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TRADITIONAL WATER HARVESTING SYSTEMS COLLECTIONS IN IRAN

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ABSTRACT

The fact that rainfall is very meager in the Arid and semi-arid regions of Iran and that one millimeter of harvested rainfall is equivalent to one liter of water per square meter, suggests the importance of WH apart from the quantity of rainwater collected.

During the summer season, warm and humid air of the Oman Sea and Indian Ocean influence the southern barrier of Elborz Mountains. In the same time, strong northerly cold currents flows to the northern barrier of Elborz Mountains and into north-south channel of Dasht area, located between Khorasan and Golestan provinces. Mentioned condition cause a convective instability in accompany with heavy rainfall. Three types of synoptic patterns have been introduced for development of heavy rainfall of the northern parts of Khorasan province and eastern area of Golestan province, located on the north east of Iran: upper level trough, twin surface pressure systems and composed jet-streams.

Arid and semi-arid regions occupy more than 80 percent of Iran's land. Short duration and high intensity are common characteristics of rainfall in these regions. The most optimistic estimation of average precipitation stands at 273 mm, which is less than a third of the world's mean annual precipitation. Temporal and spatial distribution of rainfall is quite unfavorable. The mean annual precipitation is less than 100 mm in 13% of total land area, between 100 to 200 mm falls on 61% of area, 250-500 mm are fallen in 17% of land, while only less than 8% of land get 500-1000 mm of precipitation. It should be noticed that about spatial distribution of precipitation in Iran is about %75 precipitation In %25 area and %25 precipitation in%75 area. Also temporal distribution of precipitation %25 precipitation in plant growth season and %75 precipitation in off season. The temporal variation in rainfall in wet and dry years is also large, e.g. in 1969 was high and in 1970 was low.Similar conditions prevail not only in Iran, but also in many other countries in the region. High density, short duration rainfall often generates destructive floods. At present in many parts of the country, the water levels have been falling rapidly. The demand for drinking water is also has been increasing manifold in the last three decades due to rapid increase in the population. Due to this, the stress on exploitation of water resource increased everywhere in the country. The most notable

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consequence of the agricultural development strategy has been the depletion of ground water resources. Artificial recharge techniques have become a pragmatic approach to augment depleting ground water resources. Utilization of floodwater for groundwater recharge can be a reliable solution. As, this will improve both groundwater quality and quantity.

The aim of this paper is to briefly outline the traditional water harvesting systems and the lessons learnt from the traditional activities in semi-arid and mountainous areas of Iran.

At first, the importance of soil, water, and natural resources in sustaining daily life in arid and semi arid conditions is highlighted and the recent problems aroused was discussed.

The paper also attempts to suggest ways to incorporate the traditional practices with modern water management activities to promote water harvesting in these areas. It was concluded that the traditional and modern methods have merits and limitations. By incorporating beneficial elements of both into one, a water management system can be developed that result in more water harvest and at the same time is sustainable and environment- friendly in the long run.

Finally, the strategy and action plan needed for the watershed development as well as up scaling rainwater harvesting into watershed management activities including micro and macro-planning framework in which the optimized utilization of precipitation can be ensured was discussed.

Keywords: catchments, water-harvesting system, rainwater, semi-arid.

INTRODUCTION

In Iran, for instance, Average Renewable Water Resources Precipitation is 413 Billion CM , Evaporation is 270 Billion CM ,Water renewable resources 130 Billion CM, Recharging ground water resources 38 Billion CM and Available Surface Water 92 Billion CM.

Arid and semi-arid regions occupy more than 80 percent of Iran's land. Short duration and high intensity are common characteristic of rainfall in these regions. The most optimistic estimation of average annual precipitation stands at 273 mm, which is about one third of world average annual rainfall. Spatial distribution of annual precipitation is quite unfavorable. The mean annual precipitation is less than 100 mm in 13% of the area, between 100 to 200 mm in another 61% of area, 250-500 mm in 17% of land, and 500- 1000 mm in the remaining 8%. It should be noticed that about spatial distribution of precipitation in Iran is about %75 precipitation In %25 area and %25 precipitation in%75 area. Also temporal distribution of precipitation %25 precipitation in plant growth season and %75 precipitation in off season. The temporal variation in rainfall in wet and dry years is also large, e.g. in 1969 was high and in 1970 was low. Similar conditions prevail not only in Iran, but also in most country in the region. Under such conditions, desertification and drought are threatening the livelihood of millions of people living in arid and semi-arid areas all over the region.

Meeting the water demand is a major challenge in Iran. On one hand, use of groundwater resources plays a critical role in food supply and security of rural areas. On the other hand, over abstraction will accelerate desertification. Thus groundwater recharge is considered as an effective practice for improving water supply and to meet the water needs during drought. High intensity, short duration rainfall often generates floods.

The first objective of this paper is to outline the water harvesting systems for semi-arid and mountainous areas of Iran and the futures strategies to optimize the benefits and utilization of rainwater harvesting in the semi-arid areas in the region through sharing of technology, and best practices. The next aim is to discuss the importance of up scaling and integrating rainwater harvesting into watershed management activities for a comprehensive water resource management.

Compared with other liquids such as petroleum, water cannot be easily transported. It flows under gravity and easily escapes access. Under semi arid climatic conditions, it is one of the most scarce and most vital resources with drastic quantitative seasonal and periodic fluctuations. Water inflicts great damages to human beings and property during floods and endangers social life during droughts. It is, therefore, essential to establish a balance between supply and demand prior to, and as a preparation for, the emergence of water crises. Plant and animal resources in the semi arid regions have been undergoing corresponding variations. As a result, production relies heavily on underground and surface water, which become increasingly scarcer. Water will remain a barrier to the achievement of poverty alleviation and food security. Most of renewable water resources have already been committed by conventional method of dam construction but the demand for water is exceeded renewable water supplies

WATER HARVESTING (WH) CONCEPT AND DEFINITIONS

Many definitions of WH appear in the literature. The common factor in these definitions is that WH is the capture, diversion, and storage of rainwater for many uses. therefore, the main objective is to manage the rainwater from the moment it falls and ensure that most of it used productively before it returns to the atmosphere by evaporation (Ahmed & Eldaw, 2003). WH may occur naturally or by intervention. Natural WH can be observed after heavy storms, when water flows to depressions, providing water for areas of farmers. WH by intervention involves inducing runoff and either collecting or directing it, or both, to a target area for use. WH may be developed to provide drinking water for human and animals as well as for domestic and environmental purposes. Whether used for irrigation, augmentation, or as an alternative to traditional supplies, rainwater harvesting is a viable option as water source. Depending on local environmental conditions water form of rainfall over an area is called the rainwater endowment of that area. Out of this, the amount harvested may provide a supplementary supply, an alternative supply or the only feasible supply especially in rural areas of arid and semi-arid zones

Rainwater harvesting is a popular term used for a tradition of collecting rainwater, improved by modern concepts and technologies, a result of more than two decades of research work. Today, rainwater harvesting is used in wet and dry countries, in poor and modern situations, for water supply and for homes sanitation. It is utilized in addressing agricultural productivity and food security for poverty alleviation, even in places with 200 mm of rain. Rainwater harvesting is employed in flood mitigation in rain-drenched countries, and in solving infiltration problems of sealed surfaces in urban areas and industrial complexes, or in avoiding polluted water and toxic ground water.

Most of all, Rainwater harvesting, is environmentally sound as it assists in recharging ground water, enhances wetlands, assists forest conservation, encourages ecological farming, and slows down construction of new dams for water supply thus helping the ecological flow.

It is certain that increased upstream infiltration and recharge will create a more balanced hydrological regime, providing better opportunities for direct and sustained consumption of water by various users with different environmental benefits and higher aquatic yields. In addition to this, there will be ample opportunities for multiple reuses of the existing resources when evaporation is reduced as a result of the new hydrological regime.

LITERATURE REVIEW

In the arid and semi-arid regions, the limited availability of water in most cases is a major constraint to rain fed agriculture. In these regions, the amount of rainfall is usually not sufficient for sustainable agriculture system. In the semi-arid areas, uneven distribution of rainfall, spatially and temporally, makes rain fed agriculture a risky enterprise. There are many examples of traditional use of runoff in areas where the rain is not sufficient for crop farming.

Soil erosion caused by rainfall along with flash floods is among the characteristics of these regions. So we are, in many places facing with both drought and floods. What should be done? Seemingly there is a simple solution. Here are several examples presented by Norman Hudson (1999):

In North America, Indian tribes use simple methods of floodwater farming. They use runoff from sandstone to water alluvial soils in Arizona.

UNEP (1983) reports Hopi tribe in south west of North America; cultivate three quarters of their land using floodwater.

Kenya, in pastoral community with annual rainfall of less than 200 mm, small patches of sorghum are grown using floodwater. Morgan (1974)

Kovda (1961) reported the use of natural runoff in arid areas of the former USSR called Kair farming which the name is given to cropping on flood terraces.

Trails of runoff farming have been seen in Khost plain, Paktia province in Afghanistan.

Evidences of flood farming can be found in different parts of Sudan, Morocco, Syria, Jordan and many other countries with similar climatic condition.

Gupa et al. (1995) have investigated different water harvesting and conservation techniques. The research indicates that benefit of water harvesting is high and shows an 8 times increase in total biomass compared with the control plot and also proved that there are an increase of tree height by 20% and water use efficiency from 4.78 to 39.6 Kg /Cm Ha. (Gupa et al., 1995)

Kowsar (1991) argued, ground water recharging via floodwater spreading have been carried out in Iran some 3000 years ago. He pointed out to the residences of North-eastern part of Iran have been recharging ground water by alluvial fan irrigation.

In Iran, there are different traditional methods such as Bandsars, Khoushab etc. These methods will be described in the following pages in more detail.

IRANIAN EXPERIENCES, PAST HISTORY

How People have coped with Natural Climate Change and Aridity issues in the Past?

Some of the remarkable accomplishments can be listed as follows (Karamoz 1997).

• Construction of a 50 Km water transfer tunnel (Aqueduct) from the Karkheh River to Chogha-Zanbil south west of Iran more than 3000 years ago;

• Hydraulic structures - Chogha-Zanbil temple, 3000 years ago;

• Invention and development of 80000 Qanats for groundwater extraction and utilization over the last 3000 years;

• Dam construction over the last 2000 years;

• Mizan dam in Shooshtar and bridge-dam of Shooshtar, 500 meters long with 40 bays;

• Amir dam located 35 Km from the city of Shiraz, 1000 years ago. It has been used as a bridge, for irrigation and as a water mill;

• Bahram dam on Gharah-Aghage, south of the city of Shiraz, 2000 years ago;

• Sheikh-Bahaii water allocation scheme, 400 years ago.

• In recent years, dams with a total capacity of around 20000 MCM have been built in Iran.

Iranians have a long and notable history of water resources development relying on traditional techniques. The exploitation of floods and rainwater harvesting have been practiced through flood spreading and groundwater recharge systems using BandSars, recharge ponds and Ab- Anbars by ancient Iranians.(Koochecki 1992, Ghoddousi, 1995).

BANDAR

The people living in arid and semi-arid regions are facing with water shortage and have to invent ways to overcome with this important obstacle. One of the most famous techniques vastly used is Bandar. It is widely used in north-eastern part of Iran. In fact it is somehow a flood farming method, still in use. An embankment system to use floodwater in farming and groundwater recharge called BandSar which is practiced widely in the north east of Iran (Arabkhedri and Partovi, 1997).

Bandar is composed of a small stream that conducts water from Ephemeral River to Bandsar's inner part. This decreases water speed and supplies soil moisture. In the method, natural location of floodwater spreading is formed on alluvial fans. Bansar is a plot or pond formed by embankment construction in direction of water flow. So flood is taken, water is retained until infiltrated.

Bandar has a very simple construction. It is made of the following parts:

A shallow water drainage (ephemeral stream called Kal)

A check-dam made of river sediment called Tarkehband

Embankment (the main wall of the dam)

Some parallel subsidiary walls for balancing water spreading called Mewband

A waterway for overflow of water called Goushband

Bandsars covers different areas e.g. 1000 square meters in valleys to 30 ha in low slope lands. Generally in alluvial fans, the land situated between two streams is suited for constructing Bandar. Arabkhedri (1999) reports: most of Bansars of Iran are located in the central and southern parts of Khorasan province in areas with low annual precipitation (less than 200 mm per year).

Sediment deposition in Bandsars, changes both chemical and physical characteristics of their original soils. Sediments being deposited in Bandsars are usually fine grained which decreases the permeability of the soils over the time, but annual ploughing, cultivation of divers plants along with root infiltration into soil, all improve permeability and this is the main difference between a traditional multi-purpose flood spreading system and modern recharging systems. Its simplicity in design and operation and costing effect along with public acceptance and reliability has caused to be still in use after so many years.

Fig. No.1: a Bandsar project

KHOUSHAB

Other examples of successful water harvesti ng projects over the world. Among various water harvesting methods, some use rainfall and others use flood caused by rainfall. Here are some examples.

Water collecting for agricultural purposes has been accomplished in Iran, Pakistan and India. The traditional methods are including Khoushab, Degar, etc. It is believed that these methods have transmitted from Iran to adjacent countries and visa versa. Degars and Khoushabs are only different in size and their local names.

PONDS (GOORAB AND ABANBAR)

Ponds are one of the most reliable and economical sources of water. Abanbars are the most effective way of rainwater harvesting in some regions, especially in places with very low amount of precipitation, lack of stream and river flow and lack of suitable groundwater resources.

Water tanks and ponds were dug in rain fed areas of South Iran as early as 3000 years before.

Ponds can serve a variety of purposes, including water for livestock, for field and orchard irrigation, fish production, wildlife habitat, recreation, landscape improvement,

Fig. No.2 : a Khoushab project

and with proper modifications for domestic and household use. In addition to irrigation,

Ponds are used in fish culture, breeding ducks and waterfowl as well as for landscape irrigation in parks. Thus, ponds can have an important role in the economy of villages and city life. Considering the importance of ponds in irrigation, economic and social applications, it is necessary be considered and rehabilitate as a means of water harvesting in semi-arid to humid regions.

In some cases, which topographical conditions permit ponds can be considered as detention basins and recharging spots and the recharge from it might be accelerated by equipping it with injection wells. The floodwater of small catchments or drainage of small areas in plains may be controlled by ponds.

Ab-Anbar or Berkeh is an excavated reservoir in the ground which is covered with a masonry dome roof and collects rain for drinking purposes (Movahed Danesh, 1997). A successful combination of the old practices and new technology in flood spreading aiming at groundwater recharge and regeneration were formulated and implemented by Iranian. Some of these projects have been working and promoting farmers lives since the establishments. The most striking feature of traditional water harvesting system is that the people had the right to construct and manage them. There is ample evidence to show, historically, that even when the government financed the construction or repair of water structures, some of these were quite big, the ultimate responsibility for devising the micro-level distribution and maintenance systems were left to the local communities.

ARTIFICIAL RECHARGE OF AQUIFERS AS A WATER HARVESTING SYSTEMS

This technique has become a pragmatic approach to augment depleting ground water resource. Artificial recharge of aquifers can be achieved using three different methods, namely surface spreading, watershed management (water harvesting) and recharge wells. According to the former Soil Conservation Service (USDA undated) “water spreading is a specialized form of surface irrigation accomplished by diverting flood runoff from natural channels or watercourses and spreading the flow over relatively level areas.” Artificial recharge by the spreading method consists of increasing the surface area of infiltration by releasing water from the source to the surface of a basin, pond, pit or channel. This is certainly the most efficient and most cost-effective method for aquifer recharge. However, only unconfined aquifers can be recharged by the spreading method. Watershed management offers an effective method to intercept dispersed runoff. Many techniques of water conservation have been developed along hill slopes with the intention of preventing soil erosion and reducing surface runoff, then increasing the infiltration in the ground, thus recharging the aquifers. Artificial recharge by injection consists of using a conduit access, such as shaft or connector well, to convey the water to the aquifer. It is the only method for artificial recharge of confined aquifers. Traditional methods, based on centuries of experience, are well adapted to the conditions of arid lands. They consist of the construction of earthen bunds and deflectors across the land to divert the flow into the fields. But large spates usually destroy the bunds and reduce irrigation of the fields. Furthermore, the very high sediment content of spate water tends to fill the diversion canals, which have to be cleaned regularly. So, although the bunds are relatively inexpensive to rebuild, the overall cost of seasonal maintenance and repair of the scheme is high. Artificial recharge also can be classified either in-channel or off-channel. In-channel constructed facilities are recharge facilities built into a river or stream bed to retain water while it infiltrates through the stream bed into the underlying aquifer. These structures include gated structures, levees and basins, or other devices designed to impede water flow. Levees are the least expensive of these alternatives, but are the most subject to damage from flood flows. Also operating in-channel, managed facilities allow water to infiltrate the stream channel without the aid of structures to impede flow. Off-channel artificial recharge facilities include shallow spreading basins. These basins are dug up to 2 meters deep and are usually constructed with earthen walls to hold water in place.

☐ Figure No.1 shows a schematic plan of one of the patterns used in floodwater spreading projects.

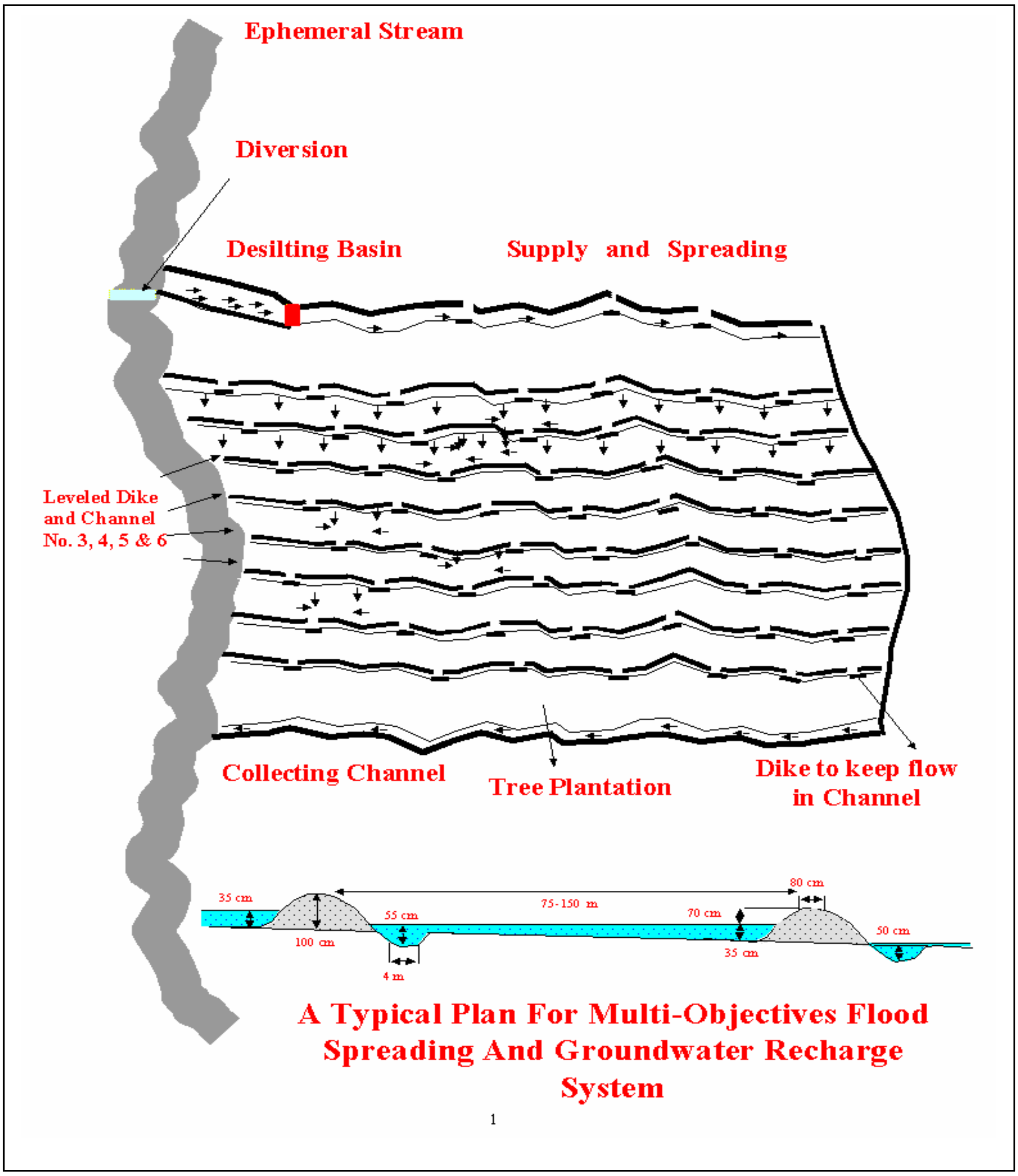

Fig. No.3: a schematic plan used in floodwater spreading projects

Floodwater spreading may be considered as a method of water harvesting too. So we should mention different old and new methods of water harvesting methods. In some traditional methods, our ancestors tried to find suitable ways to use both water and the sediment coming along with floodwaters. These sediments would be suitable for crops and were (and in some parts of the country are still) used as fertilizer or particles, which could improve the soil texture for cropping.

The most important condition in setting up floodwater spreading project is considering the slope, which should be between 1 to 5 percent. Also a floodwater-spreading site should have high infiltration soil. At low initial soil water content, rainwater infiltration is controlled by rainfall depth while at high preliminary soil water content, the rain drop impact forming the surface crusts is a deciding factor. Rainwater infiltration significantly decreases with increasing basin slope. So this indicates that the texture of the flood plain is very important for infiltration of water. Nowadays, floodwater spreading is used as a part of watershed management activities in rural areas under impact of high population and soil erosion. In fact, floodwater spreading involves operations that will increase the time and area over which water is recharged. So this involves upstream management of the flows as well as channel modifications and the plain area. As for soil characteristics, we need deep medium to moderately fine (coarser types are better) with moderately permeable subsoil. Moderately fine-to-fine textured soils are next best and may be used if land slopes are low enough to allow pounding. Topographically, land should be smooth and gently sloping. Also it is essential that expected runoff events occurred at times when the soil can store added water. Water must not contain excessive bed load, which would deposit in the spreading area. Or it must be removed from time to time. Anyhow, the catchments should not be made of marl or marl-like formations or it will cause difficulties. Floodwater spreading is an inexpensive means of applying water to an area in order to supplement rainfall. If properly designed and implemented, the system can result large returns for relatively investments. Of course, there are disadvantages in any system. Sedimentation is the most important disadvantage. Concentrated flows may cause soil erosion and sediment deposition.

The major Project components are:

River improvement work

Construction of small-scale diversion and intake structures

Construction of conveyor-spreading channel

Construction of small-scale water conversation facilities

Construction of flood control structures

Construction of sediment control structure

There are different methods of using floodwater. In rangelands, one can design special flood spreaders. These spreaders are systems of dikes constructed to divert flood flows automatically from the gullies and spread them over the adjacent rangeland. Bennett (1965) reported that: “Areas having an annual rainfall of less than 8 inches, or a growing season rainfall less than 4 to 5 inches, may not produce sufficient runoff to justify the installation of water spread system.”(Miller et al., 1969) Naturally, the diversion and spreading is controlled by a system of bunds structures, ditches or a combination of these. These constructions are designed to moderate and optimize an estimated rate and volume of flow. This is suitable in alluvial fans with good to moderate infiltration.

These systems can be divided into two types: Flow type & Detention type.

The first category incorporates free drainage from the area while in the second systems, the water retains on the area until it has infiltrated. Both two systems are further divided into subtypes as follow:

Spreader ditch & Syrup –pan & Dike and bleeder &

Detention type: Manual inlet control & Automatic inlet control

In spreader ditch flow system, short time flow of water is considered to be concentrated and distributed. The ditches are constructed to carry less water when further from the water source. The slope is reduced to 0.4- 1 percent. Water is collected from upper spreader ditches to lower ones redirected laterally.

In syrup-pan flow system, there is a single spreader ditch at the upper end of the field. Water spills over the sides of the spreader into the field below. As the water flows down the slope, it is infiltrating and its excesses, flows to the next field. The dike end is broken, leading to the next and this goes on to the last field. At the end of last field there is a waste way or channel leading possible excesses to the main channel

Dikes and bleeder flow systems are a modified type of the syrup pan system. In the system, water flows through dikes to lower portions of the field via tubes or weirs placed at intervals along the dikes. Also emergency waterway is provided in the system.

These three systems are changed or manipulated and are used in some pilot sites in different parts of the country. Normally we have built a kind of check dam to reserve water in a turkey nest or pond and then it is spread to the fields. The second category systems are not widely used in Iran. These systems are suitable for long duration flows such as from snowmelt etc.

Floodwater spreading advantages and disadvantages

a) Advantages of the project are as follows:

Increasing soil moisture & increasing farm lands & improving the fertility of the soil & Improving soil texture & Optimum use of water & Artificial recharge of ground aquifer & Increasing resident's income & preventing migration to the cities & Flash flood controlling with minimum cost & Flood farming where it is possible &Rehabilitating desert type lands

b) Major disadvantage of the project may be sedimentation. Sedimentation after flood spreading is a normal consequence. This is very important in where erosion is particularly severed. Rates may reach 10000 Tons/Km2/ years. "Studies have shown that the domains of this range could be much more (100 –2000 times)." (Meijerink 1995) in sensitive floodplains (Marl or marl-like watersheds) the floodplain is threaten by large amounts of small particles coming from top of the catchments. As a result, infiltration rate decreases rapidly and sediments are deposited in transit channels, causing great decrease in transferable magnitude flood. Sometimes degrading or flooding occurs.

COMMENTS AND CONCLUSION

Most people consider the muddy floods of winter as a useless phenomenon. While these floods are God's gift and are very useful for the human welfare. The advanced science and technology makes it possible for us to use these types of water resources.

Using these waters and make them to infiltrate into the ground may be the best method of controlling, storing and using this resources. Being practical in south of Iran, confirms this idea. In arid and semi-arid regions, precipitation is not enough. The method of artificial water recharge is a method to make maximum use of these precipitations. Although enough data gathering and scientific research has not been carried out on these projects, but farmers are very satisfied with the results of these projects.

As a result, people and farmers using underground water for agriculture are ready to take part in the investments of such projects.

A distinguished advantage of these projects relative to other projects of water harvesting like dam construction is its low cost and short construction periods. The change in water table, one to two years after finishing the project is detectable. Controlling flood hazard and stopping salty ground water attack on fresh ground water aquifers are other advantages of these projects.

Governmental executive organizations are responsible for use of simple and low cost methods for reclamation of land, natural resources, and environment. The flood spreading project has been accepted by some local NGO` s in arid a semi-arid regions of the country. Executive organizations are normally interested in a short time periods. NGO` s are eager to extend such simple approaches with low investment. Executive organizations and NGO` s can participate in providing funds, to encourage local people to co-operate as voluntary labors in several stage of executive works, especially in non-agricultural seasons. It may be easy for executive organizations and NGO` s to help project managers in planning, design, and implementation. Most of the necessary construction and plantation material may be supplied with low transportation cost.

Generally speaking, flood hazard problems, soil erosion in watersheds and farms, desertification and movement of sand dunes, low productivity of the soil and shortages of water are major obstacles toward sustainability in most parts of the country. More specific to this project, incoming sediment carried with the floodwaters impedes smooth recharge into the aquifers and must be properly dealt with. Regular maintenance and appropriate funding should be carefully planned for since most water resources projects suffer from lack of attention in their long-term existence. Mechanisms to assure sustainability may include:

Government loans with low interest rate should be made available for implementation of similar projects where needed.

Local co-operative communities have the opportunity to receive bank load to implement large-scale projects for their community.

Design and construction standards must be developed for easy application.

More economically optimized structures should be proposed.

Plants with higher-value are to be researched for adaptation in various regions.

Finally main recommendations &key messages are as follows:

1. Recognize RWH as basic strategy for poverty alleviation
2. Government should invest in rainwater harvesting for agriculture - a small fraction of investment in infrastructure for irrigation.
3. Integrated Water Resource Management should integrate rainwater harvesting as the third source of freshwater in its concept.
4. Harness rainwater for drinking and non-drinking use. It is a major Freshwater Source.
5. Advocate for mix and advanced technologies for rainwater harvesting
6. Integrate RWH in catchments management to mitigate flood
7. Local government should get involved and pass guidelines and policies
8. Local government should raise awareness by having Rain Centers for technology information
9. Rainwater Harvesting should be integrated in school curriculum for continuing education.
10. To recommend to the UN RWH as another major option of water supply in order to support choices of users for their water supply source.
11. Establish rainwater harvesting index system.
12. Harvested rainwater is a major water supply option, as important as runoff surface and extracted ground water.
13. Bring down every drop of water from the managing agencies to the communities...
14. Decentralize water utilization using rainwater harvesting for the sake of Earth...
15. Giving adequate attention, founding to RWH
16. Placing RWH in the agenda as a part of water resource management

In National level & Regional level should be:

1. Initiate Strategies and Plan of Action for Management and Preparedness Planning.
2. Enact appropriate laws and legislations to formalize and put a legal framework at the National level.
3. Ensure coordination and collaboration among various governmental institution involved.
4. Promote the exchange of information and data at national, sub-regional and global levels.
5. Give due support to sub-regional, regional and international Network, for the exchange of cross-country experiences.
6. Give due support and make necessary steps towards creating a Regional Cooperation Center of Excellence information.

7. Establishing regional network for Environmental Degradation mitigation
8. Establish and support public education centers for more awareness and good practice
9. Establishment of intra-regional economic and technical cooperation, to enhance the exchange of information and expertise among the regional countries.
10. Establishment of International Alliance for watershed development and combating desertification
11. Establishment of hazard and risk information and mapping system
12. Formulation of regional strategies for catchments management for highlighting the common problems and natural hazards facing watersheds in the region

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