Influence of Climate Changes and Geological Features on Water table Changes in Ghir Plain, Iran

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Abstract: Groundwater in the south of Iran is the most important and the most widely used water resources. Therefore, it is essential to study about groundwater resources in this region. In order to study the influence of climate changes such as rainfall, temperature and also geology on water table changes in Ghir plain, Iran has conducted an eight-year study from 2004 to 2011. Rainfall, temperature, water table and geological formations were evaluated in this study. Also, the relation between climate (temperature and rainfall) and water table and water table changes were appraised through multiple regressions in SPSS. Using Arc GIS, maps were provided to identify plains of Iran, considered wells, water table and geological formations along statistical period. According to the obtained results, it was clear that temperature is inversely related with water table so that water table showed 1.86 meter decrease per each degree more than 25.07°C. There was a direct relation between rainfall and water table height and its changes so that each 477.7 millimeter increases in rainfall increased 1 meter of water table. Based on the results, when data such as temperature and rainfall are available, water table and water table changes are 90% and 87% predictable respectively. It is worth noting that those areas with Gurpi formation showed less change in water table along statistical period in compare with other formations of the plain.

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Keywords: Climate, Geology, Water table, Correlation, Quantity

1. Introduction

The environment we live in plays a dominant role in our lives. The digerence between rain and sun on a day changes many peoples decisions for that day. But compared to the importance of the atmosphere, our knowledge about it is limited (Terkuile 2009). Many aspects of the atmosphere (temperature, wind, precipitation) may change due to greenhouse gas induced warming. It is expected that the intensity of the hydrological cycle will increase as the climate warms. In particular the intensity of precipitation extremes is expected to increase (Lenderink and Meijgaard 2008; Terkuile 2009). Many of the world's countries already struggle under existing water stress from pressures such as irrigation demands, industrial pollution and water borne sewerage. These pressures will be significantly exacerbated by climate change, which for many regions will result in reduced rainfall and increasing temperatures, further reducing the availability of water for drinking, household use, agriculture and industry (Holms 2007). Therefore, any changes in hydrological system and water resources could have a direct effect on the society, environment and economy. There are very complex relations between climate, hydrology and water resources. Water resources are influenced by various social, technical, environmental and economic factors. Climate change is just one of many pressures that hydrological systems and water resources are facing (IPCC 2001). Many people living either on farms or in hamlets and villages in the interior are dependent upon groundwater resources. The use of groundwater increased sharply with the introduction of large-scale industrialization in recent decades. Cities outgrew their water supplies and the equilibrium of the groundwater supply has been most seriously affected (Khodjini 1995). For example, in Africa's large catchment basins of Niger, Lake Chad and Senegal, the total available water has already decreased by 40-60 percent, and desertification has been aggravated by lower than average annual rainfall, runoff and soil moisture, especially in Northern, Southern and Western Africa. The consequences for water supply include smaller flows in springs and rivers, and decreasing groundwater levels (Holms 2007). Since this resource is limited, conditions dictate that the groundwater resources must be effectively developed, conserved and managed to meet the nation's goals (Khodjini 1995). Water is fundamental to human life and many other social, economic and industrial activities. It is required for agriculture, industry, ecosystems, energy, transportation, recreation and waste disposal (Frederick and Gleick 1999). Therefore, any changes in the climatic system or the energy balance in the atmosphere may alter the water balance of the hydrological cycle (Holms 2007).

It is worth mentioning that sufficient lengths of water table depth measurements are usually unavailable in developing countries (Coulibaly, Anctil et al. 2001; Sethi, Kumar et al. 2010). such countries typically have very few observable wells and lack long-period time-series data due to budget limitations and government policy (Affandi, Watanabe et al. 2007; Sethi, Kumar et al. 2010). This necessitates developing models that are capable of forecasting ground water table depth using limited data. In many other areas, efforts were made to develop neural network based forecasting models with limited data (Sudheer, Gosain et al. 2003; Aminian and Ameri 2005; Sethi, Kumar et al. 2010). Keeping it in view, an attempt was made to determine the factors that influence and control the water table fluctuation in a specific geologic situation develop ANN based model and test its potential in predicting ground water table depth with limited climatic and nearby wells data (Sethi, Kumar et al. 2010).

Management of water resources requires input from hydrological studies. This is mainly in the form of estimation or forecasting of the magnitude of a hydrological parameter. Many approaches have evolved over the last few decades to make hydrological forecasts which include conceptual and statistical methods. The conceptual or physically-based models try to explain the underlying processes. But these models require a large quantity of good quality data, sophisticated programs for calibration and a detailed understanding of the underlying physical process (Coulibaly, Anctil et al. 2001). A reliable water supply planning policy, specifically during the dry season, necessitates accurately accepTable predictions of water table depth fluctuations. The prediction of groundwater levels in a well, based on continuous monitoring of selected nearby wells is of immense importance in the management of groundwater resources (Coulibaly, Anctil et al. 2001; Sethi, Kumar et al. 2010).

mentioned that in advanced level of drought, water resources are involved with severe shortage. In most regions of the world, groundwater resources have been rapidly exploited as resources of public consumption and also agricultural activities. It means that reactions of groundwater toward drought have been too important (Calow, Robins et al. 1999; Scheidleder, Grath et al. 1999). Panda et al used Man-Kendall non-parametric statistical method to identify the process of changes in groundwater level in Orissa, India and the efect of drought and human interference. Their results showed that temprature is the reason of water loss due to shortage of rainfall in drought years and human interference has not been able to compensate this loss through nutrition in wet years (Panda, Mishra et al. 2007). Shahid and Harizaka dealt with analysis of groundwater hydrography and time group of rainfall in west north of Bangladesh; their results showed that increase in groundwater withdrawals for irrigation in dry seasons and return of droughts are reason of groundwater loss in this region and if human did not interefere, one of the factor of groundwater loss would be majorly related to decrease of rainfall (Shahid and Hazarika 2009).

Iran, with an area 1636 x 103 km^2, relies on surface water resources that derive from rainfall and snowmelt and the ground waters that underlie many part of the country. Historically, water has presented a persistent problem. Water resources in Iran are very unevenly distributed, both spatially and temporally. The magnitude of flood volume resulting from ephemeral rivers is in the order of 65 billion m3 out of 127 billion m^3 of the total surface flow from the country, most of which ends up in salt lakes, deserts, swamps and the ocean (Sharifi and Ghafouri 1998). Also the influence of geological formations on quantity of water resources is obvious.

Most of the regions in Iran are covered by quaternary sediments. Quaternary sediments, which are the most important reservoir of underground water resources, have been formed from physical and mechanical weathering of upland formations. Properties of sedimentology of quaternary can determine the hydrology and hydrogeology of water of the reservoir. Quaternary sediments are very important in Iran because they covered more than 50% of the area of country (Boustani 1994; Jankowski, Acworth et al. 1994). The pesent study has been conducted to study the influence of climate changes and geological features on water table changes in Ghir plain of Iran.

2. Material and Methods

The Ghir Plain, with an area of about 21768 ha, is located between 28°32' and 28°16' latitude, and 52°56' and 53°21' longitude. this Plain has a dry climate and groundwater is the 90% source of water for agricultural, urban and industrial uses(Wikipedia 2012). The location of this Plain is shown in Fig. 1. Increase of water demands associated with rapid urban development and expansion of agricultural lands has led to over exploitation of groundwater in this Plain, so groundwater table has declined rapidly. If this uncontrolled water withdrawal continues, water shortage crisis will happen in this area. Water table decline can reverse hydraulic gradient and consequently, saltwater intrusion may take place. In order to monitor water table elevation in this Plain, the data obtained from 41 observation wells during 2004 to 2011.

Topographic maps 1/25000 of the region was provided as basic maps of the study and considered wells were identified on maps through ArcGIS (Fig. 2). Water table changes have been also evaluated through this software by IDW method. This softwar also was used to make and study geological formations. In addition, relations between formation and changes of each region with each formation were identified along statistical period. In order to have more accurate study, Ghir plain was divided in 11 regions quantitatively similar to eachother including: Tangeroen, Shahrepir, Barikhon, Ali abad, Ghalatnahavie, Sarcheshme, Fathabad, Shams abad, Sekeravan, Ghir and Eslamabad.

Level of water table and its changes have been measured and noted each year in compare with last year. Other factors measured in this plain were average of temperature and annual rainfall in statistical period of 2004 to 2011.

Obtained data were analyzed through multiple regressions in SPSS at 95% level of confidence by stepwise method so that the related regression model was identified after identifying independent variables (Xi) and dependent variables (Y). SPSS stands for Statistical Package for the Social Sciences. It is general statistical software tailored to the needs of social scientists and the general public. Compared to other software, it is more intuitive and easier to learn; the trade-off is less flexibility and fewer options in advanced statistics than some other statistical software like S-Plus, R and SAS. SPSS is good for organizing and analyzing data.(Blumenthal 2010). Regression analysis was conducted in this study in area of selected independent variables which was included 6 variables. In this regard, stepwise method was used in SPSS. Multiple linear regression is a method of analysis for assessing the strength of the relationship between each of a set of explanatory variables (sometimes known as independent variables, although this is not recommended since the variables are often correlated), and a single response (or dependent) variable (Hoffmann 2010). When only a single explanatory variable is involved, we have what is generally referred to as simple linear regression, Applying multiple regression analysis to a set of data results in what are known as regression coefficients, one for each explanatory variable (Landau and Everitt 2004). These coefficients give the estimated change in the response variable associated with a unit change in the corresponding explanatory variable, conditional on the other explanatory variables remaining constant. The fit of a multiple regression model can be judged in various ways (Hoffmann 2010). The multiple regression model for a response variable, y, with observed values, $y1$, $y2$, …, yn (where n is the sample size) and q explanatory variables, $x1$, $x2$, …, xq with observed values, $x1i$, $x2i$, …, xqi for i= 1, …, n, is:

$$y = \beta_0+\beta_1 x_1+\beta_2 x_2+\ldots+\beta_{(n-1)} x_n+\varepsilon$$

The term ε is the *residual* or *error* for individual i and represents the deviation of the observed value of the response for this individual from that expected by the model (Landau and Everitt 2004). Affandi et al compared the capability of an ANN with five different back propagation (BP) algorithms for estimating groundwater level fluctuation. Seven different types of network architectures and training algorithms were investigated and compared in terms of model prediction efficiency and accuracy (Affandi, Watanabe et al. 2007; Sethi, Kumar et al. 2010). Result showed that accurate predictions were achieved with a standard feed forward neural network trained with the Lavenberg- Marquardt (Daliakopoulos, Coulibaly et al. 2005; Sethi, Kumar et al. 2010).

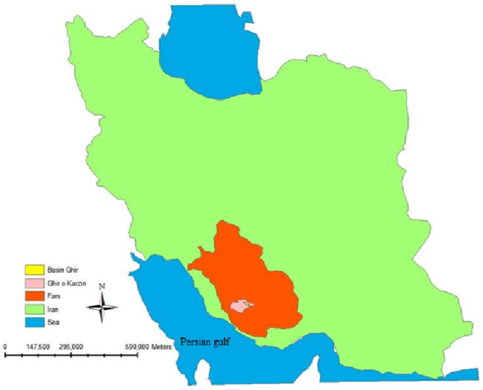

Fig. 1. Ghir Plain location in Iran

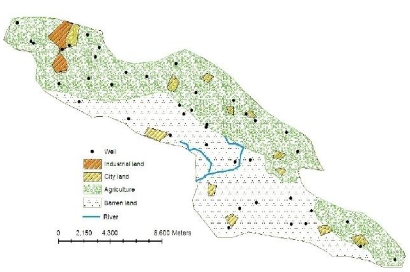

Fig. 2. Location of sampling wells within the Ghir Plain

3. Results

3.1. Rainfall and Temperature

The amount of annual rainfall over the region varies from 138.5 mm in dry years to 477 mm in wet years; long-term average temperature is 25.5 °C and average annual rainfall is 285.5 mm (Bureau 2012). (Table 1, Fig. 3, 4)

Table 1. Height of rainfall and air temperature in Ghir Plain, 2004-2011 (Bureau 2012)

Year	Rain(mm)	Temperature (c)
2004	367	25.1
2005	477	25.4
2006	186	24.9
2007	383.5	25.6
2008	138.5	26.1
2009	221.3	26
2010	230.5	25.8
2011	280	25.3
Average	285.475	25.525

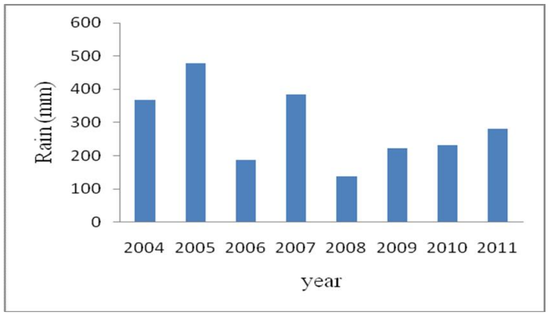

Fig. 3. Height of Rainfall in Ghir Plain, 2004-2011

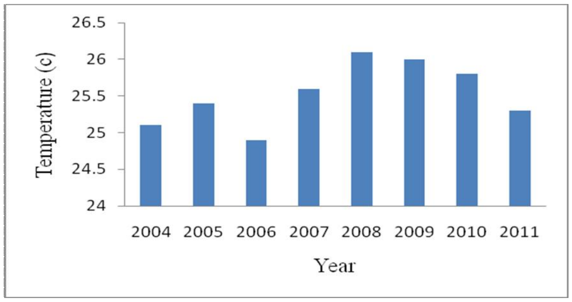

Fig. 4. Air temperature in Ghir Plain, 2004-2011

The highest rainfall happened in 2005 with 477 mm height and the lowest rainfall happened in 2008 with 138.8 mm height. The most annual temperature of the plain in statistical period belonged to 2008 with 26.1°C and the least one belonged to 2004 with 25.1°C. Average of rainfall and temperature of Ghir plain have been compared with those in Fars province , Iran and the world in Table 5. It is clear in the Table that temperature of the plain is very higher than the temperature in Iran and in the world so it is considered among hot areas. In addition, rainfall of this region is very unfavorable in compare with the word rainfall so it is among dry areas in the world level.

Table 2. Average of rain and temperature in Fars province, Iran and World (Quayle, Peterson et al. 2005)

Locations	Rain (mm)	Temperature (c)
Ghir Plain	285	25.5
Fars Province	275	-
Iran	215	18
World	880	8.5

3.2. Quantitative Statistics of Ground waters

According to the Table 3, the lowest number of wells in the plain belonged to 2004. As the plain is a "forbidden plain", no wells shall be added in that area but unfortunately the number of its wells has been annually increased. As Table 3 shows, the most slope of well growth was from 2005 to 2007; however there is not significant increase in productivity. From 2009 to 2011, you see the most slope of usage from wells' waters (Table 4). With regard that 222 wells have been added to the plain in 2005 and according to the increase of water withdrawal, we found 1.24 m decrease in water surface elevation in this year. It means that the plain had a positive balance. However, as there was less increase in the number of wells, balance of the plain was constantly negative and the most balance belonged to 2010 when just 10 wells were added in compare with the previous year. Water withdrawal also had the most rates in 2010. This shows that the number of dug-out wells did not have significant effect on decrease or increase of water table in the plain and amount of withdrawal and other climate condition influenced on elevation of water table in the plain.

Table 3. Withdrawal rate and number of wells in Ghir Plain, 2004-2011

Statistical year	Number of Wells			Withdrawal rate (MCM)
	Deep	Shallow	Total	
2004	373	1272	1645	122.000
2005	373	1272	1645	122.427
2006	396	1471	1867	122.233
2007	401	1477	1878	123.237
2008	401	1478	1879	123.302
2009	403	1480	1883	123.737
2010	410	1482	1892	135.461
2011	411	1483	1894	135.942

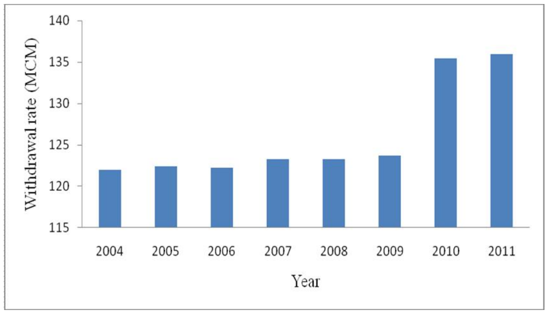

Fig. 5. Rate of water withdrawal in the Ghir Plain

3.3. Water table and its change

Changes in water table have been mentioned in Table 4 and Fig. 6. There is also the elevation of water table in compare with sea level in the Table for years 2004 to 2011.

Table 4. Water table changes over previous year in Ghir Plain: 2004-2011

Location	2004	2005	2006	2007	2008	2009	2010	2011
Tangeroen	1.18	1.26	-1.12	-0.30	-0.60	-0.32	-0.19	0.79
Shahrepir	1.18	1.26	-1.12	-0.30	-0.60	-0.32	-0.19	0.79
Barikhon	-0.97	-0.76	-1.76	-1.86	-2.02	-1.62	-0.89	-6.47
Ali abad	0.94	1.42	-0.82	-0.53	-0.54	-4.39	-1.17	2.71
Ghalatnahavie	0.58	0.39	-0.75	-0.20	-0.64	-1.39	0.16	1.11
Sarcheshme	0.76	1.14	-0.52	-0.47	-0.25	-3.93	-0.81	1.74
Fathabad	-0.34	1.32	-0.93	-1.07	-0.70	-3.99	-1.03	0.32
Shams abad	-1.54	2.61	-1.14	0.08	-1.50	-5.43	4.23	1.29
Sekeravan	0.87	1.56	-4.36	-0.26	-5.12	-5.47	-1.51	-8.52
Ghir	-0.01	1.13	-2.57	-1.52	-0.70	-0.97	-6.51	-1.41
Eslamabad	3.16	2.36	-4.48	0.13	-0.97	2.11	-9.26	0.32

Table 5. Elevation of the water table within the Ghir Plain, 2004-2011

Year	2004	2005	2006	2007	2008	2009	2010	2011
Locations				Water table (m)				
Tangeroen	682.81	681.74	681.44	680.84	680.52	680.34	681.12	680.01
Shahrepir	682.86	681.74	681.44	680.84	680.52	680.34	681.12	680.01
Barikhon	672.12	670.36	668.49	666.47	664.85	663.97	657.49	657.06
Ali abad	685.73	684.90	684.37	683.83	679.44	678.28	680.98	686.13
Ghalatnahavie	675.57	674.82	674.62	673.97	672.59	672.75	673.86	674.15
Sarcheshme	684.07	683.550	683.07	682.82	678.89	678.08	679.81	683.12
Fathabad	688.47	687.539	686.46	685.76	681.78	680.75	681.06	684.53
Shams abad	698.58	697.441	697.51	696.01	690.58	694.82	696.11	699.08
Sekeravan	689.65	685.290	685.02	679.90	674.44	672.93	664.41	654.94
Ghir	689.28	686.719	685.20	684.49	683.52	677.02	675.61	673.62
Eslamabad	721.85	717.36	717.49	716.53	718.63	709.37	709.69	713

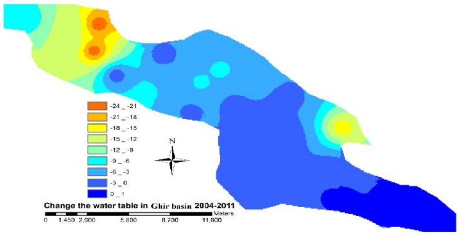

Fig. 6.Change the water table in Ghir Plain, 2004-2011

Downward slope of water table decrease has been severely started from 2007. It is clear that with regard to the increase in the number of wells and also increase in exploitation from wells, level of water table decreased and it is considered that this process will be continued in this way for years. In addition, when withdrawal increases, level of water table will decrease and downward slope of this decrease is in line with withdrawal increase. The average of drop in groundwater level in Iran has been 0.2 m per year and it has been also reported to 8 m in some alluvial aquifers of Iran (sources 2009).

According Investigation the quantitative on the Zahedan aquifer (southeast Iran) revealed that the decline in groundwater level may reach about 15 m in some places (Khazai 2001). Ground-water withdrawals in the vicinity of the well field caused a large area of water-level declines to develop in the Equus Beds aquifer. Water levels declined from 1940 through the 1950's drought, stabilized in the 1960's and 1970's, continued to decline between the late 1970's and the 1988-92 drought, and reached their maximum to date of as much as 40 feet or more during 1991-93. Loss of ground water in storage since August 1940 followed a pattern similar to water-level declines, with a maximum loss of storage of 255,000 acre-feet reached in January 1993. Water-level declines encompassed an area of about 190 square miles at their maximum in January 1993 and extended from the Arkansas River to the Little Arkansas River in the vicinity of Halstead and Sedgwick. Ground-water levels have since recovered more than 10 feet in some areas and aquifer storage replenished by 79,000 11acre-feet between 1993 and 1998 primarily as a result of decreased city withdrawals (Aucott and Myers 2000). In Kashan basin, according to the data obtained from 53 observation wells, it is found that the mean water table is decreased about 7.93 m between 1990 and 2006, indicating a mean water table decline of 0.496 m/year (Jamshidzadeh and Mirbagheri 2011). This is while that the amount of loss has reached more than 20 m in some regions and it is considered that this process will be continued along years later.

3.4. The Relation between Rainfall and Temperature with Water table Elevation

The relation between rainfall and temperature with water table (ground water elevation toward sea level) has been considered as a two independent variables and one dependent variable so that temperature and rainfall are two independent variables. The relations between rainfall, temperature and water table have been represented in Fig. 7.

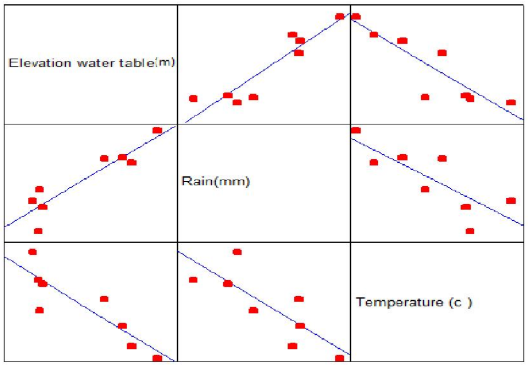

Fig. 7. Relationship of water table by temperature and rainfall in Ghir Plain

According to the Fig. 7, the relations between each component are as follow: Rainfall has a direct relation with water table. It means that as the rainfall exceeds, the water table rises. Temperature and water table are inversely related. It means that even temperature increases, water table declines. Temperature and rainfall are inversely related. Table 6 has numerically represented these relations.

Table 6.Correlation matrix of water table by temperature and rainfall in Ghir Plain

	Elevation of water table (m)	Rain(m)	Temperature(c)
Elevation of water table (m)	1		
Rain(m)	0.928^{**}	1	
Temperature(°C)	-0.876^{**}	-0.804^{*}	1

**Correlation is significant at the 0.01 level.
*Correlation is significant at the 0.05 level.

As it is clear, degree of correlation between rainfall and water table is very close to 1 and it shows a strong relation between these two components. However, the relations between temperature with water table and rainfall are negative and close to -1 which shows invers relations of these components. In Fig. 6, we have R^2=0.90. It means that R is equal to 0.95. Whatever this number is closer to 1, the relations between factors are stronger. If rainfall and temperature data of the plain are available, water table will be 90% predictable. Now, with regard to the above relations and obtained results, β coefficient will be as follow:

$$\beta_0 = 714.256$$
$$\beta_1 = 0.021$$
$$\beta_2 = -1.461$$

According to the above numbers, the following equation shows relations between rainfall, temperature and water table.

Elve water table(m)= 714.256+0.021Rain(mm) – 1.461Temp (c)

The periodic pattern of groundwater level fluctuations is investigated for six monitoring wells located in residential areas in Kuwait. Monthly water level measurements obtained from the monitoring wells for periods varying from 8 to 10 years are employed to examine the relationship with monthly-averaged temperature and totaled rainfall. The period grams of the water level, rainfall, and temperature data are also determined. The results reveal that the annual periodicity typically observed in the last two climatological data sets can significantly be identified in all the series of subsurface water level examined here and the model can possibly be used to set a time plan for starting a continuous dewatering process to avoid problems related to groundwater level rise in residential areas (Almedeij and Al-Ruwaih 2006).

3.5. The Relation between Rainfalls with Water table Elevation

This model has been represented as a dependent variable and an independent variable. The relation between rainfall and water table has been shown in Fig. 8.

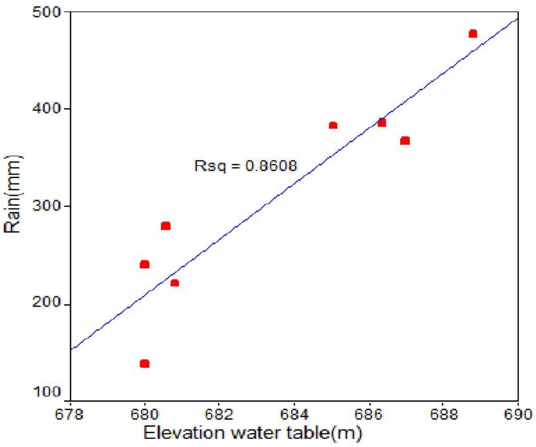

Fig. 8. Relationship of water table by rainfall in Ghir Plain

As it mentioned above, rainfall and water table are directly related. It means that more rainfall increases water table, therefore there is a significant relation at level 1%. According to the Fig., R^2=0.86. It means that R is equal to 0.92 which is very close to 1 and it shows a close and strong relation between these two factors. However, according to the statistical analysis, when we have the rainfall data, water table can be 86% predictable. This is while the temperature data make it 90% predictable. In the other words, water table is 4% more predictable when we also have the temperature data.

Now, with regard to the above relations and obtained results, β coefficient will be as follow:

$\beta_0 = 674.129$
$\beta_1 = 0.03$

According to the above numbers, the following equation shows relations between rainfall, temperature and water table.

Elve water table(m)= 674.129+ 0.03(mm)

studied the relations between climate variables and ground water balance in Manitoba State, Canada. They used data such as the average of temperature, the minimum and maximum temperature and rainfall in period of 1900 to 2000. Their results showed that annual rainfall in this region is highly correlated with the level of annual groundwater balance (Chen, Grasby et al. 2004).

3.6. The Relation between Rainfall and Temperature with change Water table

The relation between rainfall and temperature with change water table (Changes the water table from the previous year) has been considered as a two independent variables and one dependent variable so that temperature and rainfall are two independent variables. the relations between each component are as follow: Rainfall has a direct relation with change water table. It means that as the rainfall exceeds, the change water table rises. Temperature and change water table are inversely related. It means that even temperature increases, change water table declines. Table 7 has numerically represented these relations.

Table 7. Correlation matrix of Change of water table by temperature and rainfall in Ghir Plain

	Change of water table (m)	Rain(m)	Temperature(c)
Change of water table (m)	1		
Rain(m)	0.86^{**}	1	
Temperature(c)	-0.93^{**}	-0.89^{**}	1

**Correlation is significant at the 0.01 level.

As it is clear, degree of correlation between rainfall and change water table is very close to 1 and it shows a strong relation between these two components. However, the relations between temperature with change water table and rainfall are negative and close to -1 which shows invers relations of these components. We have $R^2=0.87$. It means that R is equal to 0.93. Whatever this number is closer to 1, the relations between factors are stronger. If rainfall and temperature data of the plain are available, change water table will be 87% predictable. Now, with regard to the above relations and obtained results, β coefficient will be as follow:

$\beta_0 = 40.27$
$\beta_1 = 0.009$
$\beta_2 = -1.62$

According to the above numbers, the following equation shows relations between rainfall, temperature and water table.

Change of water table (m)=40.27+ 0.009Rain (mm) -1.62Temp (c)

The aim of this study was to identify and quantify the groundwater level trend of the state Orissa (India) to understand the forcing mechanism of droughts in conjunction with the anthropogenic pressure using the non-parametric Mann–Kendall statistical procedure. The pre- and post-monsoon groundwater level records of 1002 monitoring stations during the period 1994–2003 were analyzed. The results show that the draw downs due to deficient rainfall during dry years, high temperatures, and anthropogenic pressure have not been recovered through the recharge in wet years. However, this study does not determine whether drought, high temperatures or anthropogenic effects have had largest influence on the groundwater levels decline. The cases of significant water table declines are higher in number than those expected to occur by chance. In the pre-monsoon season, 59% of the monitoring stations experienced groundwater declines as against 51% in the post-monsoon season for the study area as a whole. This could be interpreted that the fluctuation is not a part of noise, but that a signal is being identified. Further, the trend result showed wide spatial and seasonal differences. Irrespective of seasons, the consolidated rock formation that covers 80% of the geographical area experienced significant water table decline. However, the semi-consolidated and unconsolidated formations experienced water table decline in the pre-monsoon (summer) season only. The vulnerable sites where the groundwater-level declined significantly were identified so that recharge measures could be taken up (Panda, Mishra et al. 2007). Results of this study are very similar to the results obtained by Panda et al., 2007.

3.7. The Relation between Rainfalls with Change Water table Elevation

This model has been represented as a dependent variable and an independent variable. The relation between rainfall and Change water table has been shown in Fig. 9.

As it mentioned above, rainfall and change water table are directly related. It means that more rainfall increases change water table, therefore there is a significant relation at level 1%. According to the Fig., $R^2=0.74$. It means that R is equal to 0.86 which is very close to 1 and it shows a close and strong relation between these two factors. However, according to the statistical analysis, when we have the rainfall data, change water table can be 74% predictable.

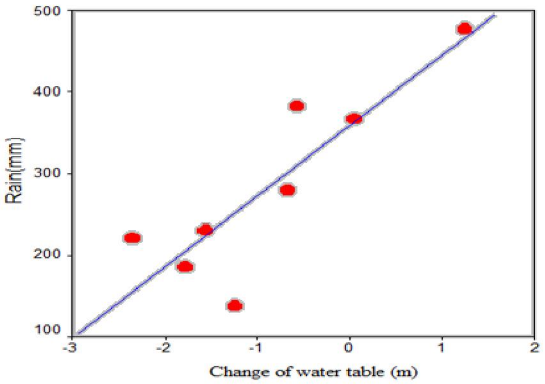

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Fig. 9. Relationship of water table by rainfall in Ghir Plain

Now, with regard to the above relations and obtained results, β coefficient will be as follow:

$\beta_0 = -3.30$

$\beta_1 = 0.009$

According to the above numbers, the following equation shows relations between rainfall, temperature and water table.

Change of water table (m)= -3.30+ 0.009Rain (mm)

Jan evaluated the influence of intensity and distribution of rainfall on fluctuations of groundwater balance in Taiwan. They used Piezometric data of two streams in centre of Taiwan and 7 Raingauge Stations. Results showed that groundwater balance are linearly correlated with rainfall (Jan, Chen et al. 2007). Lloyd-Hughesa showed that decrease of rainfall has a negative effect on soil humidity, water resources, rivers' surface currents and level of groundwater so that water resources encounter reduction (Lloyd-Hughesa and Saundersa 2002).

Literature showed that feasibility of using artificial neural networks (ANNs) was studied to estimate groundwater level in piezometers in unconfined chalky aquifer of North France (Lallahem, Mania et al. 2005; Sethi, Kumar et al. 2010) to estimate aquifer parameter values (Balkhair 2002; Sethi, Kumar et al. 2010) to forecast the groundwater level using rainfall, temperature, and stream discharge as inputs (Daliakopoulos, Coulibaly et al. 2005), and to evaluate the groundwater level in fractured media (Lallahem, Mania et al. 2005; Sethi, Kumar et al. 2010).

3.8. The Relation between temperature and Change Water table Elevation

This model has been represented as a dependent variable and an independent variable. The relation between rainfall and Change water table has been shown in Fig. 10.

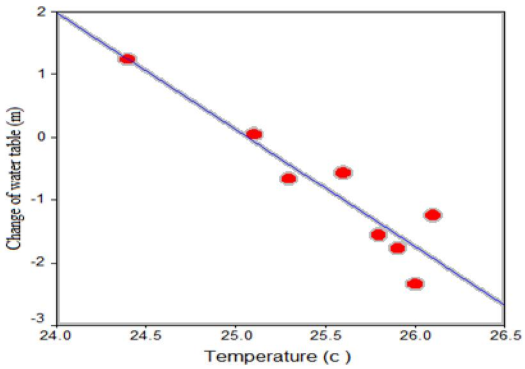

Fig. 10. Relationship of change of water table by temperature in Ghir Plain

As it mentioned above, temperature and change water table are inversely related. It means that even temperature increases, change water table declines, therefore there is a significant relation at level 1%. According to the Fig., R^2=0.87. It means that R is equal to 0.93 which is very close to 1 and it shows a close and strong relation between these two factors.

Now, with regard to the above relations and obtained results, β coefficient will be as follow:

$\beta_0 = 46.63$

$\beta_1 = -1.86$

According to the above numbers, the following equation shows relations between rainfall, temperature and water table.

Change of water table (m) = 46.63 – 1.86Temp (c)

Chen studied the relations between climate variables and ground water balance in Manitoba State, Canada. They used data such as the average of temperature, the minimum and maximum temperature and rainfall in period of 1900 to 2000. Their results showed that annual rainfall in this region is highly correlated with the level of annual groundwater balance (Chen, Grasby et al. 2004).

3.9. Geological formations

From the geological point of view the Plain is located in the Alluvium (Fig.11).

The area to the north is formed mainly of resistant formations of the Gachsaran and Gurpi groups, and to the south of the Asmari-jahrom and Bakhtiari formations. The lithological features of the formations in the Plain are presented in Table 8. Unconsolidated deposits in the all of the Ghir Plain are coarse grained materials including pebble gravel and coarse sand (Iran 2010).

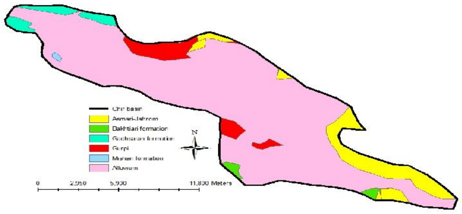

Fig. 11. Geological map of the Ghir Plain (Explanation of abbreviations for geologic units are given in Table 8).

Distribution of alluvium is in all over the plain and it is the dominant formation of the plain. Formations are equal in the regions Tangeroen, Barikhon and Ali Baba but changes in water table level are very different in these regions. For example, changes are 0.71 m in Tangeroen but they are -16.36 in Barikhon. However, it considers that Gachsaran formation which is in the regions Sekeravan, Ghir and Eslamabad, has high influence on water table decrease and enjoys more drop of water table in compare with other formations of the region. Of course, the lowest changes of water table in all over the plain belonged to Bakhtiari formation. This formation exists in Sharepir and Ghalatnahavie regions.

Quaternary sediments, which are the most important reservoir of underground water resources, have been formed from physical and mechanical weathering of upland formations. Properties of sedimentology of quaternary can determine the hydrology and hydrogeology of water of the reservoir. Quaternary sediments are very important in Iran because they covered more than 50% of the area of country (Boustani 1994; Jankowski, Acworth et al. 1994).

Table 8. Lithology of geological formations in the Ghir Plain

Geological formation	Lithology	Area (ha)	%	Location of Plain
Alluvium	Erosion of fine and coarse discontinuous alluvial fans and debris without cement as a domain	18220.5	84.2	All
Asmari-Jahrom	Dolomite and limestone, marl and limestone with thin shale	1991	9.2	East and Southeast
Bakhtiari	Conglomerate	102.7	0.47	Southeast
Gachsaran	Between the marl and limestone layers in alternation with red marl containing gypsum	425.8	1.97	West and Northwest
Mishan	Green marl and marl with limestone floors alternate between layers of shale limited	36	0.16	West
Gurpi	Alternating layers of marl, argillaceous limestone, marl and limestone and shale	863.15	4	Central and North

Table 9. geological formations and change of water table (2004-2011)

Locations	Geological formation	Change of water table (m)
Tangeroen	Alluvium, Asmari-Jahrom	0.71
Shahrepir	Alluvium, Asmari-Jahrom, Bakhtiari	0.71
Barikhon	Alluvium, Asmari-Jahrom	-16.36
Ali abad	Alluvium, Asmari-Jahrom	-2.38
Ghalatnahavie	Alluvium, Asmari-Jahrom, Gurpi, Bakhtiari	-0.74
Sarcheshme	Alluvium, Gurpi	-2.35
Fathabad	Alluvium	-6.43
Shams abad	Alluvium, Gurpi	-1.39
Sekeravan	Alluvium, Gachsaran, Gurpi	-22.80
Ghir	Alluvium, Gachsaran	-12.55
Eslamabad	Alluvium, Gachsaran	-6.63

4. Conclusion

Regarding that depth of water table decreases 1.1 m every year, it is recommended that regional authorities to identify dry years with regard to the obtained results by this research in order to decrease groundwater withdrawal or prevent withdrawal in some regions where water drop is very large if necessary (such as Sekeravan and Ghir) and to consider some arrangements for other regions such as prevention from creating new wells and increasing depth of wells.

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