J. Basic. Appl. Sci. Res., 2(6)5595-5603, 2012
© 2012, TextRoad Publication

ISSN 2090-4304
Journal of Basic and Applied Scientific Research
www.textroad.com

Impact Rainfall and Discharge on the Aquifer in Javanmardi Plain, Iran

Dariush Rahimi[1], Mohsen poorkhosravani[2]

[1]Assistant Professor in college of geographical science and planning, University of Isfahan, Isfahan, Iran.
[2]PhD student of Geomorphology in college of geographical science and planning, University of Isfahan, Isfahan Iran

ABSTRACT

The ground water resource is the most important sources of fresh water in the world which is faced with a quantitative and qualitative decrease because of overuse and precipitation fluctuations. These problems are obvious especially in some dry and low precipitation regions such as Iran. Chaharmahal and Bakhtiary province as one of the most important regions providing about 10 percent of Iran water resources is depend on groundwater resources too(more than 85 percent of used water) because of physiographic characteristics and concentration of developable lands. This situation causes a very intensive decrease in water levels and its quality of groundwater. Javanmardi region as an agriculture and habitant poles of province is faced with a very intensive decrease in water levels and its quality of groundwater too. In this paper we are going to determine the main causes of this problem with assessing hydro-climatologically factors. The results show that water table level is depend on precipitation fluctuations and natural logarithm of annual discharges with a significant correlation (0.28 and 0.744 for rainfall and discharge).These two factors in the 3rd space cover more than 56 percent of water table level fluctuations of the studied region. Furthermore, we used SWOT methods to define some strategic ways to prevent of this problem.
KEYWORDS: Water table, Precipitation, Discharge, SWOT, Javanmardi plain.

INTRODUCTION

Robins et al (1999) studying the ground water resources of Chalk water bed in England, claimed that the droughts of the recent decade had contributed to the fall of the ground water level and the shaping of social and economic strains.

The United Nations (2003) considers the regional changes of the present decade especially in relation to global warming and the change in precipitation patterns as the effective factors of the ground water resource dilemma. Iran, having a dry and semi–dry climate and an average yearly precipitation of approximately 250 mm (one third of global precipitation and unevenly distributed with 61% of the country receiving under 250 mm) is one of the most deprived countries of the world in terms of water supply (Masoudian, 2007: 82).

Iran has a precipitation volume of 413 billion cubic meters, 296 billion cubic meters evaporation, a 117 cubic meter volume of available water supply (25 billion cubic meters of which rests on ground water resources, 92 billion cubic meters on domestic surface waters and 13 billon cubic meters on incoming water from outside the country), 1900 cubic meters per head restorable water (the global average being 7200 cubic meters). 93.4 billion Cubic meters (approximately 65%) of the used water is supplied by ground water resources. In addition having 220 plains which are, from a conservational perspective, categorized among prohibited plains (of an overall number of 630 plains), the county's under groundwater resource status is unclear (M.P.O. 2004).

Iran, after the highly populated countries, china and India, is the third unrestricted exploiter of groundwater recourses and with a 75% usage of restorable resource as against the 40% UN standard, is in an unsuitable situation (The National Society of ground water Resources.2006). In light of the given statistics, a review of management strategies for water resources and a reconsideration of economic and social planning deem a serious necessity. The

***Corresponding Author:** Dariush Rahimi, Assistant Professor in college of geographical science and planning, University of Isfahan, Isfahan, Iran. Email: dariush111353@yahoo.com 00983117932813

ChaharMahal&Bakhtiari province covering an approximate one percent of the country's surface and as the supplier of 10% (10. 5 billion cubic meters) of the domestic fresh water supply (M.P.O, 2005) has a significant place in relation to the enhancement of the country's water resource status.

In this province due to certain factors including severe shifts in altitude, economic underdevelopment the high cost of pumping water, the role of surface waters in water supply is approximately 15% (equivalent to 225 million cubic meters).The remaining demand for water which is approximately 85% (10275 billion cubic meters) is supplied by the ground water recourses of the province. Over – exploitation of ground water resources in conjunction with the effect of recently occurring droughts has not only lowered the water level of the provincial water – beds with a rate of 2- 12 meters annually, but has also lowered the quality such that the electric conduction amount of some water – beds has Changed from a 300mm level to 900mm (Management and planning organization2001).

The Area of Study

In order to study and determine the degree of hydro-climatologically effects on ground water resources, the mountain-bordered Javanmardi plain in the province of ChaharMahal & Bakhtiari was chosen. This plain (water-bed) with an altitude of 1840 meters from sea level and a surface area of 15000 hectares, 21 rural settlements and one urban settlement are situated in the Javanmardi plain (Iran data center-2006). From a hydrological perspective the plain is a part of the Lordegan basin (north Karoon basin) in which the khanmirza river flows (provincial basin registration, 1998). The Javanmardi plain is, geologically speaking a descended plain constituted by quarts sediments with an alluvial depth of 60-110 meters (M.P.O 1986). Fig. 1 shows the geographical standing of the Javanmard plain.

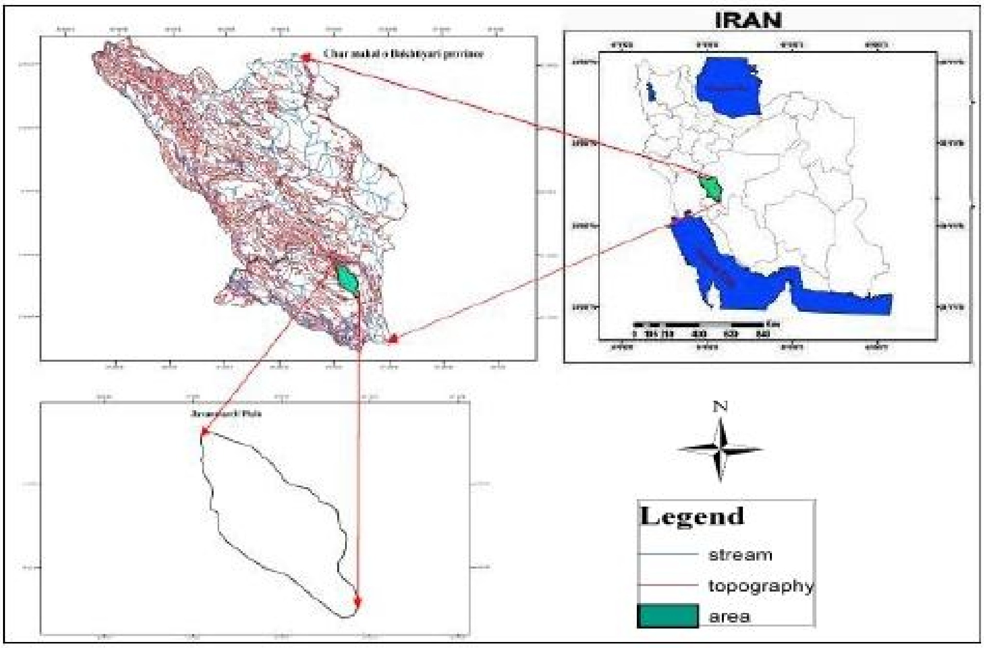

Fig. 1 The geographical standing of the Javanmard plain

MATERIALS AND METHOD

MATERIALS

In this article data concerning elevation level, annual precipitation and discharge for the period ranging from 1985 to 2005related to the Javanmardi plain was used. Included in this data was information regarding water-bed volume and the water level of wells drilled during a data gathering period ranging from 1985 to2005, water measures related to khanmirza river at Zarrin Derakht station at the farthest end of Javanmardi plain, and the precipitation data gathered at Aluni precipitation station as well as Lordegan, Malkhalifeh, Dorahan, Armand, Sarkhun and Monj stations, all data of which share a common data time range. Table (1) shows station characteristics.

Table 1 Data characteristics of stations

Station	Longitude	Latitude	Height
Aluni	51-02	31-22	1750
Armand ׳ ○	50-47	31-28	1270
Dehno	51-03	31-22	2070
Sarkhun	50-32	31-45	1575
Lordegan	50-49	31-36	1580
Dorahan	51-11	31-27	1490
Zarinderakht	50-57	31-22	1750
Berjoui	51-03	31-22	1850
Javanmardi	51-08	31-28	1870
Khosroabad	51-09	31-27	1912
Dehtorkan	51-06	31-29	1848
Dehsahra	51-06	31-30	1836

METHOD

The methodology of framework, first the data of the data gathering period was collected, then the information bank in the EXCEL statistical software was created on separate pages and using statistical completion methods, the susceptibility of the elevation level and the influence of annual precipitation and discharge was determined. Also based on the decision-making method with the aid of SWOT and fish-bone graphic a suitable strategy for the restoration of the Javanmardi plain was selected. The methodology initiated in the earliest work (Bultot et al., 1988a) consists of the following four steps:

First: A study of the fluctuations of water level and of the volume of the water-bed storage.

Second: The determination of the effect of hydro climatology factors on the fluctuations of the plain's elevation level by Correlation method between average discharge and annual, average annual rain fall and water level.

Third: The comprehension of the factors influencing elevation level decrease.

Fourth: The knowledge of advantages, disadvantages, opportunities and threats, and, the selection of an appropriate strategy by fish bone and SWOT methods.

RESULTS AND DISCUSSION

The Javanmardi plain ground water resources up to the hydro-year 2004-5 with 449 deep wells with an output volume of 95 million cubic meters, 244 semi-deep wells with an output volume of 37 million cubic meters, 16 subterranean qanat with an output volume of approximately 9 million cubic meters and 56 springs with an out put volume of 175.5 million cubic meters which constitute an overall 316/ 5 million cubic meters, and with an average 35.9 cm annual drop, are considered, conservational prohibited.

First, with the aid of the elevation level of "onlooker" wells in the vicinity of the plain, water level fluctuations and volume change of the water-bed were calculated. Table 2 shows the elevation level and the water-bed storage volume over the data gathering period. According to this table the Javanmardi plain has an average drop equivalent to 0.4 m. The maximum and minimum elevation level over the data-gathering period equals 4 and -6.16 meters respectively. Fig. 2 shows the conditions in the plain. Diagram 1 shows the annual accumulative hydrograph of the plain's ground water. According to this chart the elevation level of the plain in 1985which is the first year of exploitation is higher than the average elevation level and equals one meter, But in the following years, due to the drilling of numerous wells and the occurrence of hydro-climatology phenomena, the elevation level was subject to more fluctuations, such that, excepting the two hydro-years 1986-87 and 1992-93 the elevation level manifests a decreasing pattern in the studied region and stands below balance level (zero level).

Table 2 Water level fluctuations and volume of Javanmardi plain

year	level change (m)	accumulative water level	Aquifer volume change (m³)	Accumulative, Aquifer volume change (m³)
1985	0.72	0.72	2.70	2.70
1986	2.08	2.80	7.80	10.50
1987	-1.10	1.70	-4.13	6.37
1988	-2.39	-0.69	-8.96	-2.59
1989	-0.03	-0.72	-0.11	-2.70
1990	-0.98	-1.70	-3.68	-6.38
1991	2.30	0.59	8.61	2.23
1992	2.98	3.58	11.19	13.42
1993	-4.21	-0.64	-15.80	-2.38
1994	0.56	-0.08	2.09	-0.30
1995	-0.75	-0.83	-2.81	-3.11
1996	-1.39	-2.22	-5.21	-8.32
1997	0.22	-2.00	0.81	-7.52
1998	-2.62	-4.62	-9.82	-17.33
1999	-3.72	-8.34	-13.96	-31.29
2000	-6.16	-14.50	-23.09	-54.38
2001	3.15	-11.35	11.81	-42.57
2002	-0.33	-11.68	-1.24	-43.81
2003	0.41	-11.27	1.54	-42.27
2004	-1.17	-12.44	-4.39	-46.66
2005	4.00	-8.44	15.00	-31.66
average	-0.40	-3.91	-1.51	-14.67
max	4.00	3.58	15.00	13.42
min	-6.16	-14.50	-23.09	-54.38

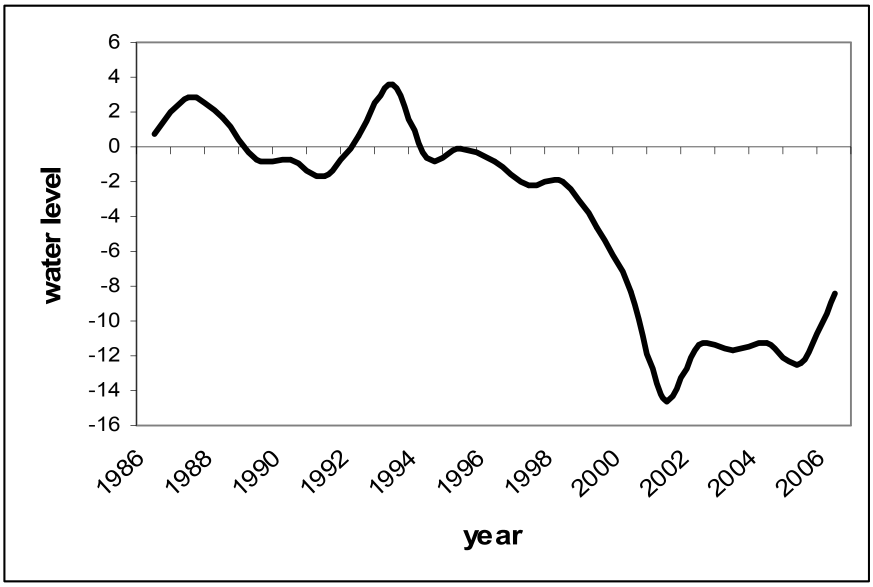

Fig. 2 Water level changes of Javanmardi plain

Changes in the storage volume of the water-bed with an average drop of 1.51 million cubic meters annually is another characteristic of the Javanmardi plain; at the end of the year 1985 the volume decrease of the water bed storage equals 31.66×10^6 m^3. Another problem is the decline in water quality which usually occurs after volume decrease and elevation level drop. In order to study the ground water quality, electrical conduction was used as the test. According to existing data the highest index for electrical conductivity (EC)of the water bed rose from a 988 in 1985 to a 5525 in 2005 (M.P.O1986 and 2005).

Second step: Precipitation and surface waters (penetration mechanism) are the most significant sources of underground water. In accordance with the second step of the prepared algorithm, precipitation and water flow (hydro-climatologically factors) over the plain area were studied as the indexes.

Precipitation was used by analyzing the annual precipitation data gathered by stations situated in the plain (Aluni station) and neighboring areas (Table.1). Then by using the "equal precipitation connection lines" method the annual precipitation map of the region was drawn, subsequently, the average annual precipitation of the plain was calculated and used for the study. Fig. 3 shows the average annual precipitation and the elevation level fluctuations of the Javanmardi plain.

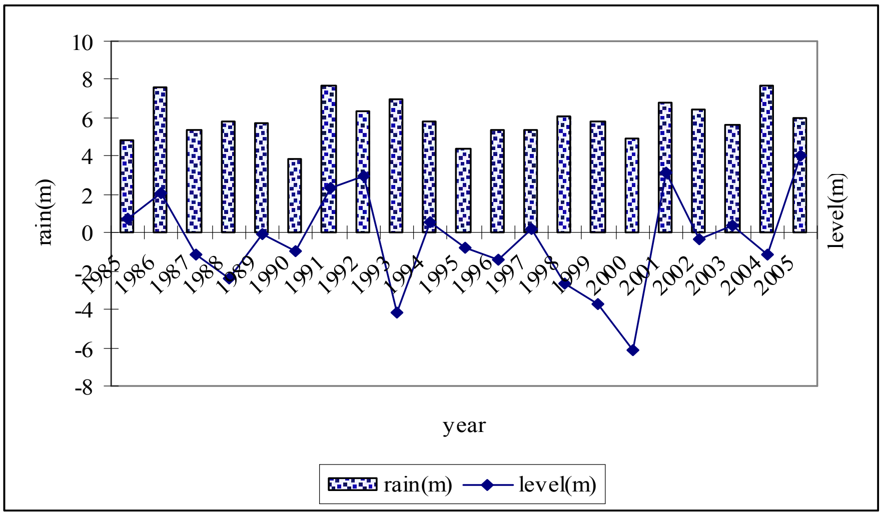

Fig. 3 Annual precipitation and water level fluctuations of the Javanmardi plain

According to Fig. 3 there is a relation between precipitation changes and the annual elevation level of the water-bed under study, such that precipitation fluctuations entail changes in elevation level; the correlation between these two variables is r=0.281 Fig. 4 shows the optimum line and the correlation of the two variables.

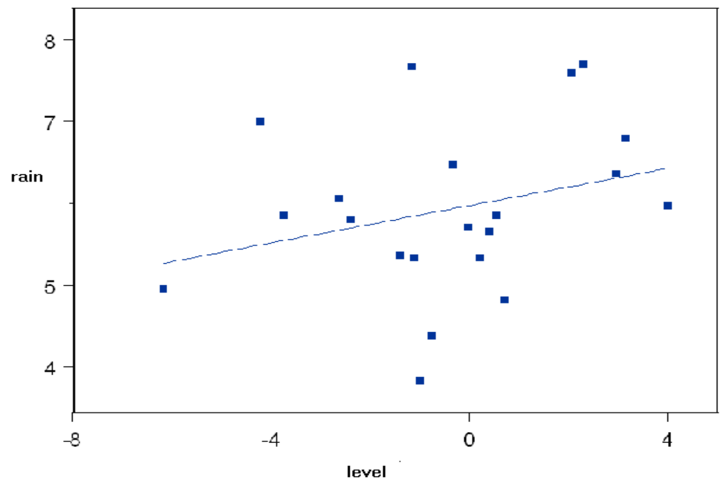

Fig. 4 Correlation diagram of water level and annual precipitation of the Javanmardi plain

Another of the factors influencing ground water resources is the regional discharge. The influence of water flow on the elevation level and the storage volume stems from its role as water-bed supplier. Supply in this case stems from the location of a primary current in the regional waterway network (Keith Todd 1954: 281). In order to study the relation between the discharge and the elevation level of the water-bed, the data from discharge measurements obtained daily at the Zarrin Derakht station were studied. First the annual hydrograph of the river at the station point was delineated. The next step was the collation with the annual ground water hydrograph which revealed a strong correspondence between the two. The degree of correlation between the two variables equaled r=0.744. Fig. 5 shows the optimum line and the correlation of the two variables. The highest correlation degree related to the N-log amounts of the annual discharge and the elevation level.

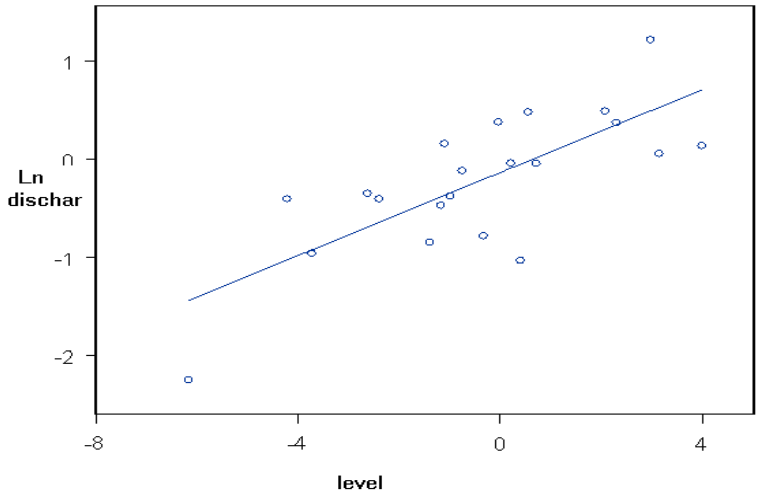

Fig. 5 Correlation diagram of discharge and level water

With regard to Figs. 4 and 5; the correlation index of precipitation, discharge and elevation level, the study of mathematical model in a 3rd dimensional scope of the precipitation, discharge and elevation level was attempted. Therefore, initially, the relative and accumulative variables of the elevation level, the relative and accumulative storage volume, precipitation and the annual discharge were tested in various distributions with the aid of SAMDA and S-plus software. As a result, considering the same susceptibility of the relative and accumulative elevation level, the relative and accumulative storage volume and elevation level was chosen as the dependant variable. The fitness test showed that the highest correlation was between elevation level data and annual precipitation data and the annual discharge data, Fig. 6 shows the distribution and correlation of the three variables on a three dimensional basis.

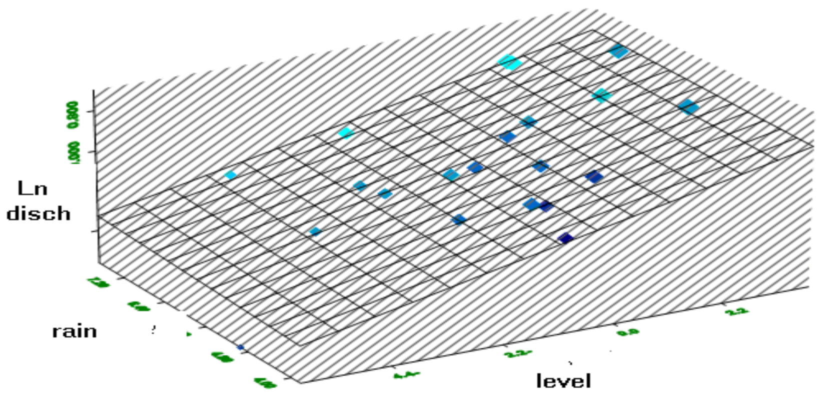

Fig. 6 The distribution and correlation of 3rd dimensional

Now, the mathematical model and the quantities of the model suited to the variables will be presented. Table 3 shows the quantities of the optimum line model.

Table 3 The correlation index amounts and R^2

Variable	Level	Rain	Ln discharge	R^2 و P-value
level	1	0.28	0.744	$R^2 = 0.56$
Rain	0.28	1	0.284	0.065
Ln discharge	0.744	0.284	1	0.003

According to table 3 and based on the p-value standard in both variables especially in the case of the discharge, considering it is less than the index value o.o5, the R^2 index of precipitation and discharge variables accounts for 56% of the elevation level fluctuations. The mathematical model of the above mentioned variables is as follows in model no1:

L= -o. 89116 t* (o. 1841)*(R) + (2. 5584)*LN(dis)*

The variables of the model are as follows:
L: Elevation level fluctuations (meters)
R: The plain's annual rainfall (millimeters)
LN dis: The natural log. For annual discharge data (cubic meters)

According to the above, hydro-climatologically factors, the management of water resources and the number of deep wells are the most influential factors of elevation level fluctuations and storage volume.

Third step: The main factors and processes involved in the Javanmardi plain elevation level drop are a conjunction of factors involving official management and factors caused by natural phenomena. With regard to the systematic behavior of human and ecological factors, an understanding of the reasons underlying the fall in the Javanmardi plain elevation level is faced with its own unique complexity; in this relation using methods involving the cognition of the structure of problems (fish bone) deems appropriate.

Following the algorithm (prepared in order to determine the factors involving elevation level drop based on a study of hydro-climatologically factors and ground water resources) the next phase was the use of the fish–bone graph. According to the studies carried out in the first and second stages of the algorithm and with regard to the data indices, the averages and correlation indexes, Figs. 2-6 and tables 1 and 2, the increase in the number of wells from 2 in the year 1985 to 693 (deep, semi-deep) in the year 2005 and a fall in the quality of ground water resources are the most influential factors concerning the drop in the elevation level of the Javanmardi plain. Fig. 7 shows the causes leading to the drop in the elevation level of the javanmardi plain.

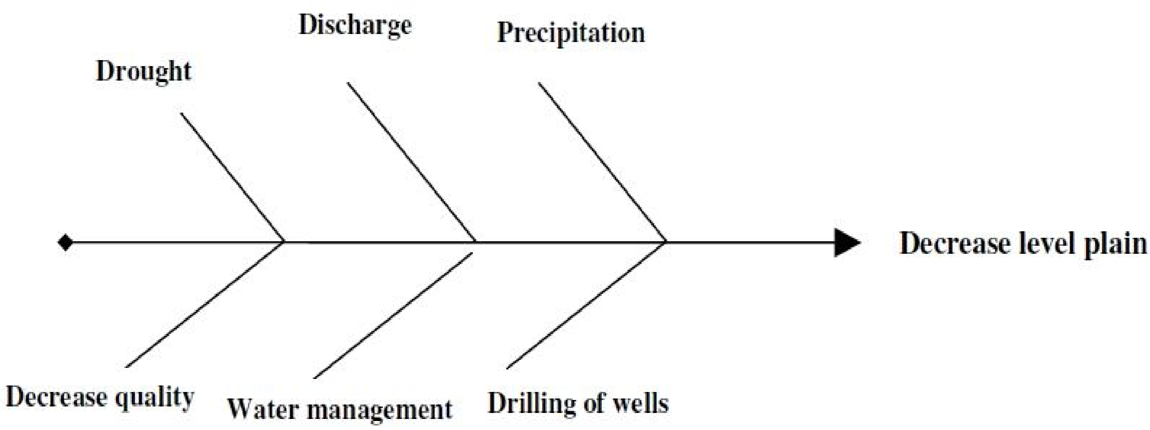

Fig. 7 Fish-bone diagram of the elevation level drop

As the diagram shows the causes of elevation level drop in the Javanmardi plain are categorized into two parts: natural causes (top) including fluctuations in precipitation, discharge and recent droughts, and human causes (bottom) including unrestricted well drilling, water resources management and ground water quality

Fourth step: In order to determine the strengths, weaknesses, opportunities and threats and subsequently choose a suitable strategy, based on multi-criteria decision-making, the SWOT method was used. In this model, external factors (opportunities, threats) and internal factors (strengths, weaknesses) are taken into consideration.

Table 4 The result of SWOT method

SWOT			
Strength	**Weakness**	**Opportunity**	**Threat**
1-The stable geomorphology of the plain 2- The alluvial condition of the plain at the waterway entrances to the plain and a high degree of penetration 3- The suitability of conditions rendering adequate provision for the plain such as the Sini village 4- The presence of high-rising lands around the plain 5-the relatively high degree of precipitation in the plain (the average amount approximates 600mm). 6-The presence of the constantly flowing Khanmirza river with an effective discharge in the vicinity of the plain 7- The existence of farming as the central economy and the ability to authorize appropriate regional management.	1- The smallness of the alluvial depth and storage volume of the water – bed. 2- The existence of the Bagh – Behzad salt dome (water quality drop) 3- The occurrence of severe droughts 4-Severe fluctuations in precipitation and discharge 5-Unrestricted drilling of deep wells 6-The high degree of traditional-watering practice and the loss of unused water.	1-The existence of Vank and Armand rivers 2-The minor difference in the altitude and the short distance of the plain relative to the above mentioned rivers, and the ability of water transfer (increase in hydrologic input) 3- The ability of easy technological transfer to the town and the aptitude for educational activity.	1-management decisions for the resources, and strategy selection which is usually effected by authorities outside the region 2-The lack of consideration for the ecological potential of the area.

In this process and in each stage, two factors (internal and external) have been compared, but the aim is not to determine the best strategy, rather, pinpointing strategies that can be carried out is the goal. Therefore all of the strategies that are presented in the threats, opportunities, strengths and weak nesses matrix will not be chosen and executed (Parsian,2009) with regard to the issues presented in table it ,the most appropriate strategy to deal with the problematic drop in the elevation level and ground water recourses quality of the Javanmardi plain is a multi–aspect strategy involving strength (internal) and opportunities (external) with a consideration of threats and weaknesses, therefore, the proposed strategy is as follows:

-The execution of water- bed care projects such as artificial supply (strengths)

-The prohibition of unlicensed well drilling and a review of the rules and regulations of ground water resources conservation

-The execution of a water transfer project from Vank river (short distance, minor difference in altitude) (opportunity)

-A review of the management involved in regional resources

-The execution of projects proportion ate to the environmental potential of the region on an experimental level.

Acknowledgments

The authors are thankful for the help provided by the University of Isfahan, Chahar Mahal and Bakhtiari Regional Water Company, and Iran Meteorological Organization.

REFERENCES

Bultot, F., Dupriez, G.L., Gellens, D.,(1988),Estimated regime of energy-balance components, evapotranspiration and soil moisture for a drainage basin in the case of a CO2 doubling, Climatic Change, 12, 39–56.

El-Naqa A,Al-Shayeb A (2008) Groundwater Protection and Management Strategy in Jordan. Water Resour Manag 23:2379-2394.

Foster S (1998) Groundwater: assessing vulnerability and promoting protection of a threatened resource. Proceedings of the 8th Stockholm Water Symposium, 10-13 August, Stockholm, Sweden, pp 79-90.

http://www.chaharmahalmet.ir.

http://www.gwea.ir.

MadanK.Jha&Y.Kamii&K.Chikamori(2008)Cost-effective Approaches for sustainable Groundwater Management in Alluvial Aquifer Systems, Water Resour Manag 23:219-233.

Management and planing organization chaharmahal and bakhtiari province, 2005, the report of economic and social water resouece sector.

Manangement and planning organization (M.P.O.) (2004) the report of water resources of Iran, Management and Planning Publication.

Masoodian SA, Kaviani MR (2008) Climatology of Iran. Isfahan University Publisher.

Meteorology organization, annual calendars of stations (1952-2001).

Planning and budget Chaharmahal and Bakhtiari province (1986), Report Geology and Pedology.

Planning and budget Chaharmahal and Bakhtiari province (2001), the review of plan of water resource.

Rezaei A, Soltani A (1998) an introduction to Applied Regression Analysis. Isfahan University of technology.

Robins NS, Jones K, Ellis J (1999) An Aquifer Management Case Study-The Chalk of the English South Downs, Water Resour Manag 13: 205-218.

Sedaghat M (1993) Water resource and land. Payamenour University Publisher.

The center of researches water sheet of Chaharmahal and Bakhtiari province (2001) the identify of watershed basinesof CHB. Province, the center of research of natural resource.

UN (2003), Water for people, water for life. The UN World Water Development Report (WWDR), UNESCO, Publishing and Berghahn Books, UK, pp 34.

Water Resource Company Chaharmahal and Bakhtiari, (2005), Analysis of water resources. 2:35-50.