Int. J. Environ. Res., 9(2):621-634, Spring 2015
ISSN: 1735-6865

The Development of Strategies for Wetland Restoration by Comprehensive Assessment of Hydrological, Land Use and Climate Changes

Karbassi, A.R.[1*], Amiri, M.J.[2], Zoghi, M.[2], Sadat, M.[2] and Tajziehchi, S.[3]

[1]Department of Environmental engineering, Faculty of Environment, University of Tehran, P.O.Box 14155-6135, Tehran,Iran

[2]Department of environmental Planning and Management. Faculty of Environment, University of Tehran, Tehran, Iran

[3]Department of environment, Faculty of Environment and Energy, Science and Research Branch, Islamic Azad University, Tehran, Iran

Received 19 Oct. 2014; Revised 10 Jan. 2015; Accepted 15 Jan. 2015

ABSTRACT: Wetlands are ecosystems with specific features and functions which have been unfortunately damaged by recent pressures and limitations. Fast reduction of surface flows, water and wind erosion of soil, changes in the quality of water and soil resources, increasing exploitation of underground water, agricultural development, climate change, etc. have had the most effect on these ecosystems. So this study shows that in the last two decades, the level of groundwater has dramatically decreased as a result of human activities. Together with the decrease of water resources in Agh-Gol wetland area, land use has been also changed with a faster pace. Considering the studies on land use changes it can be stated that the amount of water in the area have had a decreasing rate so that it has been completely dried up these days. But hydrology studies warn us that there has been a thirty- five- meter reduction of water level in last years the main reason of which is planting products with the high water requirement. Also the minus water balance of this sub-area shows the unsuitable situation there. In general, this area has been faced with an instability which is caused by mismanagement. With a precise observation and control on water withdrawal from wells, using counters and plumbing illegal wells, banning planting close to the wetland, changing the planting patterns toward the products with less water requirement and also optimizing watering, we can be hopeful that in future the situation will be improved and Agh-Gol wetland will revive.

Key words: Wetland**,** Emolition, Ground water, Climate, Unsustainability

INTRODUCTION

Water is a constrained natural resource, and in many areas of the planet water shortage is considered to be one of the most important issues to be resolved (Kondilia, et al, 2010). Freshwater resources around the world are under pressure from growing populations and significant increases in agriculture and industry demand for water. These problems are most acute in Africa and West Asia (Morrison & Gleick, 2004).

Natural limitation which Iran country is faced with, causes fast reduction of surface flow, underground water decrease, wind and water erosion of soil, changes in the quality of water and soil resources, increasing exploitation of underground water and ground settlement (Piri & Ansari, 2000). All over the country the level of groundwater decreased from 92 million cubic meters in average to 48 million cubic meters. It means that groundwater level has been halved. Due to unsustainable development pattern during last decades, approximately 80 percent of Iran's wetlands has got damaged or at the moment do not have a good situation (IWIP, 2000).

Groundwater usage in different agricultural, drinking, industrial, and environmental sectors influences its quantity and quality significantly. Lack of attention to each of theme output severely damages the sectors and the environment in general. Through better management in water consuming sectors, groundwater preservation both in terms of quantity

*Corresponding author E-mail: akarbasi@ut.ac.ir

and quality will be possible (Abode *et al.*, 2014) On the other hand, water requirement of plants in semiarid climate, where water resources are endangered due to over-exploitation, puts water resources under the pressure and must be considered (Kardavani & ghaleei, 2000). Indiscriminate withdrawal of groundwater in many places all around the world has caused dramatic decrease in the level of groundwater. Therefore, this pressure on water resources of Iran and our target area considering its vast farming areas th can be of great importance. Lack of groundwater all around the world is about 700 to 800 million cubic meters 1 percent of which (equals 7-8 million cubic meters) belongs to Iran (Kardavani, 2007). Consequently, along with the developmental trend and population growth, lack of water resources has threatened ecosystems and human communities. Among these ecosystems, wetlands are known as one of the most important and valuable ecosystems having a vital role.

Wetlands which are covered by lagoons, ponds, swamps, mudflats, natural and artificial basins, whether temporary or permanent, fresh, salty or bitter, still or current, as well as coastal ponds which are lower than 6 meters at the minimum height of the tide are called wetlands. Thus, wetland is an environment that water is the main constituent of its animal and herbal environment. (Ramsar Convention Secretariat, 2007; Soltani & Jafari, 2009; Bagherzadeh Karimi & Rohani Rankuhi,). These ecosystems, in which complicated relationships not only between their internal elements but also with external environment exist, are one of the requisite conditions for the overall equilibrium in the environment (Elmberg, 1994). Despite the importance and the role of these unique irreplaceable areas (Dong *et al.*, 2014) and providing many ecosystem services such as resourcing and depleting underground waters, preserving water quality, soil erosion, rich sediments, flood and drought, biomass export, filtration and refinement of water from nitrogen and phosphor combinations, reduction of air pollution, possession of significant genetic resources and fertile ecosystems and etc. (Kim *et al.*, 2011; Majnuniyan, 1998), their services and values have remained largely unknown (Khaliliyan, 2011). Therefore Throughout the world, wetlands are increasingly being recognized as important elements of the landscape (Acreman *et al.*, 2007; Dong and *et al.*, 2014).

The loss and destruction of wetlands is a common problem that stems from increased natural and human activities (O'Neill *et al.*, 1997). The most important of them are:

1. Land use change: one of the items which generally alters the ecologic functions of wetlands is changing the land use in which focused agriculture replaces natural vegetation of the land (Ghorbani *et al.*, 2012). Evaluation of the transformation process of land use is a process which leads to a proper understanding of human interaction with the environment. This issue is more significant in sensitive environments especially wetlands (Lambin & Geist, 2006). Accordingly, monitoring the transformation process of wetlands and its surrounding areas can be of great help in the management of these valuable systems (Ozemi & Baure, 2002). Hence, recognition of lands and wetland margins is also of great importance. On this basis, monitoring the changing process of wetlands in several decades and identifying the direction of such changes are necessary for the management and exploitation of these wetlands, as well as presenting strategies which prevent the wetlands to be included in Montero Record (Ghorbani *et al.*, 2012).

2. In the ongoing discourse of global, climatic and environmental change – today's vast fields of research-environmental degradation as well as environmental behavior and awareness should play a central role (Baier *et al.*, 2014). Climate change which will affect the hydrology of individual wetland ecosystems mostly through changes in precipitation and temperature regimes with great global variability (Kevin & Erwin, 2009).

3. Pressures on wetlands are likely to be mediated through changes in hydrology, direct and indirect effects of changes in temperatures, as well as land use change (Ferrati *et al.*, 2005).

Projected impacts in some key water-based systems and water resources under temperature and precipitation changes approximating those of the special report of emission scenarios (Table 1), (STRP 2002).

Various studies have been done for the assessment of climate change, water resources and wetlands use including the following articles:

Pastor et al. (2010) investigated the effect of drought in Mediterranean wetland in southeastern Spain and by using satellite pictures identified that the land cover in this area (plant coverage, soil and water) has been damaged heavily compared to the previous years (Pastor, 2010). Zhao et al. (2010) conducted a research on the pearl river mouth by using Landsat satellite images from 1979 to 2009, and finally found that this wetland has been reduced in size into pieces due to the diverse natural and human factors such as change in the level of underground waters, over-exploitation of water for agricultural uses and

Table 1. Impacts of temperature and precipitation changes approximating on some key water-based systems and water resources (STRP 2002)

Indicators	Condition in 2025	Condition in 2100
Freshwater wetlands	Widespread stress on many marshes, swamps, vernal pools, etc. Some will disappear	Most systems will be changed significantly, many such as prairie potholes and vernal pools will disappear with some spatial drifting
Water supply	Peak river flow shifts from spring toward winter in basins where snowfall is an important source of Water	Water supply decreased in many water-stressed countries, increased in some other water-stressed countries
Water demand	Water demand for irrigation will respond to changes in climate; higher temperatures will tend to increase demand	Water demand effects amplified
Floods and droughts	Increased flood damage due to more intense Precipitation events. Increased drought frequency	Flood damage several fold higher than ''no climate Change scenarios''. Further increase in drought events and their impacts

pisciculture, urban development and etc. (Zhao *et al.,* 2010). Kashaigili (2006) studied the changes of Usangu wetlands from 1994 to 2000 by using Landsat satellite images. The findings of this research show that these wetlands are on the verge of complete destruction due to the raise in human activities and their destructive effects. Moreover, this research reports a 14 percent increase in wetland vegetation and 77 and 70 percent decrease in closed and open forest coverage, respectively (Kashaigili *et al.,* 2006). In 2005, another study was conducted on saline wetland in the central Spain by Schmid et al. In this research, in order to determine the characteristics of wetland changes over time, multispectral data from airborne and satellite sensors have been used. The findings show that the constituents of wetland have gone under great changes regarding the area and spatial transmittance which human effect is identified as its main cause (Schmid *et al.,* 2005).

In the field of climate change, Moreno and Serrano in 2005, investigated hydrological responses of different time scales of climatic drought using the standardized precipitation index (SPI) in the Plain of Aragon River. The SPI index were compared with surface hydrologic changes in this plain in several time scales and the advantages of various time scales of this index were analyzed for identifying the droughts in useable water resources. The findings show that SPI index can estimate the situation of drought in various time scales and also monitor various types of drought; SPI long-term induces are related to hydrologic drought (Serrano & Moreno, 2005).

Rahimi & Malekmohammadi (2013) identified the most important stressors which are threatening Shadegan wetland in Khuzestan province in southwestern Iran. The findings of this research show that physical changes such as changing the land use of natural habitat and the water supply system of wetland such as damming, water pollution due to the depletion of sewage into wetlands, inappropriate exploitation of biologic productions and also occurrence of drought phenomenon are the most crucial threatening risks of Shadegan wetland (Rahimi & Malekmohammadi, 2013).

Ghorbani et al. (2011) examined and analyzed the changes of land use in the area of international wetlands of Ala-Gol, Alm-Gol, and Aji-Gol in Turkmen Sahra of Iran by using satellite Images of Landsat in 1987, 2000, 2005, and 2010. The results indicate that the recent droughts in the region, damming, inappropriate use of wetland waters for agriculture, pisciculture, construction of canals and roads in the area and between wetlands are the main causes of a decrease from 2591.8 acres in 1987 to 1280.6 acres in 2010 in the wetland level of water. Moreover, reducing the saline lands and plant coverage with high density and increasing the coverage with medium and low density, and finally, no change of the sterile lands and its area were identified as the most important changes of the region (Ghorbani *et al.,* 2011).

Jafari et al. (2013) developed management strategies for the conservation of Miankaleh wetland. According to the results of this study, several strategies have been proposed among which Zoning of area for efficient allocation of resources to activities for the conservation, ecotourism, agriculture and development has the highest charm score and pest management program and controlling the use of chemical fertilizer have the lowest charm score (Jafari *et al.,* 2013).

Astani et al. (2011) investigated the role of climate type and drought on Agh-Gol wetland located in Hamedan province and found that the most significant factor of environmental deterioration of the wetlands include population growth and agricultural development, excessive exploitation of groundwater resources and violation of wetland realm (Astani *et al.,* 2011).

In 2012 Farzin et al. investigated the changes and predicted of Urmia Lake water surface evaporation by chaos theory in the 40 years. In this way, they have calculated the delay time (T=7.5) by using average mutual information method (AMI) and embedded dimension (d=3) by using false nearest neighbor algorithm (FNN), the slope of correlation dimension diagram has been computed. After that, the amount of evaporation in the last 10 years (1997-2007) have been predicted by means of false nearest neighbor algorithm and verified with the observed data. The results agree with the high accuracy of chaos theory predictions so the amount of evaporation of the Lake is predicted for 10 following years of 2007-2017 (Farzin *et al.,* 2012).

In total, it can be said that Hamedan wetlands such as Agh-Gol enjoy a relatively good diversity and abundance of species, because they are located in a biogeographic Palearctic area. Besides, they are of great importance regarding ecology, botany, zoology, hydrology, and limnology; among which the important role of ecology and limnology in the energy cycle of the environment of Hamedan can be emphasized (Ghasemi *et al.*, 2012). Agh-Gol wetland has a special geographical situation as a corridor and water habitat in the country, and connects Fars and Khuzestan provinces to northwest habitats of the country including the coastal area of the Caspian Sea and Uramia Lake. (Cheraghi *et al.*, 2008), measures such as the management of wetland, evaluation of draught, investigating the land use change, hydrologic examination of subfields related to Agh-Gol wetland and also socioeconomic evaluation of this wetland margins can provide guidelines for sustainable management of the ecosystems in this area; thus, research in this region is essential due to the drying process of this wetland.

MATERIAL & METHODS

The Natural and seasonal wetland of Agh-Gol is located in 34 degrees 49 minutes east longitude, 29 degrees 2 minutes north latitude, between the provinces of Hamedan and Markazi, in 20 kilometers north-east of Malayer and 1 km south-east of the kord-khurd (Islam-Abad) village, below Komijan catchment (Figure.1). Wetland vegetation includes *Phragmitesaustralis*, *Typha latifolia*, *Carex*, *lemna minor* and *Medicago sativa.* A total of 46 species of aquatic birds such as *Egretta garzetta*, *Egretta Alba*, *Ciconia ciconia*, *Ciconia Nigara*, *Aquila chrysaetos*, *Numenius arquata*, *Tringa stagnatilis*, *Pelecanus* and etc. are identified in this habitat. Also, mammals living in wetland margins are generally consistent with cold and mountainous regions, notably including Canis lupus, hyena, Capra aegagrus hircus and Ovis Aries (Cheraghi *et al.*, 2008).

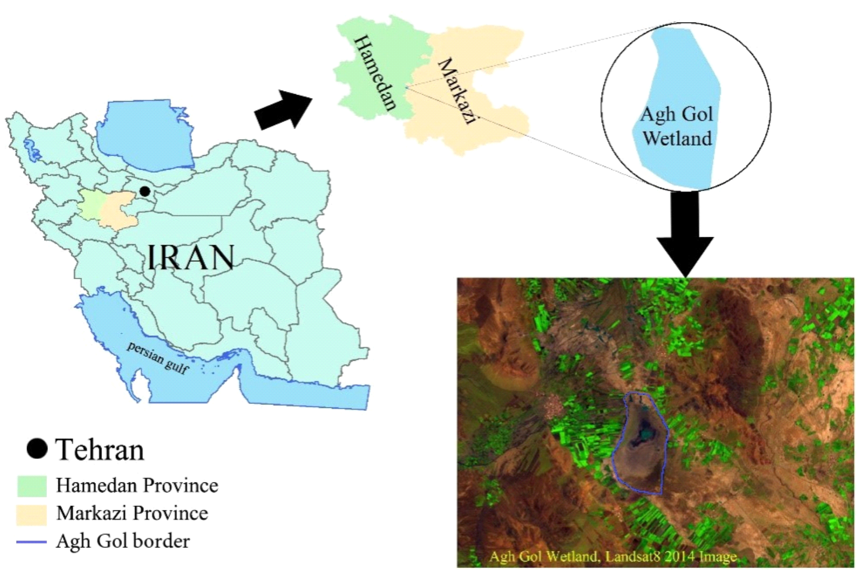

Fig.1. Agh-Gol wetland in bordering of the Markazi and Hamedan provinces

Wetland inundation season starts from late December to mid-June each year. Of course, it is directly related to the amount of annual rainfall, the depth of water varies from 0 to 1 m and its surface area reaches 15 square kilometers during high water seasons. With the progress of water in the central parts, islands with a height of 6 meters may appear. Thus, it is classified in floodplain freshwater group of wetlands. The main water resource which is accessed by Agh-Gol wetland includes two parts: first part is Shara or Qara-Chai River which passes by 5 km west of wetland and the second part is formed by rainfalls. However, during the past years water flow had completely stopped and with respect to the walls which are constructed in the wetland margins, the water from melting precipitations cannot find their way to the pond. So Agh-Gol wetland as a hunting preserve area located in Hamedan province has been over-exploited of its water resources in the recent years, like many other wetlands of the country and a collection of various factors ultimately led to drying of this wetland during 2008-2009. In this research, the attempt was to investigate the climatic changes and hydrological features, land use and other affecting factors and influential strategies for restoring the wetlands.

The primary information for the study stem from library documents, field observations and interview with the local people including farmers, stakeholders, to name but a few. . In the next step, basic information were prepared and collected by researchers based on the maps of Iran national Cartographic center in 2011, updated in 2014. For statistical analysis of climatic and hydrologic resources, data were collected from Meteorological Organization and water resource management in a period of 30 years. For studying the land coverage and its changes, data from images of Landsat satellites (Landsat 7 and Landsat 8) in 2000 and 2014 were used. GIS were used in order to localizing the information and data and pictorial analysis were used. Then, by using GIS technique, the needed maps were prepared with 25000/1 scale and statistical (quantitative and qualitative) analysis of indices were conducted using inductive method. After all, the sustainability and quality of region's environment, its hydrological situation, distribution of water resources and agricultural lands were determined using the findings and the final maps.

In order to examine land coverage, remote sensing technique (RS) and ENVI 4.7 software were utilized. After geometric and atmospheric correction of data by Maximum Likelihood method where k=0.82 were classified and presented. One of the key issues of hydrological discussions is water balance calculation which provides quantitative estimation of water resources and their changes under the influence of various factors such as watering by dams, water extraction by pumping wells, reduction of rainfalls and increased evaporation from the catchment due to climate change. In order to do this calculation, the following equation was used:

$$P + Q_{Si} - Q_{so} - Ets - I + R_g = \Delta Ss \qquad (1)$$

In this relation, P is the Atmospheric fallout volume within the basin area, Q_{si} is the volume of surface currents entering the study area, Q_{so} is the volume of surface currents leaving the study area, *Ets* is Evapotranspiration, *I* is the infiltration of water, R_g is the volume of groundwater to the basin and the volume of surface water changes. The different balance scratches were calculated and mapped. Drought studies of the region were selected after illustrating the basic information and selection of common methods according to the available data. In investigation of drought in Komijan watershed basin, the normal percent index was used as the statistical method. In this relation, PN: precipitation normal index, P: annual precipitation (mm or m), P: the average precipitation of period (mm or m). Using this index is one of the simplest methods of evaluating the severity of drought which is determined after calculations regarding Table 2.

Table 2. The qualitative situation of normal precipitation index

<40	40-55	55-70	70-80	80	Mean percentage of monthly precipitation
Severe	Extreme	Moderate	Weak	Threshold	Severity of drought

In the next step, SPI index was used in order to confirm the situation of drought in the region. SPI index is presented by McKee et al. in 1995 which is estimated based on the difference of precipitation from mean in a specific time scale, divided on standard deviation. The only effective factor in estimation of this index is precipitation element.

$$\mathbf{SPI} = \frac{\frac{\mathbf{X}}{\boldsymbol{\mu}}}{\boldsymbol{\sigma}} \qquad (2)$$

As another feature of SPI index, this method can be used for determining the threshold of drought for every time period; as a result, it is possible to calculate both the severity of drought and its length by this index (Table 3) (McKee *et al.*, 1995).

Table 3. Drought class classiûcation of Standardized Precipitation Index (SPI ((McKee *et al.*, 1995)

SPI values	Drought class
2 and higher	Severe wet
1.5 to 1.99	Extreme wet
1 to 1.49	Average wet
-90.9 to 90.9	Normal
-1 to -1.59	Average drought
-1.5 to 1.99	Extreme drought
2 or lower	Severe drought

Data related to annual precipitation of this region of 30 years was used for calculating the SPI index in the area of Agh-Gol wetland. At the end, some guidelines were proposed to revive the wetland on the basis of the results, so that we could revitalize the wet land with the help of principled planning and proper management.

RESULT & DISCUSSION

A comprehensive evaluation of land use change, hydrology and climate of Agh-Gol wetland can explain the main causes of wetland drought; and accordingly develop corrective measures for improving the Condition of wetland in this regard. The following results were found in this study:

•Change of land coverage:

After categorizing the images, lands of region were divided to 5 classes including recognized Green space, build space, open space, wet soil and water. For classification of lands in the region, an ecologic realm was defined 5 km from Agh-Gol wetland and the change was calculated using the following table for 14 years (2000-2014) (Fig. 3).

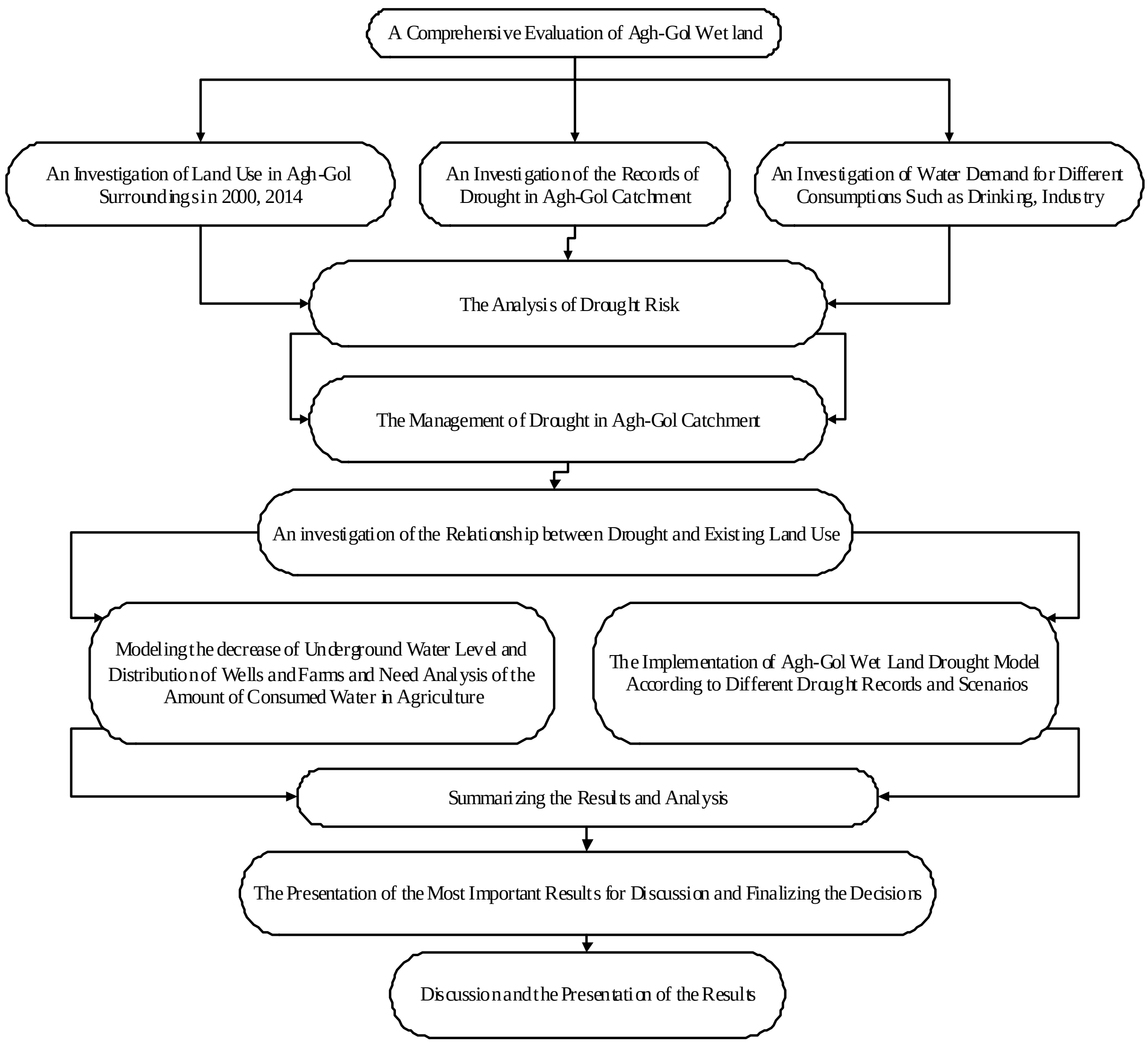

Fig. 2. The process of Different Stages in the Research

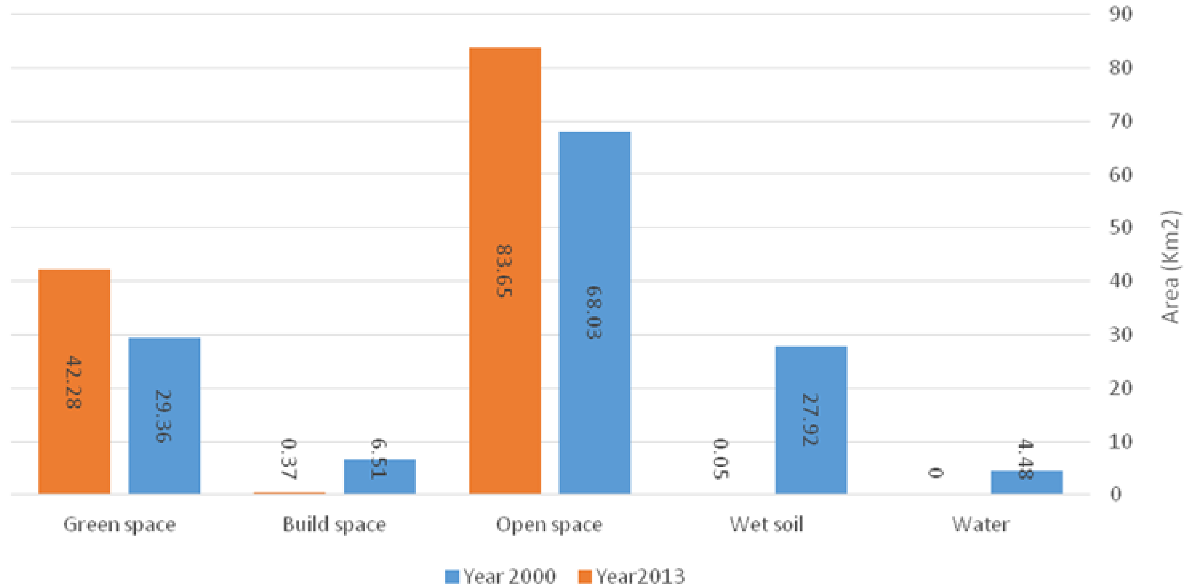

Fig. 3. The area of various use classifications in 2000 and 2014

The increasing of agricultural lands in the studied region is highly noticeable. Regarding the findings of this study, the villages which are located around wetland and the lands with wet soil are changed to agricultural lands in the studied years. The change of land use to this extent must be heeded in the region and its sustainable development. This phenomenon has leaded to a considerable change in the process of drying unused lands which have stone and soil, leading to the drying of wetland. Moreover, the maps show that as much as we go farther than wetland center i.e. between 1 to 3 km margins of wetland, more agriculture and exploitation of water could be seen; beyond that, the numbers of farms reduce, and have a considerable decrease (fig. 4).

•Investigating the quantity of water in Komijan watershed area:

In the studied region, some human interfering phenomena such as changing the lands use and agriculture cause fluctuations in the level of groundwater where the main reason could be the difference between exploitation and replacement of groundwater in the area. Since this important issue

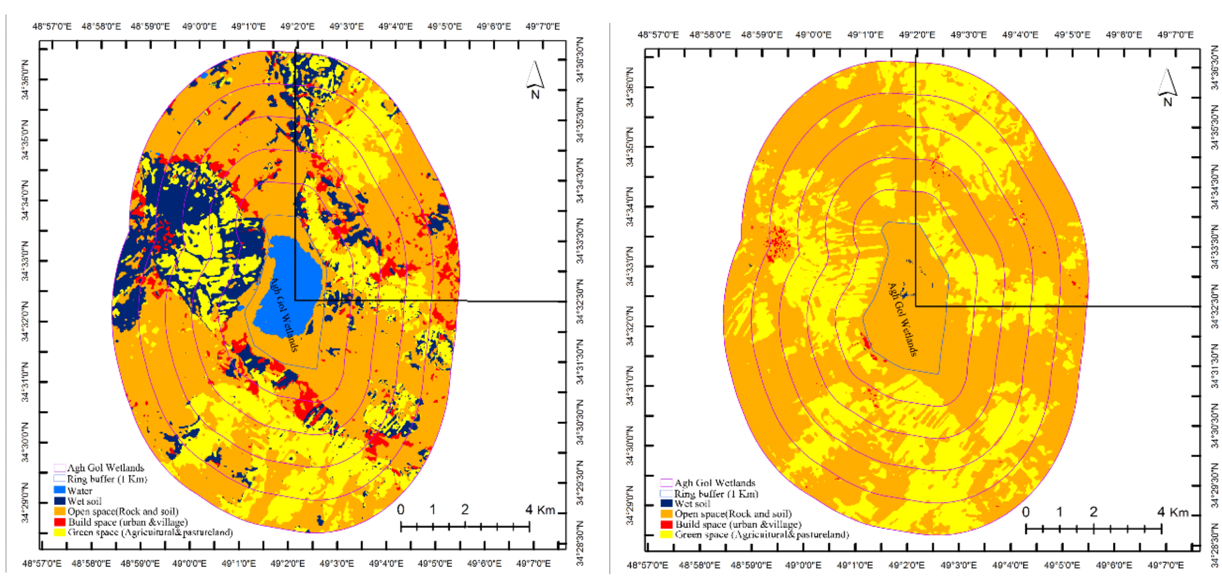

Fig. 4. The slope of change of land cover in 2000 (A: in Left), and 2014 (B: in Right) in the margins of Agh-Gol wetland

affects the wells and aqueducts of the region, the continuation of this process will lead to drying of these valuable hydrologic resources in the margin of Agh-Gol wetland.

The result of investigating the distribution of water wells and agricultural lands in the region (fig. 5) shows that the dispersal of built wells were more in the areas that irrigated farming exists which caused a decrease in the level of its water during years due to the exploitation of water from wells for agricultural use.

Interview with local people and the analysis of documented reports show that in the past years when a part of wetland water was coming from Shara and branches of Qara-Chai rivers, the level of underground water was high and the ecologic life which was existed in the region. However, reduction and fading out of water resources have been occurred. From the entering rivers to the wetland, and over-exploitation of resources in the margins of Agh-Gol wetland for agricultural use has reduced the level of underground waters in this area. Because of the fact that the main supplier of the river that is to say the river streams have gradually exhausted, the wetland begin to dry up. In general, Agh-Gol wetland position in Komijan catchment, witnessed the highest decline in groundwater levels in its surrounding area. The maps presented in figures5 in a 20 years period, examine the amount of change in the level of groundwater and substrates in the margins of the wetland. According to the studies from 1991 to 1996 in Agh-Gol wetland, accessibility to groundwater has become possible in the depth of 8 to 15 meters in the margins and 50-60 meters in the worst situation which indicates an optimal condition of region and balance between groundwater's harvesting and recharge. However, the field data and prepared maps from this region in 2006-2011 indicate a reduction in the accessibility level of groundwater over 40 meters which is due to the over-exploitation of water resources and lack of recharge of substrates. The average of this number shows 135 meters of decline in the whole sub-area. During the last twenty years, lack of recharge and over-exploitation of groundwater substrates cause an annual loss of about 40 million cubic meters of water in the sub-areas of Komijan, in addition to its effects on the wetland and it's drying (Fig.6).

According to the statistics related to the period from2001 to 2011, the amount of flow rate of wells and aqueducts has decreased significantly in all three areas related to the wetland. Accordingly, the water flow has decreased from 12 to 5 cubic meters per second in the sub areas of Agh-Gol wetland. This reduction in the region is indicative of reduction of wells and aqueducts in the region, and encourages the farmers to increase their working hours and depth of wells.

On the other hand, in the sub-area of Komijan, 36 wells are dried since 2009-2011, exactly when the wetland is on the verge of drying. It can be said that the drying of wetlands as a source of groundwater recharge contributes to the reduction of water and its drying. On the other side, regarding the diagram, the relationship between depth of wells and the cultivated area under each well shows and increase of cultivated areas in the wetland adjacent villages. Moreover, in this region the depth of wells is increased due to the higher consumption and affected level of underground substrates which may create various problems in the future (Table 4 & Fig. 7).

•cultivation of land planed and water use in Komijan watershed:

According to the statistics declared by the Iran Water Resources Management Company in 2014, the subarea of Komeijan having 1212 licensed well with the surrounding average area of 16.64 hectares for each well, used 20167 hectares of its total land for cultivation of various crops. Assuming that the majority of these crops include *Triticum aestivum*, *Hordeum vuIgare* and *Medicago sativa*, the average water requirement would be over 14359 million cubic meters.

In the first assumption, Mathematical calculation estimated the water requirement of agriculture field of the region to be approximately 290 million cubic meters. In the second one, if the majority of corps is Medicago sativa alone (based on various field observations and local interviews), the water requirement of the region will be equal to 586 million cubic meters. While the total volume of annual precipitation is approximately 24.1 million cubic meters and over 609 million cubic meters evaporates per year. Regarding the absence of needed water resources in the region i.e. komijan basin, the ground water sources have been overused, hence, the wetland ponded waters have become used as the only alternative for local stakeholders. The outcome was nothing but ecological disasters, environmental catastrophes and the loss of sustainable development which threaten all upcoming generations.

•The watershed of wetland's water balance

The result of the water balance calculation shows that the amount of water storage is remarkable and impressive in south and west of the watershed. Although, water storage has been reduced in the central, north and east of the watershed and resulted in negative water balance (Fig. 8).

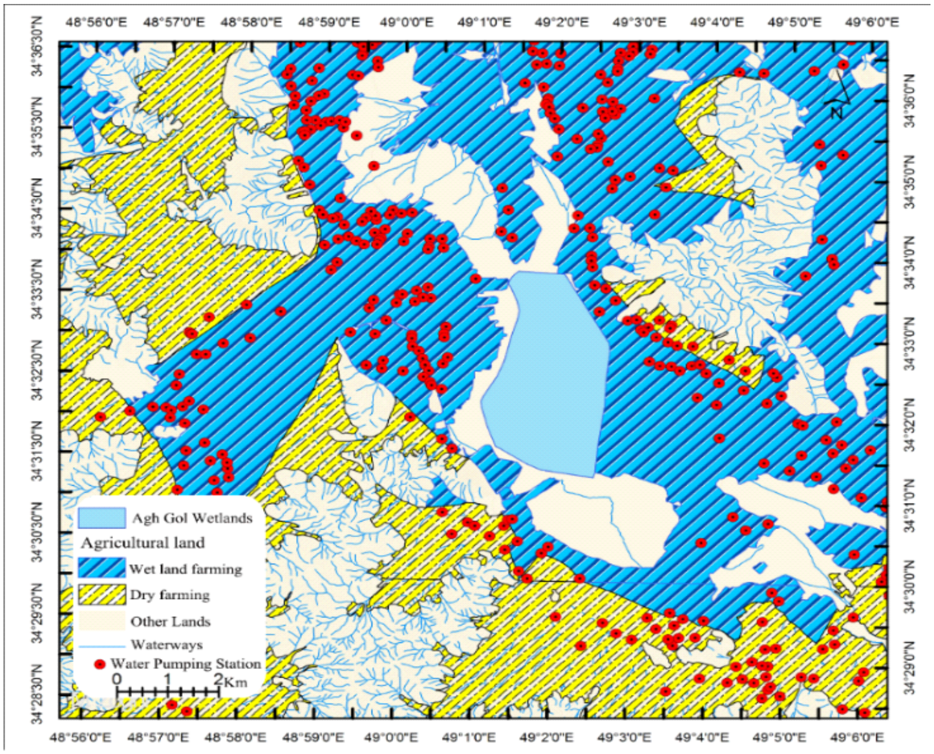

Fig.5. The agricultural lands under the area of Agh-Gol wetland

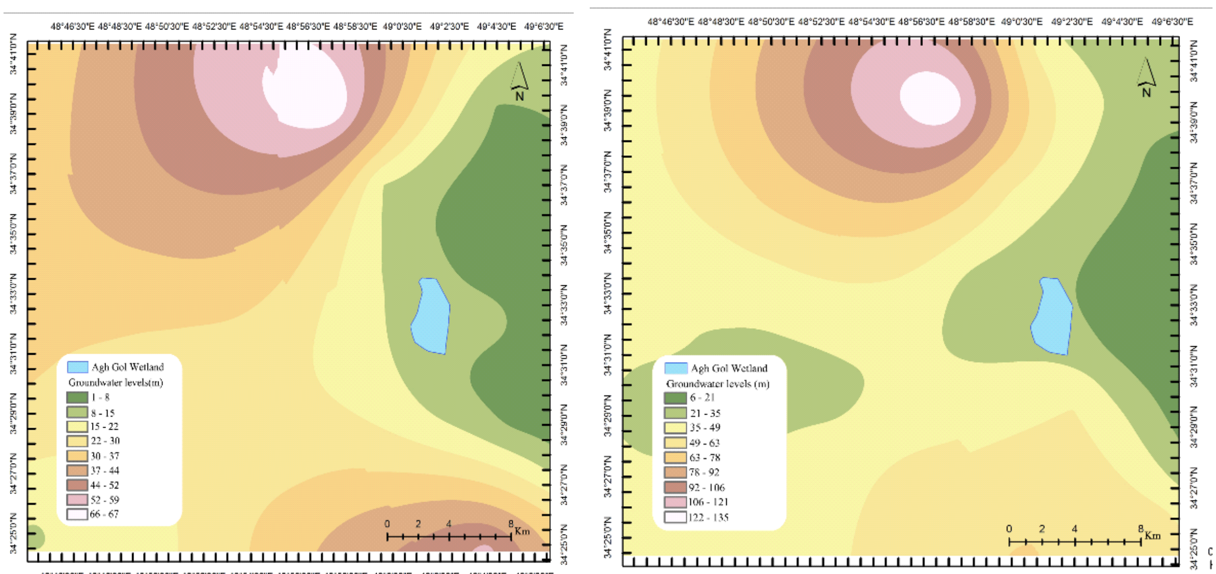

Fig. 6. The average level of underground waters level of underground waters of Agh-Gol wetland marginal lands (A in right 1991-1996), (B in Left 2006-2011)

Table 4. The mean of change in water level, discharge wells, flow rate of aqueducts and dried wells during 2001-2011

vel of water in 2011 (m)	level of water in 2009 (m)	level of water in 2001 (m)	Factors examined
38.02	31.78	23.79	Average level of water
11.86	13.22	13.5	Average flow rate of wells
5.07	6.48	12.2	Average flow rate of aqueducts
39	3	0	The number of dried wells

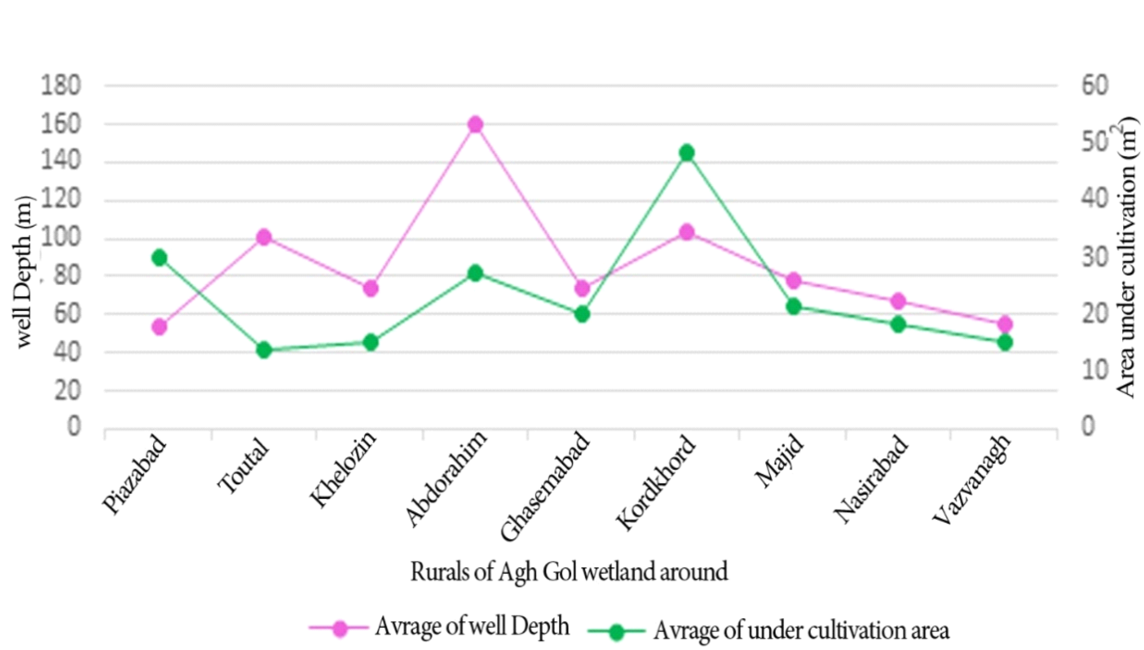

Fig.7.The amount of cultivated lands and the consumed water in Komijan sub-area

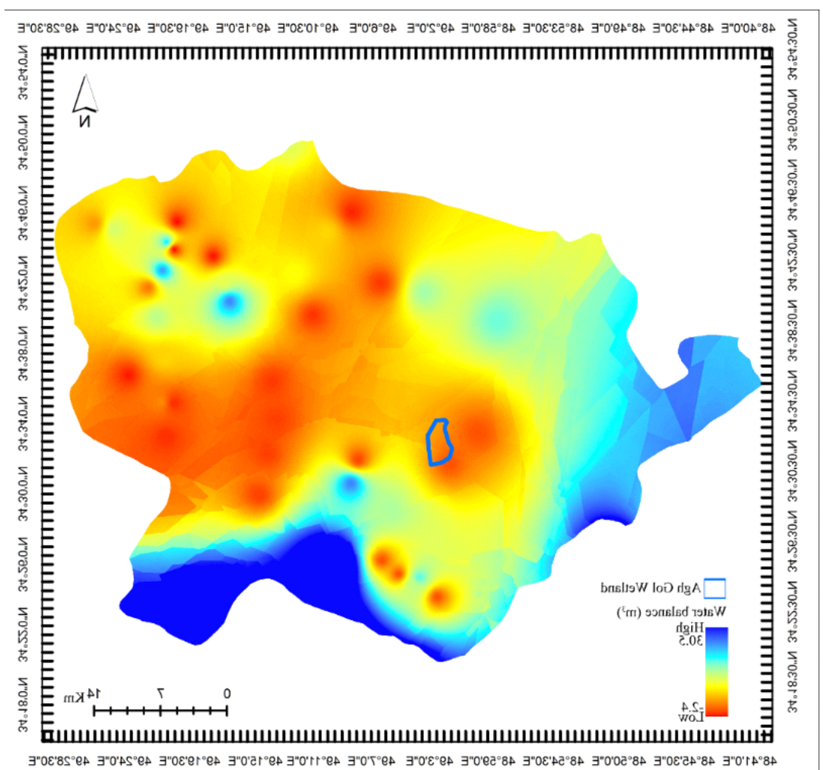

Fig.8.The watershed of wetland's water balance

The results of normal rainfall index show that a devastating drought that could modify the appreciably in the hydrological resources of the area has not occurred from 1995 up to 2013. Therefore, the main cause of drought is not climate change. Hence, it could be said that the drought had little effect on the quantity of water resources in the watershed Agh-Gol wetland (Table 5).

Comparing these numbers with the SPI index classification standard table shows that watershed Agh-Gol wetland has experience a normal mode in terms of classification in this period.

Table 5. SPI index of the synoptic stations in the region in 1995 to 2013

Station	Khondab	Nozhe	Malayer
Location	34 24 N 49 24 N	35 12 N 48 43E	34 15 N 34 15 N
SPI index	-0.00716	- 0.00704	-0.00680

Also the result of NP index for synoptic stations of the region from 1995 to 2013 is calculated in (Table 6):

Comparing of NP index results shows that very little drought happened in June and August in Malayer and September and March in Khondab station. Additionally, the Result of Thornth Waite chart implicates the severe climatic changes in the region (Fig. 9).

The rate of rainfall, evaporation, runoff height in the watershed are shown in the following figures (Fig. 10).

Table 6. NP index for synoptic stations of the region

	MOUNT	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC
PN index	Malayer station	125	152	222	290	92	13	60	14	52	59	170	133
	Nozhe station	150	156	193	199	122	17	94	80	50	66	129	147
	Khondab station	184	154	23	191	170	90	40	60	30	60	119	158

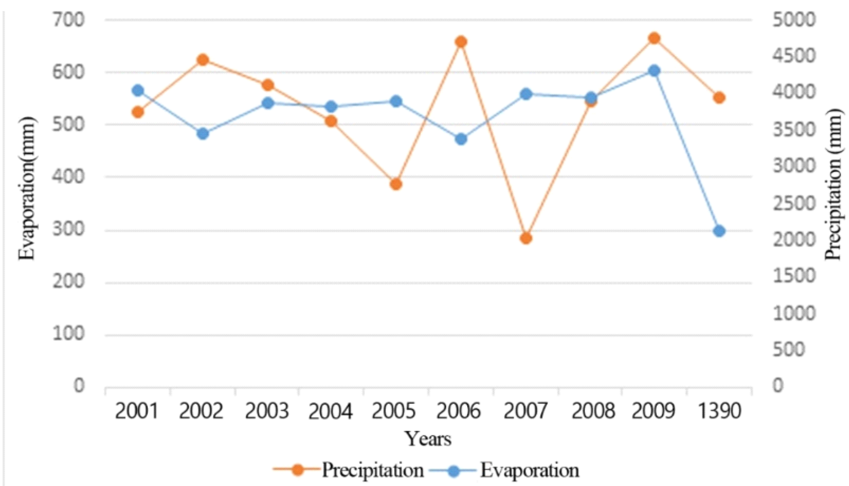

Fig. 9. Thornth Waite index of the synoptic stations in the region

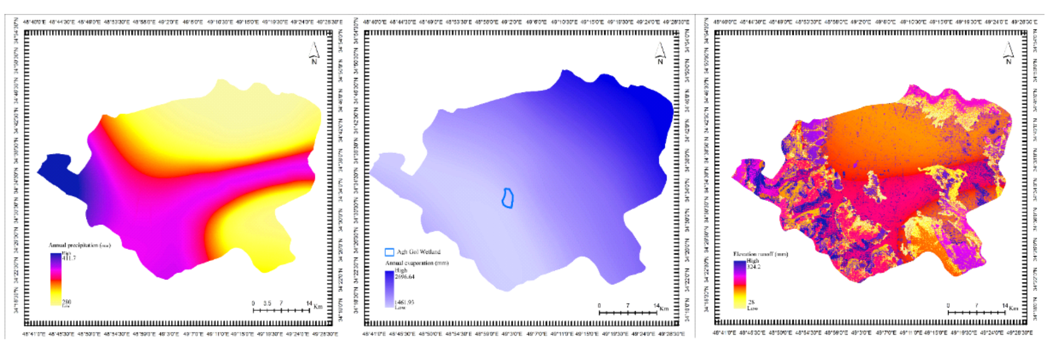

Fig.10. Rate of rainfall (A), evaporation (B), runoff height in the watershed (C)

According to the rainfall and evaporation maps, the eastern part of the sub basin has the highest amount of rainfall (411 mm) and the lowest amount of evaporation in the year. Therefore, Agh-Gol wetlands condition in the term of parameters is in the normal rate. Also highest runoff depends on the area topography. At the end, we can say that the wetland drying process can be controlled by comprehensive and accurate planning and management and we can rescue the area of the drought crisis in the coming years.

CONCLUSION

Given the drought in the region, we have encountered some crucial problems such as soil erosion, infertility of the agricultural lands and reducing of the groundwater storage. Hence, the change in land use. To prevent the exacerbated situation (to deal with the problem) the sustainable management is needed. The sustainable management could be achieved with nothing but using modern agricultural techniques and cropping varieties which require less water consumption and is compatible with regional climate.

The study also shows that human factors especially unsustainable and non-normative agriculture in the area are the main causes of reduction in groundwater level around the Agh-Gol wetland; therefore, sustainable water resource management approaches with emphasis on the economic, social and cultural conditions of the region should be applied to improve the situation. In this way, along with applying scientific management and using modern environmental education, all potentials of the local communities should be materialized, in order that they can find the opportunity to make their positive contribution to the same.

The present study also indicates that the wetland soil is very suitable for agriculture. Unfortunately, in the past, due to inefficient management and failure of supervising system in the region, agricultural activities increased with alarming rate regardless of environmental conditions of the wetland, resulting in invading its buffer zone and violating wetland marginal lands.This issue has caused exceeding development of agriculture which is the most important reason for the wetland's destruction and drought. Therefore, a comprehensive management of agriculture and establishment of the new systems for agriculture can be employed as another way of corrective measures to control the process of drought in the region.

Also hydrological changes in Komeyjan sub basin and Agh-Gol wetland margins show a process of reduction in region's water resources resulting from consumption by individuals.

By supervising and controlling the water taken out of the wells through installment of water meters, closing unauthorized wells and the prohibition of planting in the lands surrounding the wetland, one may hope the Improvement of water ground bad situations and restoration of Agh-Gol wetland.

According to the water balance studies, it can be said that by a proper planning on southern and eastern sections of Komeyjan watershed, a transfer of water from this section to the wetland can be managed successfully leading to the balanced cultivation and water consumption which in return the region can be saved from absolute drought and its side effects including the advent of particular matters, land's subsidence and erosion and water quality degradation.

ACKNOWLEDGEMENTS

Finally, due to the fact that this research was a proposal which was approved in Hamedan province, it is necessary to express our deepest gratitude to the Environmental Protection Department of Hamedan province for their financial and ethical attempts and cooperation. At the end, we appreciate all the experts and colleagues who made a contribution in this study.

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