ICIWRM – 2000, Proceedings of International Conference on Integrated Water Resources Management for Sustainable Development, 19 – 21 December, 2000, New Delhi, India

Assessment of water harvesting structures
(Case studies in three different parts of Iran)

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Abstract
Iran is placed among the dry region of the world and does not receive plenty of precipitation annually. The annual precipitation of about 413 bm^3 is negligible as compare to its total geographical area (1648000 km^2). Moreover, this amount is unevenly distributed within the country and therefore, certain areas of the country experience acute shortage of water, which largely depend on groundwater resources. In these areas, due to over exploitation of groundwater the drop in water table has been serious and consequently has effected the basic human activities. To tackle the problem, the government has undertaken watershed management practices. The prime aim is to mitigate destructive floods and harvest excess runoff water by means of artificial recharge structures. It is evident that a number of crucial factors affect applicability of artificial recharge, which are different for divers region of the country. The present paper intend to evaluate the impact of water harvesting structures on quantity and quality of groundwater, coastal zone saline water intrusion and flood mitigation for three case studies in SW, NW and West central Iran. Since these areas are located in different climatic-geological settings the importance of site selection, physical and hydrologic parameters of watershed on efficiency of harvesting structures are discussed. Keeping the above in mind, the feedback on efficiency and depiction of factors causing unproper functioning of the system would help how to encounter ever existing difficulties in establishing such structures.

INTODUCTION

The survival of every society is bond to availability of enough and good water resources. The low and erratic rainfall leads to an acute problem of water resources in major part of the country. This problem is more severe in the semi and arid zones, which is characterized by high temperature and evaporation rate. The people of the country have confronted from the ancient times with the problem by constructing primitive Rain Water Harvesting systems (RWH) for optimal utilization. The RWH is a cultural tradition (Fig 1) and was the means to secure livelihood.

With development of diverse modern techniques for RWH, the application of Storage Basins (SB) and Water Spreading (WS) were recommended. Such establishments were strongly supported by water resource authorities in the water deficit regions in particular to replenish aquifers and to meet the other purposes. Therefore, in the early 1970s the government has incurred enormous expenses for establishment of such structures and it was considered as a remedial measures and a viable option to solve the existing water scarcity problems. The main objectives of these systems were to (1) enhance groundwater, (2) to improve agricultural development, (3) to increase farmer income and (4) to control the floods and its damages.

The success of RWH systems, depend, to a large extend, on physical characteristics of site, watershed and the recharge water. Performance evaluation has been developed by (Bouwer, 1988, Schun, 1988, Urban, 1988 and Raesi,1998), which constitute the main theme of the present paper. In order to explore this, the following issues are discussed:

The physical characteristics of watersheds and their impacts on practical performance of RWH systems.

Whether the establishments are able to fulfill the aims of the projects.

THE STUDY AREAS

For the purpose of study three in use RWH systems in, Jashak, SW of Bushehr city, Kabotar Ahang (KA), NW Hemadan city and Daryan Chai (DC) southwest of Tabriz city were selected (Fig 1). Table 1 and 2 exhibit the characteristic features of the above mentioned study areas.

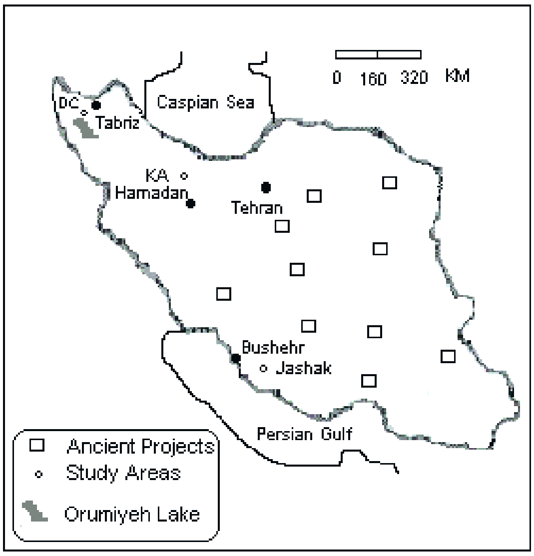

Figure 1. Location map of the study areas.

Table 1. Climatically characteristics of the areas.

Area	Average rainfall mm	Evaporation	Mean temp C°
Jashak	221	2420	26
KA	350	1643	10.7
DC	435	1338	10.3

RESULTS

The study of the Jashak , KA, and DC was commenced during exploitation in 1997, two years after performance in 1998 and three years after operation in 1999, respectively For the comparsion purpose following parameters were measured before and after intake of the basins: 1- Static water level; 2- Chemical analysis of water samples of aquifers; 3- Infiltration rate on the bottom of the basins and on undisturbed contiguous ground; 4- Computation of sedimentation load of the watersheds and on the basins; 5- Physical characteristics of the watersheds.

Table 2. Characteristics of recharge sites.

Area	Jashak	KA	DC
Lithology	Gravel	Silt, Clay	Gravel
Depth to water table m	17	27	38
Total basins area m^2	$1.95x10^4$	$5x10^6$	$7.2x10^4$
No of basins	2	5	5
Recharge source	Rainfall	Rainfall	Rainfall
EC of recharge water	1412	1320	345
Type of recharge	Storage	Spreading	Storage
Average thickness of sediment in one season	18 cm	7 cm	7.6 cm

Table 3. Representative chemical analysis in pre (1) and post (2) intake meq/l.

Area	Jashak		KA		DC	
	1	2	1	2	1	2
Ca^{+2}	16.5 17		2.1 3.5		3.2 2.6	
Mg^{+2}	6.2 8.0		1.4 1.59		3.1 2.6	
Na^{+}	20 28		2.2 3.02		0.9 0.72	
K^{+}	0.2 0.3		0.04 0.045		0.32 0.2	
$HCO3^{-}$	0.4 1.2		1.9 3.07		5.0 4.0	
Cl^{-}	10 11		2.2 3.0		0.7 0.5	
$SO4^{-2}$	19 43		0.6 0.8		1.3 1.2	
EC µs/cm	2710 3017		554 727		665 642	

The static water level of the Jashak aquifer on October 1996 was taken as a base and plotted subsequent records on hydrograph have shown the rise of 50 cm during one season intake of the project. Furthermore, a piezometer located about 700 m away from the project has shown a temporary increase trend of water level, which was more than 8 m. Results of chemical analysis of groundwater samples of the Jashak aquifer in pre and post intake indicate increase trend of salinity (Table 3). But farther deterioration of groundwater quality is not expected to occur and this temporary increase in salinity would be improved with the next intakes. On the other hand, water table data and chemical analysis of groundwater samples revealed that due to geological nature of the site (Table 2), the KA project had no effect on quantity and quality. Although, since establishment of the project a little but gradual falls of groundwater was observed, change in water chemistry was not noticeable. In spite of surfacial relevant site and promising aquifer impact of DC project on quantity and quantity was limited to a small area and the ISO-Cl and ISO-Na maps designating farther coastal saline water wedge movement.

The basic infiltration rate on the bottom of basins and undisturbed soil were measured (Table 4) by double ring method and the remarkable difference was resulted due to deposition of fine grain sediments on the basins. In general the nature of stream flow in an area relies on rainfall input, vegetation cover and climate. The watershed behaviour is by much determined by its geology, area, slope and drainage basin hydrodynamics. It is also evident; that the rate of sediment transported in suspension greatly depends on stream flow, velocity and slope of stream. Keeping in mind the above, it is eminent from the Table 5 that the, geologic, morphometric and hydrologic characteristics of the watersheds are responsible for high rate of erosion and in turn accumulation of sedimentation load in the recharge schemes.

Table 4. Basic infiltration rate of experiment sites (Cm/h).

Area	Jashak	KA	DC
Undisturbed soil	6.4	2.15	8.2
Basin	3.5	1.7	3.1

Table 5. Watersheds characteristics.

Area	Jashak	KA	DC
Rock type	L.stone,Marl,Shale,Gypsum	L.stone,Sandstone,Marl,Shale,Ig rocks	Almost similar to KA
Basin shape	Elongated	Flate	Elongated
Compactness Factor	1.4	0.8	1.1
Stream order	5.0	6.0	4.0
Drainage density	3.0	1.9	2.2
Slope %	3.5	4.4	6.0
Area Km^2	99	643	58
Concentration time h	2.36	7.0	1.10
Max discharge m^3/s	13	31	16
Elevation m: Max	510	1960	2336
Min	56	1743	1870

Some governing factors for erosion in the watersheds including; geology soil, climate, run off, topography, vegetation cover, land use and channel erosion were taken into account. The rating parameters of each watershed were then computed and with the help of the erosional rating (total rating) and applying the following equation the annual sedimentation load of the watersheds were calculated.

$Qs=38.77\ e^{0.0355R}$ Qs= Annual sedimentation load m^3 R= Total computed rating

Computed data indicated that over 60% of total watersheds sedimentation load had been deposited in the recharge basins.

CONCLUSIONS

The summarized data presented earlier indicates that the artificial recharge depends on many factors, two of which were found to be the most limiting ones in the study areas. The first is geological characteristics of sites (Table 2) and the second one is physical characteristics of watersheds(Table 5). The former influencing infiltration rate and the later is responsible for a remarkable amount of sedimentation load.

A successful recharge project should have the design criteria. Depending upon the existing condition it may be considered as a favorable one but at the same time it may lack one or two factors. As such it is true in the case of the Jashak project, because while it controls flooding which leads to aquifer recharge and raising up of water table, the disposition of the sedimentation load is a banding norm. Therefore, the Jashak artificial recharge project was evaluated as a moderate effective project and return on investment was also relatively good. However, due to acute shortage of water resource in major part of the country it is suggested to construct such RWH systems in areas with only relevant site criteria. The KA project, on the other hand with very low infiltration rate, does not have the basic requirement and it can just control floods. In spite of the fact that the DC project has most of the essential prerequisites, the subsurface conditions and relatively thick clay bed, reduce its efficiency. Therefore, out of these three, the Jashak project relatively fulfill most of the predicted aims but the other two are utilized for flood control, prevention of soil erosion and farm destruction, therefore they are also regarded a manner of investment.

In general, to a large extend the economic life of artificial recharge systems, remains a challenge for planner and implementers of this types of projects. Therefore, in order to have a successful project the design criteria should be taken into account both during construction and operational stages. Turbidity of flood waters emanating from most of the watersheds is also important norm, which is bounding artificial recharge project development. Therefore, very large sedimentation basins have to be incorporated into design and in particular in areas such as Jashak. In order to reduce farther turbidity it is suggested to employ the followings in the upstream: Terracing, Gully control structures, check dam, contour bunding and reducing steep slope.

Acknowledgement
The author is very much thankful to water resources management of Iran for providing financial support and valuable help of Chamran university authorities throughout of present investigation.

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