Available online at www.elixirpublishers.com (Elixir International Journal)

Agriculture

Elixir Agriculture 48 (2012) 9681-9684

ISSN: 2229-712X

Role of watershed management operations in reducing of drought effects (Case Study: Fojerd catchment, Qom province)

Raed Kamali Moghadam[1] and Noredin Rostami[2*]

[1]Watershed Management, Islamic Azad University, Science and Research Branch, Tehran, Iran.

[2]Watershed Management Sciences and Engineering, University of Tehran, Iran.

ARTICLE INFO

Article history:

Received: 19 April 2012;

Received in revised form:

20 July 2012;

Accepted: 30 July 2012;

Keywords

Artificial Recharge,

Drought,

Qanat (aqueduct),

Watershed management.

ABSTRACT

Drought is one of the natural disasters which annually cause to millions of dollars damage to agricultural communities around the world. In recent decades among the natural disasters, frequency of drought in terms of drought intensity, duration, total affected area, life and economic losses and social impacts on community, had more effect on human populations than other natural disasters. The most important effect and consequences of drought is water shortages for various purposes like agriculture. Qanats (aqueducts) construction and use of them is an ancient method for supplying water in Iran. In this way, without spending energy and only through the force of gravity, a part of required water of agriculture, drinking water and residential area has been supplied since long time ago. Using this method of water supply after development of equipments for drilling of semi-deep and deep wells is reduced, and in some parts of the country construction of new Qanats has stopped. Uncontrolled withdrawal of groundwater by excessive exploitation of wells with increasing of wells number and lack of natural recharge, for various reasons like changing of land use and climate changes, cause to decreasing of Qanats water yield or even dried them. So, the purpose of this study is analyzing the effects of watershed management operations like artificial recharge to increase the discharge of Qanats using flood control.

In this study, the quantitative and qualitative data of Qanats water evaluated where artificial recharge of aquifers has done using trend analysis of hydrological behavior changes in selected Qanats and results of changes in water yield of Gambleh and Noh Abad Qanats, before and after of artificial recharge, including construction of recharge pools and flood spreading, during 1995 to 2010 showed that discharge of Qanats from 5.6 and 5.8 liters per second in 1995 (before artificial recharge), increased to 12.5 and 8.3 liters per second in 2010 respectively which had an effective role in reducing of drought effects in study area.

Introduction

Qanat construction is one of the ancient methods of water supply in Iran. In this way, just using force of gravity, a part of needed water for agricultural, drinking and domestic purposes has been supplied from long time ago. After expansion of facilities for drilling of deep and semi-deep wells, use of this method is decreasing and in some parts of the country construction of new aqueduct has stopped. The uncontrolled exploitation of groundwater through the wells with excessive increase in number of wells and lack of natural recharge for various reasons, especially land use and climate changes cause to reducing the discharge or even drying the qanats. According to available statistics, currently in Iran about 35,000 strings of qanats exist with about 9 billion cubic meters discharge annually, which mainly are located in the regions of Khorasan, Fars, Kerman, Yazd, Isfahan, Semnan, East Azarbaijan and Markazi Provinces.

Exist qanats because of inadequate maintenance and lack of affordable financing of farmers, particularly in rural areas in order to dredging and reconstruction and rehabilitation of them are destroying and some of them had been destroyed (Ebrahimi and Zamzamyan, 2001). Consider to wide range of arid and semi-arid climates in country (about 90% of country area) and scarcity and water crisis due to occurrence of several droughts (especially in the last three decades) on one hand and increasing of floods number on the other hand, maintenance and using qanats seems to be helpful in problem solving crises caused by dehydration and at least provide a part of agricultural water needs. But considering the hydrological conditions of arid and semi-arid watersheds and situation and characteristics of existing qanats and construction of new systems, unknown and obscure aspects in revival, equipping and operation of qanat systems are their discharge stability and solutions to resolve these challenges and how to achieve them.

In this regard, the most important variables are amount and rate of natural recharge and its adequacy and appropriateness for continuity of qanats water yield in accordance with the minimum water requirements especially for agricultural activities and also having to justify the scientific and practical artificial recharge of qanats with regard to floods and surface runoff that cause to less infiltration of water in soil. So, this study done in Fojerd catchment of Qom province to analyze the effects of artificial recharge in increasing of qanats discharge using flood control.

Tele:

E-mail addresses: noredin_rostami@ut.ac.ir

Materials and Methods

Study area

Fojerd catchment, a sub basin of Thoghroud river, with 26741.2 ha area and 70 km distance from Qom city is located from 50° 03′ 28″ to 50° 24′ 24″ eastern longitude and 34° 31′ 09″ to 34° 39′ 33″ northern latitude. Main channel of this sub basin after connecting to other branches joins to Gharehchay River (figure 1). Two qanats of Gambleh and Noh Abad studied in Fojerd catchment which specified by F1122 and F114 codes respectively (figure 2).

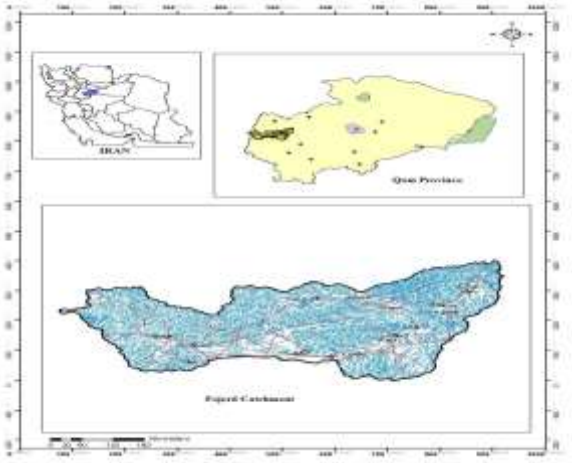

Fig. 1: location of study area

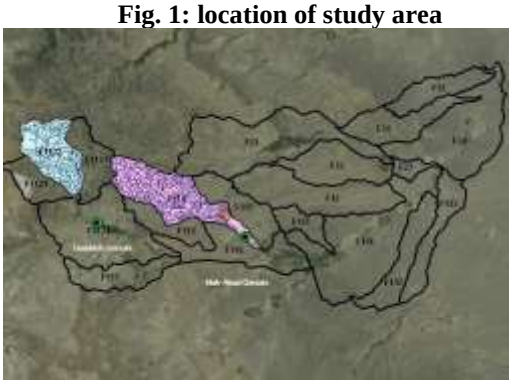

Fig. 2: location of Gambleh and Noh Abad qanats in study area

Methodology

- Extraction of descriptive and quantitative data in fields of geology, soils, and vegetation cover and relevant maps from reports of natural resource projects, watershed and flood spreading studies for collecting of required information.
- Providing of precipitation, temperature and hydrology data including depth, discharge and volume of surface runoff.
- Specify the location of watershed management structures including flood spreading systems and masonary dam in GIS environment.
- Define the area, slope, height and drainage density of streams using Arc-GIS and Auto-CAD software within catchment, and area of artificial recharge based on flood spreading limits in study area and selection of control points randomly which classified based on slope, height and drainage density of streams (at least 3 points in any group or class),
- Selection of points randomly based on units characteristics like type of rock and formations, soil type, vegetation cover and density (at least 3 control points),
- measuring dimensions of qanats outlet and their discharge using sharp crested Parshall flume installed in the qanats outlet,
- Analysis of above statistics and information using GIS and relationship between characteristics of catchment, quantity of runoff used for artificial recharge in the area of flood spreading with changes in discharge and hydrological behavior of qanats in study area. Arc-GIS and Auto-CAD software were used for providing necessary layers and maps, as well as Excel and SPSS software were used to determine the correlation between variables by linear regression method.

Results and Discussion

Surface Runoff

The average annual volume of rainfall and surface runoff in catchments of both qanats with regard to characteristics of rainfall, air temperature and calculated average height of surface runoff based on Justein method are presented in tables 1 to 4.

- The average amount of precipitation in Gambleh and Noh Abad catchments is 3.49 and 4.78 million cubic meters per year, respectively.
- Average volume of surface runoff in Gambleh and Noh Abad catchments, is 1.51 and 1.73 million cubic meters per year, respectively.

- Status of qanat's water yield

A - Groundwater budget of qanats

Based on field survey and studies, ground water in catchment of Gambleh and Noh Abad qanats, water drained by wells, springs and qanats (figure 3&4). As, its average rate, in F1122 and F114 catchments is 2239056 and 567648 cubic meters per year, respectively (Table 5).

B - Technical characteristics and discharge of qanats

Results which obtained from two strings of studied qanats are summarized in table 6 (figures 3 & 4).

Fig. 3: Outlet of Noh Abad qanat

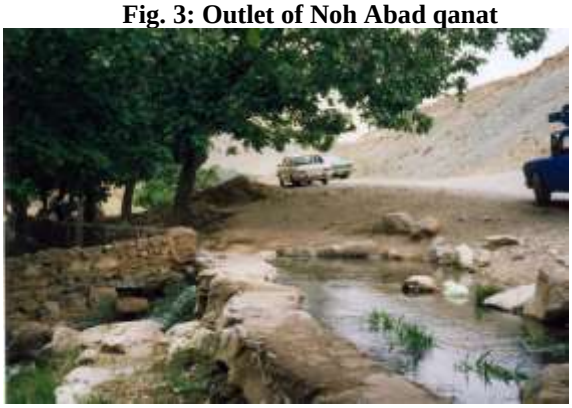

Fig. 4: Outlet of Gambleh qanat

Furthermore, average discharge of qanats based on measurements during 1995 and 2010 is shown in Table 7 (figure 5).

Variation coefficient of annual rainfall from 1995 to 2010 is about 0.09%, so that statistically is not significant. But consider to construction of two artificial recharge projects including recharge basin by construction of masonary dam in catchment of Gambleh qanat and flood spreading in catchment of Noh Abad qanat after 1995 (between 1995 and 2008), a part of surface runoff (as flood) in F114 and F1122 catchments controlled for artificial recharge of qanats with aim to increase the water yield of qanats.

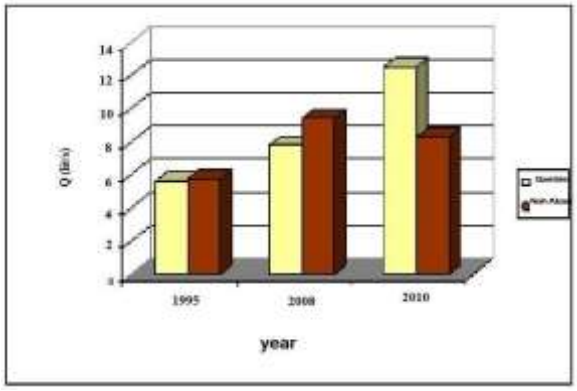

Fig. 5: chart of discharge changes of qanats

Conclusion

Considering the results, characteristics of studied qanats are as below:

- Status and distribution of rainfall and surface runoff are two effective factors in natural recharge of aquifers and water yield in study area. Highest rainfall falls in the spring (106.6 and 94.3 mm in catchments of Gambleh and Noh Abad qanats, respectively) and also difference between average rainfall and surface runoff in catchments of qanats is 27.5 and 3.6 mm, respectively. In other words, this indicates little difference between the input water to the aquifer and rainfall.

- changes in discharge of Gambleh and Noh Abad qanats before and after projects of artificial recharge during 1995 and 2010 indicates that discharge values has increased from 5.6 and 5.8 liters per second in 1995 (prior to the operation of artificial recharge) to 12.5 and 8.3 liters per second in 2010, respectively. Because of insignificant changes in amounts of precipitation and evapotranspiration in study area, reason of this increase in discharge of qanats is direct impact and effectiveness of artificial recharge of aquifers.

- A significant issue is effectiveness of artificial recharge in comparison with flood spreading method which changes of Gambleh discharge from 5.6 to 12.5 liters per second and discharge of Noh Abad qanats from 5.8 to 8.3 liters per second approve this result. Reason of this result is concentration of floods and water retention in the reservoir pools with two meters depth and due to hydrostatic pressure. So, hydrostatic pressure cause to aquifer recharge under pressure. While, in flood spreading method this pressure is too small because of distribution of floods in water spreading channels and spreading in area between canals.

These results are in accordance with studies of Ghoddousi (1999), Kowsar (1991), Raeisi (1997), Semsaryazdi (2000), Dadresi (2001) and Yosefi and Kheirandish (2001).

References

1 - Dadresi, A., 2001, Evaluation of artificial recharge methods in Qanats rehabilitation using Flood spreading. Proceedings of aqueduct articles. Vol. 1. PP: 158-161

2 - Ebrahimi, M. and S.M.R. Zamzamyan, 2001, artificial recharge of groundwater to increase Fariab Qanat discharge in Boshehr province, Proceedings of aqueduct articles. Vol. 2. PP: 457.

3- Ghoddousi. j. 1999. An Overlook to the Developmenet and Use of Rainwater Harvesting Systems in Iran. pro. 7th Internationl Conference on Rainwater Catchment Systems. China. 4on PP: 26-36

4- Kowsar. A. 1991. Floodwater spreading for Desertification Control: An Inteyrated Approach. Desertification Control bulletin. UNEP. NO19, PP: 3-18.

5- Raeisi, E. A. and F. Koohyan Afzal. 1997. Evaluation of Idje artificial groundwater recharge project. Estahban-Iran. pro. 8th Internationl Conference on RWCS. Vol.1. PP: 207-216

6 - Semsaryazdi, A.A, 2000, Aqueduct, Proceedings (first and second volumes). Regional Water Company of Yazd. Page 116 & 252

7 - Yousefirad, M. and M., Kheirandish, 2001, Qanat role in groundwater control. Proceedings of aqueduct articles. Vol. 1. PP: 183.

Table 1: Average monthly and annual rainfall (mm)

Catchment code	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Annual average
F1122	13.8	28.6	34.1	38	43.3	45.6	45.6	45.4	13.8	3.2	2.5	1.6	315.4
F114	12.2	25.5	32.6	35	40	7.22	41.7	40	11.9	2.8	2.1	1.3	287.9

Table 2: Average monthly and annual potential evapotranspiration (mm)

Catchment code	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Annual average
F1122	94.4	61	31.4	20.8	25.1	49.5	83	114.3	146.7	166.4	136.2	109.6	1038.3
F114	109.5	70.7	36.4	24.1	29.1	57.5	96.3	132.7	170.2	193.1	158	127.2	1204.9

Table 3: Seasonal rainfall and volume of annual rainfall

Catchment code	Area (ha)	Fall (mm)	Winter (mm)	Spring (mm)	Summer (mm)	Annual (mm)	Rainfall volume(Mm^3)
F1122	1106.2	77.9	122.6	106.6	8.2	315.4	3.49
F114	1659.3	71.7	115.7	94.3	6.8	287.9	4.78

Figure 4. Average annual surface runoff based on Justein method

Catchment code	Qanat name	Area (ha)	Rainfall (mm)	Mean temperature (°C)	Elevation difference(m)	CN (%)	Runoff (cm)
F1122	Gambleh	1106.2	28.79	8.7	735	43.4	10.42
F114	Noh Abad	1659.3	31.54	10.7	806	36.2	13.69

Table 5: Annual water yield of studied Qanats

Catchment code	Number of Wells	Qanat (string)	Qanat Discharge (m^3)	Number of Springs	Spring Discharge (m^3)	Total Discharge (m^3)
F1122	---	9	977616	11	1261440	2239056
F114	1	4	409968	2	157680	567648

Table 6: Technical characteristics of qanats

Catchment code	Qanat name	depth of mother well (m)	Number of Shafts	Length (m)	Formation
F1122	Gambleh	25	52	800	Old alluvial Quaternary
F114	Noh Abad	25	44	1400	Old alluvial Quaternary

Table 7: Average discharge and annual volume of qanats during 1995 and 2010

	1995		2008		2010	
Qanat name	Discharge (lit/s)	Volume (m^3/y)	Discharge (lit/s)	Volume (m^3/y)	Discharge (lit/s)	Volume (m^3/y)
Gambleh	5.6	175200	7.8	245280	12.5	394200
Noh Abad	5.8	183960	9.4	262800	8.3	297840