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Wet and Dry Periods and its Effects on Water Resources Changes in Bouin Plain Watershed

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ABSTRACT

Water Resources have close relationship with precipitation and runoff in the watershed, and rainfall that coming on watershed, support water consuming by plants. Drinking water, industry and agriculture from ways including infiltration in soil, surface and subsurface flow. On this basis, studies about rainfall and ground water has been aimed in Bouin watershed with area 290.95 Km2 Located in Isfahan province. This watershed has a good situation from rainfall and surface and ground water aspects in Isfahan province. But in some recent years because of annual and rainfall reduction over exploration of water resources, resulting in water shortage in agriculture thus it is necessary that to investigate rainfall changes, wet and dry period predication and their effects on water resources changes (surface and ground water). In this study , with investigation of rainfall trend changes , flood discharge determination by manning , fuller , SCS methods and flood hydrograph in different return period , determined flood situation in watershed , after that with investigation of ground water level changes, determined rainfall changes effects on ground water changes in study area using correlation coefficient in lag time 0,1,2,3,4,5, and 6 monthly for recent years (2000-2003) in 36 month duration .Result shoes that is a significant relationship between rainfall and ground water level changes in study area, and it can be described that a for majoring of station is a 3 monthly lag time from rainfall occurrence to ground water changes. Additional, common trend of ground water level changes has a Descending status.

Keywords: *Wet and dry periods, Piesometric level reduction, ground water, Bouin plain watershed, Iran.*

INTRODUCTION

In last two recent centuries, by industry development and quick increasing of population, restraining waters to make under the control waters that are evicted without use, was noticed and conclusion of this notice is quick developing of dam construction science. In recent years, especially in developed countries that huge part of surface waters is restrain there, they resulted that best way to struggle with water crisis is optimum water using and preventing of polluting water.It's clear that water crisis emerges more in years that drought happened and one of the result of drought is minimizing of rivers water level. With environment, minimizing of rivers water level make pollution density to increase and as result make oxygen solution to decrease that its consequences are fish and other marine's death and damaging rivers environment strongly.

Hence, knowing of watering potential and hydrologic condition of upstream watershed, for desire using of these sources and predicting of wetness and drought period and knowing of water sources changing in watershed to remove their problems are necessary. In this case of study, effects of these periods in changing of basin water's sources is determined by determining drought and wetness periods.

Iranians were first people who invented Subterranean to compensate dehydration approximately 3500 years ago. Study of waters has been noticing in Iran since ancient times and prominent example of that is dam construction and different lines in direction of rivers water. Brat expressed rain as sources of groundwater in seventeenth centuries (1608-1680) and after that the relation of rainfall and level of groundwater reservoir was studied more accurate.

In field of drought's effect on groundwater in Iran, variety studies have been done, Maleki (1996), Khoshakhlagh (1997), Alikhani (1999) and Farajzadeh (1999) each one after doing researches, mentioned to maintain, water protecting and optimum management of water sources (Biabanaki,2004) in other investigations, it's determined that rainfall is main scale of drought meteorology (Gibbs et al and Palmer, 1967) and waterway's flow is the main factor of hydrologic drought too (Ben et al- Karl et al,1967). In this case of study, the condition of drought and wetness years and their relation with groundwater basin in Bouin's watershed has investigated by doing some steps that is coming in continue.

Area's Situation of Study:

Bouin's basin has 290.9516 km2 area with longitude coordinate of 50 degrees 02 minutes9 seconds to 50 degree 19 minutes 59 seconds east and latitude of 33 degree 11 minutes 45 seconds to 33 degrees 00 minute 32 seconds north.

This basin is ended up to Ghouzaei and Gharehdagh mountains from north, Panjpanjeh mountains from east, Aghdash mountain from south, Gharakh Ghazlar and Khoshkeh round from south and Ghebleh, Sonboleh and Sorkh mountains from west.

Average height of Bouin's basin is equal to 2559 meter and its average gradient is equal to 12.07 percent. The most amount of vegetation of this basin are pastures with 185 km2 wide that is equal to 63.5 percent. Atmospheric precipitation in this area is usually snow and has the most rate of rainfall in winter (42 to 50 percent). By measuring the rate of rainfall in adjoining stations of area through the 25 years' statistical period (1976-2001), average amount of rainfall is equal to 479.2 millimeters and temperature is equal to 8.9 degrees of centigrade and according to Domarten method, it has semi-wet climate.

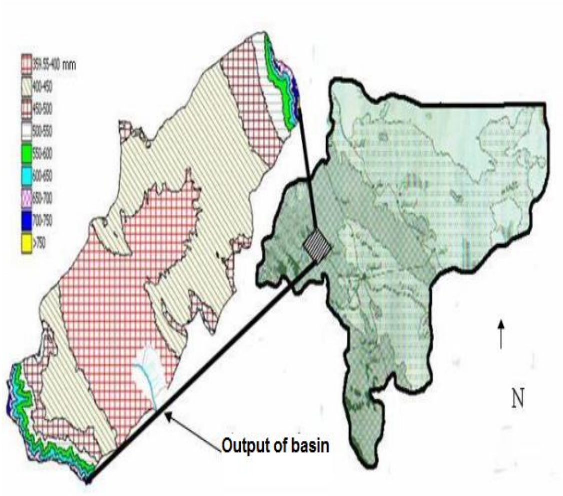

Figure1: *Situation of basin in Isfahan province with map of Rain-mate and output of water way of Bouin's basin*

METHODS AND MATERIALS

Method of Research

After collecting statistics and information of physiography (area, perimeter, impact of waterway, gradient, average height, etc.), meteorology(condition of rainfall in area according to adjoining stations distribution such as 8 station of Aligoudarz, Aznavele, Kazemabad, Badijan, Fereydounshahr, Damaneh, Chadegan and Daran through the statistical period since (1976 to 2001) that based on rain gauge station of Aznaveleh that is near to area of case study, its statistics are used to determine changes of rainfall than average, the moving average changes of 3, 5, 7 and 9 year through the statistics period for area. Hydrology of surface waters and groundwater (average watering, height of runoff, hydraulic radius, determining special flow and runoff coefficient, statistics of groundwater's level changes in 1997-2003 years, etc.) meanwhile field view of basin to control data by using Excel, SPSS software's data were processed. Due to the effective factors in water flow such as area, gradient, shape of basin, average height, direction of hillside, factors of geology, soil and lands cover and also climate factors such as intensity and duration of rainfall and type of rainfall, flow of floodwater in three methods SCS, Fuller and manning was calculated for basins and artificial single hydrograph in return durations were drawn up.Experienced method of Manning usually uses when the target is estimating flow of floodwater after their stream. If floodwater goes out of substrate and enters to floodwater plains, velocity and area of each part can be calculated and their flow rate can obtain that results of their sum give flow rate of floodwater. Area is calculated based on hot water of recent floodwaters or based on historical evidence and velocity is obtained from Manning formula as following and has credit for uniform flow:

$$V = K * \frac{1}{n} R_b^{2/3} * S^{½}$$

K: constant coefficient that depends on using units and in metric systems is equal to 1.

V: average velocity of water in m/s.

R_h: hydraulic radius that is ratio of wetted surface to wetted environment ($\frac{A}{P}$).

S: gradient of energy line that is equal to gradient of water surface and it's in m/m that is actually equal to floor gradient and is obtained from length of main waterway.

n: roughness coefficient of substrate that depends on diameter of rivers substrate's material and should be used in way that approximately has same area and same shape in direct distance that gradient of water surface is measured. In addition, the roughness coefficient in this distance isn't variable and there isn't suddenly changes of length's gradient too.

One of the experienced methods to estimate of flood is Fuller formula (Mahdavi-1999). Experienced formulas of Fuller to achieve to maximum flow rate of flood explained as follows:

$$Q_{ave} = CA^{0.8}$$

$$Q_{max} = Q_{ave} [1+0.8(\log T)]$$

$$Q_p = Q_{max} (1+2.66A^{-0.3})$$

Q_{ave}: most flood average in 24 hours of basin in m^3/s.

Q_{max}: maximum flood in 24 hours in return duration of T years in m^3/s.

Q_p: maximum probable flood in return duration of T years in m^3/s.

C: constant coefficient, its amount is variable depends on gradient and cover of basin between 0.25 and 3.

A: area in km^2.

SCS organization's method has been used to determine the artificial single hydrograph and floodwater. In this method, first peak time of basin's hydrograph was determined according to time of extra rainfall and amount of peak flow rate is calculated as follows relations:

$$Q_p = \frac{2.083\ AQ}{tp}$$

$$t_p = \frac{D}{2} + T_L$$

$$D = \frac{1}{7} t_c$$

Q_p: peak flow rate

t_p: peak time

Q: height of flow water

T_L: delay time

D: duration time of extra rainfall

t_c= time of concentration

Then amounts of Q_p and t_p in dimensions of dimensionless single hydrograph that was presented by Makos in year 1975, is multiplied to in order Q/Q_p (dimensionless flow rate) and t/t_p(dimensionless time) and dimension of single hydrograph will be obtained for each basin (Mahdavi,1999).

Also by using of rainfall's statistics through the 25 years' statistics duration (1976-2001) diagram of rainfall changes process and moving average of 3,5,7, and 9 years were drawn and drought and wetness durations were determined. Several years' changes of groundwater's level were drawn by using of statistics of Isfahan zonal water organization and the rate of groundwater level's drop in basin was determined by that. By using of statistics of groundwater in recent 36 months (2000-2003), diagram of groundwater changes process has been drawn. To investigate how rainfall's change effects on groundwater's sources changes by using of gotten statistics from Isfahan's climatology and zonal water organization, the correlation coefficient is calculated between amounts of level of groundwater and amount of rainfall in 5, 4, 3, 2, 1, 0 and 6 months' delay times.

CONCLUSION AND DISCUSSION

According to presented expresses in materials and methods chapter, flow rate of floodwater was calculated in three methods Manning, Fuller, SCS and conclusion are as follows:

Amounts of floodwater in Manning experienced method have been estimated according to flow section and existing of hot water of recent floodwater. Table (1) illustrates amounts of estimated floodwater in measured section of basin. Based on done estimates and comparing with amounts of floodwater estimated in experienced method, happened floodwater was to the extent of 25 to 50 and 100 recent years.

Table (1): *Estimated amounts of flow rate of floodwater in recent floodwaters section in Manning method*

Section of measuring	Roughness coefficient n	Wetted area $A(m^2)$	Wetted environment P(m)	Hydraulic radius R(m)	Gradient S(m/m)	Average velocity of water V(m/s)	Flow rate of floodwater $Q(m^3/s)$
Basin's output	0.052	18.8	23.5	0.80	0.011	1.74	32.68

One another experienced methods of determining flood is Fuller formula. Amounts of flow rate floodwater for return durations based on this method in Bouin's basin is illustrated in table 2. In SCS method according to time of extra rainfall, peak time of basin's hydrograph, artificial single hydrograph and floodwater are determined.

Table2: *Amounts of floodwater's flow rate for duration of returning in Fuller method in Bouin's basin*

Duration of returning (year)	2	5	10	25	50	100
Flow rate (m^3/s)	28.86	32.49	37.51	44.14	49.16	54.18

Table 3: *Estimated amounts of some hydrology's parameters in SCS method*

Parameter	Time of concentration t_c (hr)	Time of delay T_1 (hr)	Time of extra rainfall D (hr)	Peak time t_p (hr)	peak flow rate $Q_p(m^3/s)$	one hour rainfall with 10 years of return duration P(10y,1H)
Amount	5.39	3.23	0.77	3.61	167.72	25.88

Table 4: *Amounts of floodwater's flow rate for duration of returning in Bouin's basin*

Duration of returning (year)	2	5	10	25	50	100
Flow rate (m3/s)	33.87	77.41	114.91	170.55	215.3	262.48

According to effective factors in floodwater happening and its event in zone and with considering amounts of floodwater's flow rates in returning durations in Fuller and SCS method, we can acknowledge that, because in Fuller method the area parameter had role of main factor in estimating floodwater and it's considered approximately as an old method, so it's not able to show the accurate estimate of floodwater's amounts in surface of basin. But amounts in SCS method can be more confident why the SCS method gives satisfaction results by taking many effective factors in flow rate of basin and by considering other researchers' obtained experiences.

According to amounts of floodwater's flow rate in SCS method and measured amounts of flow's section and estimated flow rate based on hot water in Manning method, amounts of floodwater's flow rate in Manning method and SCS method with 2 years returning duration, are near to each other, then these two methods are determined suitable for zone. By considering that floodwater happening is probable once in a while in zone and causes to floodwater and damages downstream zones especially agricultural lands and related buildings. Therefore, to reduce the damages in drought and wetness times, the necessity of running plan of watershed and controlling of floodwater and surface flow water, is more touchable. Amounts of floodwater's hydrograph for returning duration for basin has been presented in table 4 and related hydrograph has been drawn.

Amounts of special flow rate and flow water's coefficient have been illustrated in table 5 and 6.

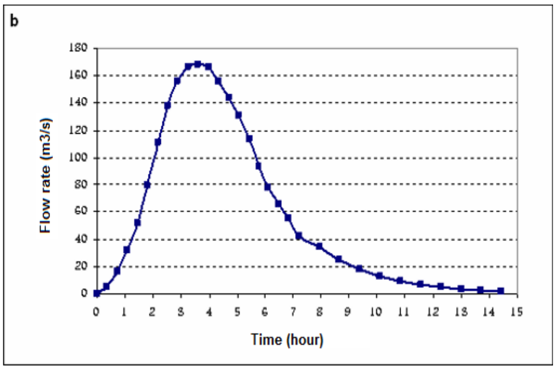

Diagram 1: *Hydrograph of floodwater in Bouin's basin in SCS method*

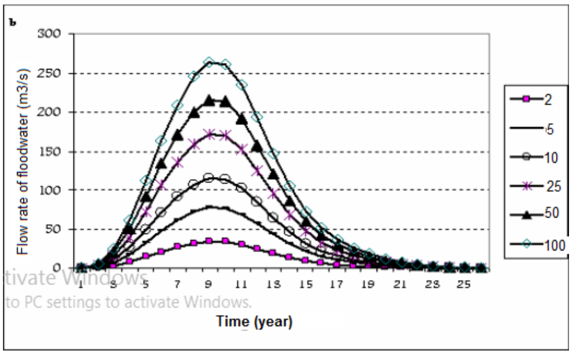

Diagram 2: *Hydrograph of floodwater for returning duration case in Bouin's basin in SCS method*

Table 5: *Amounts of special flow rate of floodwater for durations of returning case in sub-basins of zone*

Duration of returning (year)	2	5	10	25	50	100
Special Flow rate ($m^3/s/km^2$)	0.12	0.27	0.39	0.59	.074	0.90

Table 6: *Amounts of flow water coefficient for durations of returning case in sub-basins of zone*

Duration of returning (year)	2	5	10	25	50	100
Flow water coefficient	0.20	0.31	0.38	0.45	0.50	0.54

According to that, rain gauge station of Aznavelehi s near to area of case study and has 50 07sec longitude and 33 06sec latitude and 2400 meters' height from level of sea, their annual information was used to illustrate the histogram of rainfall changes through the statistical duration.

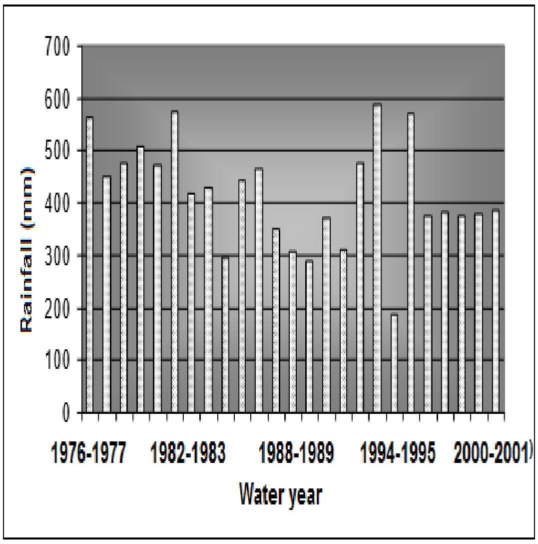

Diagram 3: *Histogram of amount of annual rainfall through the statistical duration of Aznaveleh station*

Adduce to 25 years' statistics (1976-2001) to investigate changes of rainfall toward the average, curve of moving average changes 3, 5, 1 and 9 years that make easier determining the duration of drought and wetness, has been drawn for zone that based on it, in statistical years of 1988-1989 to 1992-1993 and again since year 1996-1997 to 2000-2001, the amount of rainfall is less than annual average 417.85 millimeters in Aznaveleh station. Therefore, these years determine drought durations for zone through the statistical duration (diagram 4).

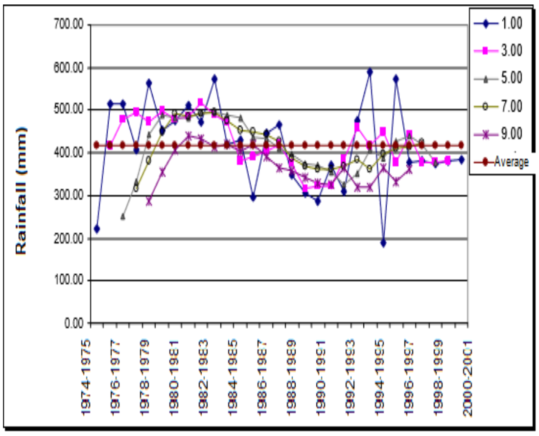

Diagram 4: *Moving average of Aznaveleh station*

Aquifer of Bouin's unit actually isn't fed from adjoining basins. This unit, mostly is fed by atmospheric rainfall and watering lands and then surface flows and backwater of drinking and industry that is equal to 220.7-million-metercube and tanks of this unit are fed by penetrating in heights that is equal to 60.8-million-meter cube. In water years 2002-2003, the sum of groundwater's discharge through the boreholes, subterranean and founts of basin is equal to 188.8-million-meter cube and based on the rate of feeding and discharging, in this zone exist 92.7-million-meter cube of extra feeding. According to the heights surround the Bouin's basin and limitation of soil's depth in them, especially in north zones, east and west of basin, the potential of penetration is less in these zones and therefore surface flows and floodwaters are more. In lower heights zones because of better potential of penetration, some amounts of atmospheric rainfall penetrate to groundwater's reservoir. Several years' changes of groundwater are presented in table 8 and histogram diagram of groundwater's level is illustrated in diagram 5.

Table 7: *Groundwater's balance in Bouin area in million-meter cube*

Bouin	Range		
0.0	Input of adjoining basin	Feeding	Tanks of hard formation
60.8	Penetrate in heights		
60.8	Sum		
14.7	Statistic fount	Discharging	
0.0	Borehole and subterranean		
40	Feeding of alluvial aquifer		
0.1	Unknown		
54.8	Sum		

0.0	Input flow from adjoining plain	Feeding	Alluvial aquifer
40	Input flow from heights		
77.9	From rainfall		
18.3	From surface flows		
80.7	From watering		
3.8	From backwater of drink and industry		
220.7	sum		
135.2	Borehole	Discharging	
39.6	Subterranean		
0.0	Alluvial founts		
36.8	Canalization		
9.1	Evaporating from groundwater		
0.0	Output flow		
220.7	Sum		

Table 8: *Changes of groundwater's level of Bouin Miandasht in different years of basin*

Row	Year of measuring	Level of groundwater
1	1997-1998	+0.28
2	1998-1999	-1.83
3	1999-2000	-1.35
4	2000-2001	-0.95
5	2001-2002	+1.49
6	2002-2003	+0.94

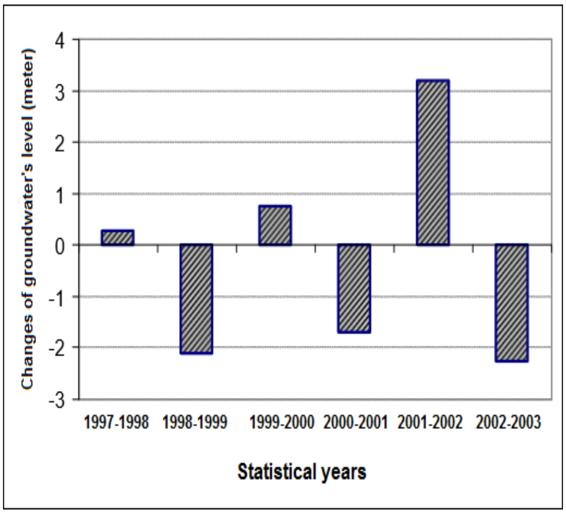

Diagram 5: *Histogram of groundwater's level of case study zone*

According to table 8, total lowering of groundwater's level equals to -4.02 meters and 2.71 meters of this amount has been made up and -1.31 rate of this remains that has to be made up.

Diagram of groundwater's level changes has been drawn by statistics of recent 36 months of groundwater's level (2000-2003).

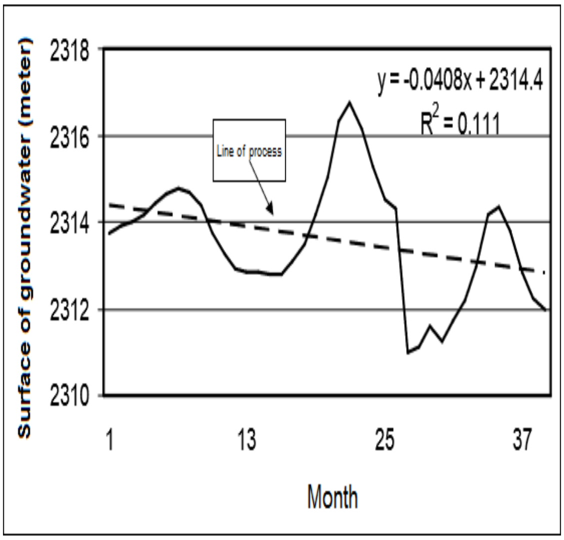

Diagram 6: *Changing process of groundwater's level in 36 months in Bouin*

Table 9: *Amounts of correlation coefficient between two variables of groundwater's level and months' rainfall*

	Kendall	Spearman	Pearson
Correlation coefficient	-0.40	-0.61	-0.66
Level of meaningfully	0.04	0.02	0.01

According to the hydrograph of groundwater's level and their process, can be concluded that changes of groundwater's level of zone have downward trend and based on calculation of correlation coefficient in Pearson, Spearman and Kendall methods, it was negative and has meaning in 95% level. To investigate the way of effecting of rainfall changes on changes of zone's groundwater sources and using of gotten statistics from zonal water organization, table of correlation coefficient between amounts of groundwater's level and amount of rainfall in recent years (2000-2003) have been determined 36 months. Conclusions show that decrease or increase of rainfall on groundwater was mostly with 3 months' delay and for two Damaneh and Aligoudarz stations, this delay is 4 months.

Table 10: *Correlation between rainfall and changes of groundwater's depth in different delay times in month*

Delay time (month)	Badijan	Daran	Aznaveleh	Aligoudarz	Fereydounshahr	Damaneh
Lag0	-0.018	-0.21	-0.27	-0.219	0.106	-0.001
Lag1	0.536	0.376	0.355	0.236	0.5	0.343
Lag2	0.724	0.583	0.631	0.476	0.653	0.514
Lag3	0.795	0.629	0.758	0.636	0.776	0.666
Lag4	0.726	0.534	0.744	0.667	0.72	0.673
Lag5	03585	0.425	0.638	0.633	0.568	0.609
Lag6	0.392	0.229	0.431	0.545	0.317	0.462

SUGGESTIONS

According to gotten results that show the total condition of climate, floodwater and geohydrology of the area and necessity of struggle to optimize and use better of soil and water sources of the area, following suggestions are presented:

- User management of lands such as observing of correct and scientific doctrine of agriculture in inclined land and related to productivity depth of soil, with choosing a suitable and adaptable breed or breeds of plants that play positive and useful role in increasing of pore, intensity of penetration and reducing of water flow's velocity. Among these functions, linear cultivating in direction of vertical on incline of hillsides, observing limitation of appropriate incline for any kind of cultivating and also frequency arable, can be named.
- Biologic function of watershed such as transplant, bramble plant and seeding in unchained suitable areas of agriculture.
- Mechanical or structural function of watershed such as installing banquette, terrace and other ways of saving rainfalls in hillsides.
- Constructing corrective and protective lines in waterways that has rightful effective in increasing penetration and in reducing surface flows and sediment of clay flows that finally has effect in reducing peak flow rate and volume of floodwater. Constructing of these structures should be done with study and scheduling.
- Using of controlling floodwater structural methods with constructing soil lines as a comprehensive management method in watershed basins of area is useful and whilst picking up worthy effects in reducing peak flow rate of floodwater and feeding groundwater's sources, it's an economic collection water method for watershed neighbors and causes to increment of producing of agricultural products and reducing floodwater in downstream areas.
- Using of new methods and tools such as remote sensing and Geographical information system in determining and investigating of line's role (crevice of ground) in directing of surface water to area of case study.
- Using of time ordered models and lateral correlation coefficient in studying of rainfall's effects on frequencies of groundwater.

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