

# WATER RESOURCES MANAGEMENT AND ENVIRONMENTAL IMPACTS OF CLIMATE CHANGE ON ORUMIHE BASIN WATER QUALITY

## GESTION DES RESSOURCES EN EAU ET IMPACTS SUR L'ENVIRONNEMENT DU CHANGEMENT CLIMATIQUE SUR LA QUALITE DE L'EAU DU BASSIN ORUMIHE

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### ABSTRACT

*Effects of climate changes are inevitable in near future and many scientific evidences demonstrated rapid destruction of the ecosystem that we are familiar with. Water resource is one of the most threatened entities due to Climate change, which affects its quantity, variability, timing, form, and intensity of precipitation. This paper provides an overview of the projected physical effects of climate change on quality of water resources in Orumihe Basin (with a focus on drought) and the resulting consequences.*

*Orumihe Basin is mostly a plain land which surrounds the Orumihe Lake. The studied region as well as the basin is semi-high with cold winters and temperate summers. Average annual rain is 357.8 mm. The additional effects of climate change that have important implications for water resources in this basin include decreased evaporation rates, a low proportion of precipitation received as rain, poorer water quality in both inland and coastal areas and generally, a reduced water supplies. The consequences of each of these effects in the basin are discussed with respect to both surface and ground water resources.*

*Water users will eventually adapt to more frequent and severe droughts, by shifting limited water supplies towards higher-value uses. According to researches, drought in western and eastern parts of the Orumihe Basin is more than southern part and the more intense amounts have been recorded at the location of reservoir dams.*

*Rising surface temperatures are expected to increase the proportion of winter precipitation*

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received as rain, with a declining proportion arriving as snow. Inflow to the basin comprises precipitation, runoff and transferred surface and ground water flows of the region. Outflows comprise evaporation, transpiration, runoff outlet and transferred surface and ground water flows. Research showed that the total volume of precipitation over the Orumihe basin has decreased from 15290 MCM to 10454 MCM in 2001-2 water year and has reduced from 5678 MCM to 4132 MCM in the study area. Surface inflows have declined from 220 MCM to 130 MCM, and groundwater from 80 MCM to 68 MCM. The total decrease of water resources in the region is 954 MCM.

Climate change is expected to affect water quality in both inland and coastal areas. Specifically, precipitation is expected to occur more frequently via high-intensity rainfall events, causing increased runoff and erosion. More sediments and chemical-contaminated runoff will, therefore, be transported into streams and groundwater systems, impairing water quality. Water quality may be further impaired if decreases in water supply cause nutrients and contaminants to become more concentrated.

Increasing the evaporation rates in many regions are expected to diminish water supplies and cause so many irreversible harms to the environment. Rising air and water temperatures will also impact water quality by increasing primary production, organic matter decomposition, and nutrient cycling rates in lakes and streams, resulting in lower dissolved oxygen levels. In Orumihe Basin all these matters lead to increase the salinization in the lake of Orumihe during the past 20 year period. The high amount of salinity of the water is harmful to a kind of rare species of shrimps calls *Artemia*, to spawn and survive. The migratory birds that used to feed on the *Artemia* did not find enough food and lots of them have perished in the last few years.

The last important effect of the water resource impacts discussed here is the potential for more frequent and intense interstate and international water allocation conflicts.

**Key words:** Climate change, environmental impact, Orumihe basin, water quality, multi criteria decision making

## RESUME

Les effets des changements climatiques sont inévitables dans un avenir proche et de nombreuses preuves scientifiques ont démontré la destruction rapide de l'écosystème qui nous est familier. Les ressources en eau sont une des entités les plus menacées en raison du changement climatique. Ces changements ont des conséquences sur la quantité, la variabilité, le calendrier, la forme et l'intensité des précipitations d'eau. Cette étude donne un aperçu des effets physiques estimés du changement climatique sur la qualité des ressources en eau dans le bassin Orumihe (avec un accent sur la sécheresse) et les conséquences.

L'Orumihe bassin est surtout une plaine qui entoure le lac Orumihe. La région étudiée et le bassin sont semi-hauts, avec les hivers froids et les étés tempérés. L'intensité moyenne de la pluie annuelle est 357,8 mm. Les effets supplémentaires du changement climatique qui ont d'importantes implications pour les ressources en eau dans ce bassin comprennent des taux d'évaporation diminués, une faible proportion des précipitations reçue sous forme de pluie, de moins bonne qualité de l'eau dans les régions intérieures et côtières, et en général,

*un approvisionnement en eau réduit. Les conséquences de chacun de ces effets dans le bassin sont discutées à la fois pour les ressources en eau de surface et du sol.*

*Les utilisateurs d'eau devront éventuellement s'adapter à des sécheresses plus fréquentes et plus graves, en déplaçant l'approvisionnement en eau limité à des utilités supérieures. Selon les recherches, la sécheresse dans les régions occidentales et orientales du bassin de l'Orumihe est plus importante que celle au sud et l'intensité de la sécheresse enregistrée est plus forte près de l'emplacement des barrages des réservoirs.*

*La hausse des températures de surface pourra augmenter la proportion des précipitations hivernales qui sont reçues sous forme de pluie, avec une proportion décroissante attendue sous forme de la neige. L'apport au bassin comprend des précipitations, du ruissellement, de la surface transférée et de l'écoulement d'eau souterraine de la région. Les sorties d'eau comprennent de l'évaporation, de la transpiration, du ruissellement, de la surface transférée et de l'écoulement d'eau souterraine. La recherche montre que le volume total des précipitations sur le bassin Orumihe a diminué, passant de 15290 MCM à 10454 MCM en 2001-02, année de l'eau et a réduit de 5678 MCM à 4132 MCM dans la zone étudiée. Les entrées de surface ont diminué de 220 MCM à 130 MCM, et les eaux souterraines ont diminué de 80 MCM à 68 MCM. La diminution totale des ressources en eau dans la région est 954 MCM.*

*Le changement climatique est censé affecter la qualité de l'eau dans deux régions intérieures et côtières. Plus précisément, il est prévu que les précipitations se produiront plus fréquemment via des événements d'intensité forte des précipitations, entraînant une augmentation du ruissellement et de l'érosion. Conséquemment, plus de ruissellement des sédiments et des produits chimiques contaminés seront transportés dans les ruisseaux et les eaux souterraines, ce qui altérera la qualité d'eau. La qualité de l'eau pourra être compromise encore davantage si la réduction d'approvisionnement en eau amène des nutriments et des contaminants à se concentrer.*

*L'augmentation de taux d'évaporation dans de nombreuses régions est censée diminuer les réserves en eau et provoquer de nombreux dommages irréversibles contre l'environnement. La hausse des températures de l'air et de l'eau aura également un impact sur la qualité de l'eau en augmentant la production primaire, la décomposition des matières organiques, et les taux de recyclage des éléments nutritifs des lacs et des ruisseaux, entraînant une baisse des niveaux d'oxygène dissous. Dans le bassin Orumihe, à cause de tous ces problèmes le lac d'Orumihe est devenu saline pendant des 20 dernières années. Le montant élevé de salinité de l'eau est nuisible à une sorte d'espèces rares de crevettes appelé Artemia, car il les empêche de frayer et de survivre. Les oiseaux migrateurs qui se nourrissaient d'Artemia, n'ont pas trouvé suffisamment de nourriture et beaucoup d'entre eux ont péri dans les dernières années.*

*Le dernier effet important de l'impact sur les ressources en eau en question ici est les potentiels conflits interétatiques et internationaux plus fréquents et plus intenses sur la répartition de l'eau.*

**Mots clés :** *Changement climatique, impact sur l'environnement, bassin Orumihe, qualité de l'eau, prise de décision multicritères*

# 1. INTRODUCTION

Orumieh Basin is a Closed Basin. Closed Basins mostly lead to Lakes and Lagoons while Open Basins usually lead to free seas or oceans. In open basins climate change effects are less drastic due to the influence of the seas and the oceans. However, in closed basins by using excess amounts of water from the basin lowers the share of the tailrace lake or lagoon, which can affect the climatology characteristics of the region in terms of drying up the lake or lagoon little by little and. In other words in closed basins an equilibrium should occur between the water coming to the lake or lagoon from the basin and the loss of water in the lake or lagoon as a result of evaporation or any other cause.



Fig.1. The location of Orumihe Basin in Iran



Fig. 2. Map of Orumihe Basin

## 2. DEVELOPMENTS AND CLIMATE CHANGES IN THE REGION

The regime of water usage has gradually changed from 25 years ago in the basin. As the main economic activity of the area the development of agriculture became the most important goal for the government. Side by side, development of other fields such as industry, mine and ranching are also in the national agenda. All these would require increasing the efficiency of water use. As an example, the efficiency of water use for agriculture in the area is 35% and if they could increase this efficiency factor to 65% there would be no need to use more water in this part. But instead of increasing the efficiency, construction of dams and drainage and irrigation systems became the policy to obtain more water for different purposes. With more water collection in the reservoirs, more evaporation loss occurred in reservoirs whereas, more lands were allotted to agriculture. As a result in the last twenty years the share of agriculture water has increased by approximately 50% and on the opposite the share of the lake has decreased. Unfortunately in the last 15 years the amount of rainfall has also decreased as a result of drought. During these years the reduction of stream flows was compensated by pumping water from illegal wells which have reached 20000 in number now. So the reduction of rainfall not only caused a reduction in agricultural use of water, but also caused people to feel free to use illegal water sources for their farms and all these led to a situation in 2010

where only 1.5 BCM of water came to the lake. Continuing these conditions will lead to complete termination of the lake within less than 10 years.

### 3. ORUMIHE LAKE TRAGEDY

Orumieh Lake is the second largest salt water lake in the world and is located in the northwest of Iran. It is fast drying out. This lake is the largest internal water reservoir in Iran and is the habitat of about 212 species of birds, 41 reptiles, 7 amphibians, and 27 species of mammals, including the Iranian yellow deer. With regard to its size, depth, chemical composition, ecology, water currents and wild species, this lake has been listed as a Biosphere Reserve by UNESCO. Serious environmental consequences may lead to a real disaster in Orumieh Basin Lake. Water brought to the lake from the basin before construction of about 10 large and more than 20 small dams on the rivers flowing into Orumieh Lake in the last 25 years are compared with the amount of water flow after construction of these dams (Table 1).



Fig. 3. Islands, present and past



Fig. 4: Transportation, Present and Past

## 4. DEVELOPMENT AND ENVIRONMENT

In the period between 1990 and 2005 Satellite photos of different lands in Orumieh Basin indicate huge development of agriculture. It is interesting to note that the least rainfall in the last 50 years has happened in most of the years in this period. These photos and other agronomical studies indicate more than 80% development in agriculture. The development of other fields such as industry, mining, fish production and ranching have also been considerable. On the other hand unfortunately there has been destruction of environment. As an example, during these years the Lake of Orumieh has been going into a deep coma and everything that depended on it for survival has fallen in the blind spot of managers. Statistical data have been recorded and archived for this period of time without any effective practical output for processing the survival of the lake. The data of the lake from the water year 1998-1999 till the water year 2008-2009 is shown in Table 1.

Table 1. the summarized ground truth data from Orumieh Lake

water years	precipitation (mm)	change in precipitation (mm)	water level (m)	change in water level (m)	area (km <sup>2</sup> )	change in area (km <sup>2</sup> )	water input lake (mcm)	Change in volume (mcm)
1976-1998	281.08	0.00	1276.042	0	5227	0	3147	0
1998-1999	165.83	-115.25	1276.407	0.365	5206.79	-20.21	536.7	-2610.3
1999-2000	168.03	-113.05	1275.436	-0.606	4656.24	-570.76	347	-2800
2000-2001	197.59	-83.49	1274.44	-1.602	4342.28	-884.52	262	-2885
2001-2002	295.36	14.29	1273.759	-2.283	4185.13	-1041.87	1502	-1645
2002-2003	320.23	39.15	1273.616	-2.426	4329.07	-897.93	4675	1528
2003-2004	320.41	39.34	1273.728	-2.314	4241.98	-985.02	2749	-398
2004-2005	270.61	-10.47	1273.572	-2.47	4146.16	-1080.84	2126	-1021
2005-2006	287.90	6.82	1273.189	-2.853	4099.57	-1127.43	1701	-1446
2006-2007	319.58	38.50	1273.158	-2.884	4063.97	-1163.03	2798	-349
2007-2008	205.78	-75.30	1272.214	-3.828	3497.31	-1729.69	509	-2638
2008-2009	219.25	-61.83	1271.144	-4.898	107.78	-2119.22	233	-2914

Responsible managers should have used a Multi Criteria Decision Making (MCDM) Method in order to consider both development and protection of environment, which unfortunately, was not done. Environment activists tried to help others see and hear the voice of the disaster but they did not succeed and only when plenty of dams had been constructed and plenty were under construction they noticed what the danger was. The destruction of the beautiful lake was not the only problem. The absence of Artemia and migratory flamingoes and other species of wild and even the unique Iranian yellow deer might be considered unimportant compared to the development of green and fertile lands and economic growth of the region. But dimensions of the disaster will be more enormous. An eight billion ton salt bomb is now switched on. The spread of the salt powder in the area will lead to so many diseases. This is in addition to the other effects such as the destruction of a large part of agricultural lands that will cause migration of a large part of the habitants of the area. Unfortunately, according to various calculations the death of Orumieh Lake is quite certain. The graph in Figure 5 predicts the future conditions of the lake according to statistical data.

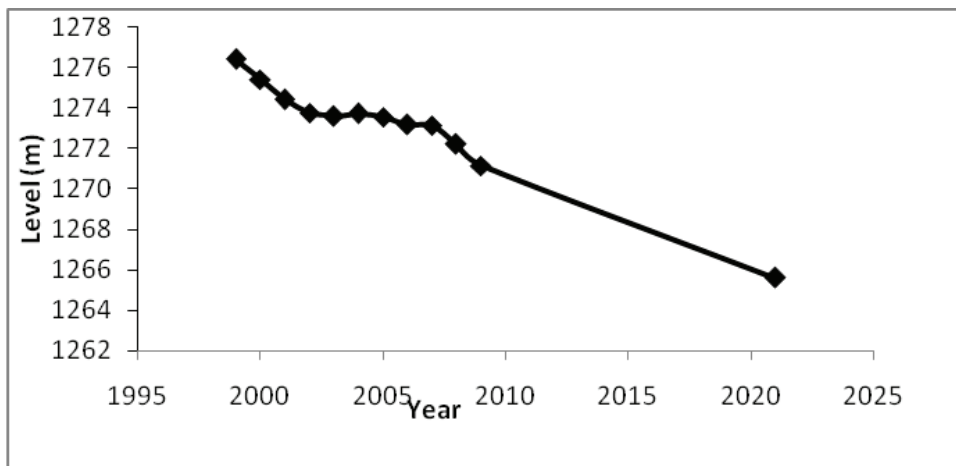


Fig. 5. The prediction of Orumieh Lake water level in future

## 5. CONCLUSIONS

Mismanagement of water resources and further climate changes has crucial impacts on environmental issues on Orumieh Basin in Iran, so as in many other regions worldwide in recent decades.

Another victim of what we call sustainable development is the Lake of Orumieh, with another example being the Aral Lake.

There may be many other victims not only in lakes and reservoirs but also in wild species and even human beings. But there's no doubt that the construction of dams have been an effective factor in what is going to happen to this basin.

Here is the question of safety and survival of the species of flora and fauna, deserts, forests, and other ecosystems as well as overuse of natural resources.



The matter is that; “Has the right of harming this innocent planet been given to human, to abuse any resources to develop his egoistical needs?” If yes, what will happen to the environment and what will mankind do with these extreme changes that absolutely affect his life in the near future? And if not, what are the red lights and which international organization is responsible for the natural disasters that occur due to our nonchalance and consequently influence the survival of our planet and indeed the next generations?

We hope that the accurate management of water resources and studying the environmental effects of climate change will help nations protect their natural endowments from possible damages.

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