sensitivity survey of the regulators and off takes should be carried out along MC and SC.

The Third Step (Perturbation): The research reveals that errors measurement in the gate, wind or storm and changing water level cause perturbations with magnitude of small to medium. It is more pronounced at the tertiary canal; particularly in the tail area.spillways can be used to evacuate surplus (positive perturbation) and stricter tolerance on water level and water delivery for negative perturbation in order to cope with it.

The Fourth Step (Water Balance): it shows that almost 90 percent of the water demand is supplied by irrigation and 38 percent of the irrigated water would be used by crops, 12 percent would be evaporated and 50 percent would be drained from the system. The overall efficiency of the system is 30 percent which is too low and it shows that large savings can be generated after raising efficiency at field and on canals.

The Fifth Step (Cost of O&M): it Maps the costs associated with current operational techniques and resulting services, disaggregating the different cost elements; cost analysis of options for various level of services with current techniques and with improved techniques is as the following pie chart figure 2. Total expenditure per hectare reported 95 US$ and total revenue is 92 US$, therefore 96 percent of the budget would come back.

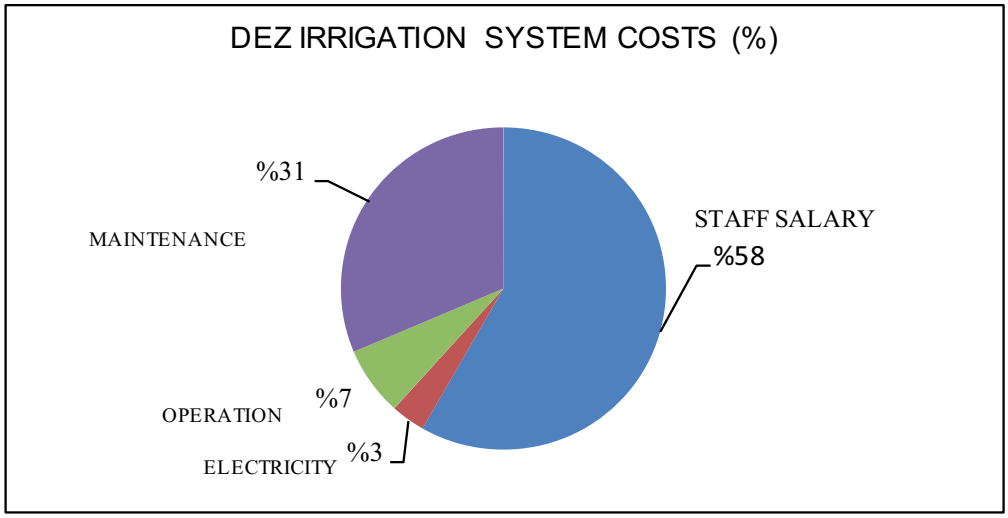

Figure 2. Total annual cost of Dez irrigation system (Total coût annuel du système d'irrigation Dez)

The Sixth Step: Services and visions as the sixth step play important role modernization programming. The vision of Dez irrigation system determined being modern and profitable with environmentally sustainable, as well as, market oriented and productive irrigated agriculture, which contributes to the wellbeing of farmers and rural population. This will be achieved through i) improving water delivery services, efficiencies, and water productivity; ii) expansion of irrigated areas; iii) cultivation of high value crops; iv) involvement of water users in the decision making; iv) and covering full O&M budget/costs through irrigation service fee.

The Seventh Step: the percent of participation in irrigation networks will influence on many duties in operation of the system. And if it will have been done in a proper way many challenges in management of irrigation system would have been decreased. So participation and management in irrigation system play an important roles. In this step it should be mentioned that in the farm level and issues related to farmers the indicators such as water user associations is not acceptable and as there are no associations in the network so regarding this matter it is a weak point. WUAs have received much attention in the last two decades in many countries. In many cases, discussions appear to assume that if a WUA is formed, many irrigation project problems will disappear. However, the WUA also has to survive and flourish in order to be effective. There appear to be several key ingredients found in the strongest WUAs, which need to be supported by the legislative, executive and judicial tbranches of the government. So it is necessary to reinforce this potentially useful item to improve the operation of the system. Of course, the reform in this sector needs a comprehensive study of social behavior of the farmers and their relation with each other in irrigation and operation of canals.

The Eighth Step: knowing about the amount of demand will show the conditions of water resources and dictate our operation policy. Therefore, in this step mapping the demand for operation should have been done, the demand seems to be even in East and the West irrigation network but higher in Sabili network. Furthermore, more investigation is needed for staff allocation to perform a cost effective service provision.

The Ninth Step: the ways that have been planned to improve the operation of each system is important this step deals with operation improvements, the issues that should be addressed in this step are

- High drainage and low overall efficiency;
- Low water productivity ($/drop, crop/drop);
- Accuracy of discharge measurements
- Monitoring of service;
- Very low water efficiency in distribution and field application;
- Pumping station efficiency; and
- Night irrigation.

The Tenth Step: this step is about Aggregating and consolidating management. The objective of this step is Aggregation of options at the system level, and consistency check. Consolidating and designing an overall cost-effective information system for supporting operation and service-oriented management. This step cannot be addressed at this stage when the previous ones have not been completed. Therefore, improvements in water productivity should room in order to gain high return on our modernization investment by saving water, energy and thus money, and the agriculture vision is highly productive irrigated agriculture.

3. MODERNIZATION PLANS FOR DEZ SYSTEM

Modernization plan for Dez irrigation system is divided into three phases based on short term plans, midterm plans and long term plans. These plans made up through recommendations of the participants in the workshop that held in 2010. The recommendations set according to three categories as follows:

I) Plans for short term

- Preventive maintenance of Irrigation System
- Routine Maintenance of structure bass on the scheduled program
- Considering of farmers benefits and gives enough information to them to decide crop pattern by marketing needs
- Volumetric selling of water to farmers
- Considering of farmers benefits and gives enough information to them to decide crop pattern by marketing needs
- Volumetric selling of water to farmers
- Recovery of water charge to MOM Cost
- Evaluation of various cost elements of current operation techniques and services for controlling annual budget to improve the investment
- Financial management in order to reduce the costs and make the system more productive.

Table 3. The internal indicator results (Les résultats des indicateurs internes)

RAP Internal Indicators		
Internal indicator	**Term**	**score**
Social order		
	Social "order" in the canal system operated by paid employees	3.3
	Degree to which deliveries are not taken when not allowed, or at flow rates greater than allowed	3
	Noticeable non-existence of unauthorized turnouts from canals.	3.5
	Lack of vandalism of structures.	3.5
Service to farmers (canal)	Actual water delivery service to individual ownership units (e.g., field or farm)	2.2
	Measurement of volumes	1
	Flexibility	2.5
	Reliability	2
	Apparent equity.	2.5
Service by main canal	Water delivery service by main canal to the second level Canals	3.1
	Flexibility	3
	Reliability	3
	Equity	3.5
	Control of flow rates to the sub main	3
Main Level Canals	Cross regulator hardware (main canals)	3
	Turnouts from the main canals	3.2
	Regulating reservoirs in the main canals	0
	Communications for the main canals	3.4
	Existence and frequency of remote monitoring (either automatic or manual) at key spill points, including the end of the canal	1
Second Level Canals	General Conditions	2.6
	Cross regulator hardware (second level canals)	2.1
	Turnouts from the second level canals	2.8
	Regulating reservoirs in the second level canals	0.0
	Communications for the Second Level Canals	2.8
	Existence and frequency of remote monitoring (either automatic or manual) at key spill points, including the end of the canal	0
	General Conditions	3
	Operation of the Second Level Canals	3.1

II) Plans for midterm

- Low pressurized pipe for irrigation for better distribution for water in the field.
- Mapping of sensitivity of offtakes and cross regulators for providing well services to users.
- Automation of systems to new technology for controlling and measurement of water flows.
- Professional training of operators to better operation of system.
- Lining of unlined canals in the rural area.
- Different range of water fee in day and night in order to encourage farmers to irrigate during the night.
- Automation of systems to new technology for controlling and measurement of water flows.
- Low pressurized pipe for irrigation for better distribution for water in the field.

III) Plans for long term

- Establishment of WUA's under secondary canals and effort to promote the mission to higher level.
- Physical Development of irrigation system.
- Improvement of crops verity to adapt with local climate towards higher production, more tolerate to high temperatures, water stress.
- Development of Greenhouse for controlling of water saving and better marketing.

Masscote important features

Four important features of Masscote methodology are as follows:

The first feature is the relation between Masscote methodology and rapid appraisal process within a modernization project.

The second feature is the matter of time period in doing the rapid appraisal process and all steps of Masscote methodology and in the end implementation of the proposed strategies project.

The third feature associated with stepwise revolving frame of Masscote. Thus to achieve a complementary phase of the project analysis, several steps of try and error should be done.

The fourth characteristic of Masscote methodology is the operation of network for diagnosis and for design improvements. However, the overall objective in carrying out a Masscote exercise is modernization of management. Canal operation is a critical entry point because; (i) It is the activity that puts management decisions into tangible outputs; and (ii) It is there that the current management performance is sanctioned and expressed in the most obvious manner (its symptoms). Field survey along a canal system is the most effective and reliable way of identifying management problems.

4. CONCLUSIONS

Application of Masscote methodology on Dez irrigation system in Iran helped the group of researchers to better understanding of different aspects such as social, technical, managerial and economical of the system; in fact it opened a new window on modernization of irrigation system for who involved and responsible for M (O&M). For analyzing the system, rapid appraisal process applied to diagnosis weakness and strengthens of water delivery service quality, system capacity and sensitivity, perturbation, cost, efficiencies, and others main factors in order to make a better decision on improving of irrigation management and approaching to modernization of irrigation system. Multi-step procedure implemented for evaluating the status and the current situation of Dez irrigation and drainage Network. Performance assessment parameters based on the RAP indicators shows that the current status of Dez irrigation network is improved comparison on previous assessment that applied ten years ago. But the performance was not completely satisfied, anyhow reforms should be considered in order to access an ideal situation. One of issue in Dez irrigation system which clearly recognized was lack of water user's participation in operation and management of the system. Researchers made a list of methods on modernization of irrigation system based on three phases of short, mid and long term periods. The modernization generally needs a long time to have been implemented and it is also a continuous process. Finally, the vision of Dez irrigation system determined being modern and profitable with environmentally sustainable, as well as, market oriented and productive irrigated agriculture, which contributes to the wellbeing of farmers and rural population. This would be achieved through i) improving water delivery services, efficiencies, and water productivity enhancing; ii) expansion of irrigated areas; iii) cultivation of high value crops; iv) involvement of water users in the decision making; iv) and covering full O&M budget/costs through irrigation service fee.

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