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Introductory Chapter: Lake Urmia - A Witness to the Simultaneous Effects of Human Activities, Climate Change, and Global Warming

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<http://dx.doi.org/10.5772/intechopen.83605>

1. Climate change and global warming

In spite of the irregular behavior on a daily basis, observations show that, in the atmospheric character of some geographic area, there is some long-time regularity. However, in the twentieth century, the world temperature increased which influenced the world climate. Climate scientists reported that humankind's growing emission of greenhouse gases will make the long-term change in the climate and global temperature. As organizations, governments, and people have moved onward with strategies and actions to decrease greenhouse gas (GHG) emissions, to adapt to the impacts of climate change, the need for information to support climate-related decisions has grown rapidly in recent years. There is a lack of credible information system to inform climate adoptions and estimate their efficiency.

Greenhouse gases enter the atmosphere through burning coal, natural gas, oil, solid waste, wood products, and trees. The greenhouse gases are emitted during the production and transport of fossil fuels or as a result of livestock and other agricultural practices. Changes in greenhouse gas emissions are influenced by many long- and short-term factors. Larger releases of greenhouse gases result in higher concentrations in the atmosphere. However, as a part of the biological carbon cycle via a certain chemical reactions, carbon dioxide, as a main greenhouse gas, is removed from the atmosphere when it is absorbed by plants. The removal and emissions of greenhouse gases by natural processes tend to balance. Human activities, since the industrial revolution, by adding heat-trapping gases to the atmosphere, have contributed substantively to climate change. It seems that there are enough scientific evidences to prove that the greenhouse gases caused the climate alteration and global warming [11]. In addition, we realized that global temperature was increased over the last decades. However

as stated by [6], the climate change holds significant risks to the natural resources, environments, and societies on which they depend. Climate change and global warming affect human life, meanwhile human activities are also influencing climate.

2. The climate effects on human life

Humans for food, livelihood, commerce, natural resources, and security rely on earth which is a complex and dynamic system. Climate always influences the humans. In recent decades, regardless of the wealth and technology of modern industrial societies, in many ways, climate still affects human life. The impacts of climate change and consequently the rising greenhouse gas levels including warming temperatures lead to extreme weather events, altered weather patterns, crop failure, rising sea levels, ocean acidification, marine ecosystem shift, and homelessness. These impacts directly or indirectly threaten our health by affecting the weather we experience, the water we drink, the food we eat, the energy we use, the air we breathe, and other aspects of human health and well-being.

3. The human contribution to climate change and global warming

Although there are scientists who suspect that the human activities could have emotional impact on recent changes in climate and global temperature, the Intergovernmental Panel on Climate Change, IPCC, approved that the warming detected over last 50 years is attributable to man-made activities [7]. It seems that there is no doubt that human activity has changed the composition of world's atmosphere and environment. The noticeable problem is that human activities' influences will continue to alter atmospheric composition through the current century and hydrologic cycle and temperature are expected to be change inconsistently. Climate change and global warming, in complex ways, interact with other ongoing changes in human and environmental systems. For example, humanity's choices about land use, energy, and food makings affect and are affected by climate change and global warming. Although the details of how the upcoming influences of climate alteration will unfold are not as well understood as the basic reasons and mechanisms of climate alteration, we can rationally assume that the consequences of climate alteration will be more severe if actions are not taken to limit its magnitude and adapt to its impacts.

4. Climate change in Euphrates-Tigris Basin

The increase of the frequency and intensity of droughts in Asia and Africa is reported as an evidence of climate change in recent years [8]. Most regions in the Middle East including Iran are in the midst of a water crisis and their worst drought in decades. As a result, the water resources declined considerably. At the current rate of decline, the basin's water supply will not be enough to avert a widespread humanitarian crisis [2]. [10] used Gravity Recovery and Climate Experiment (GRACE) satellite mission and concluded an alarming rate of decrease in total water storage equal to 143.6 km³ from January 2003 to December 2009. Amini analyzed the climate data from Iran and its riparian countries [1]. The results revealed

the considerable spatial and temporal changes in the precipitation total series of regions during the last 10 years. The human activities such as dam construction and interbasin water transfer intensify such changes [1]. The most well-known evidence to demonstrate the effects of climate change and human activities is shrinking and drying up of Lake Urmia in Iran.

5. The Lake Urmia

So far managing renewable resources and infrastructure in much of the nation's experience is based on the historic record of stable climate. The Lake Urmia basin in northwest Iran is a closed drainage basin with an area of 51,876 km² and maximum depth of 16 m, making it one of the largest lakes in the world. In addition, Lake Urmia is the second largest saltwater lake in the world. As a result of arid to semiarid climate of the Lake Urmia basins, the agriculture is mainly dependent on irrigation. The sprinkler irrigation was developed, and large numbers of wells were excavated to supply the required water in the agricultural sector. The reduction in rainfall along with decreasing groundwater tables and a rising population in the basin will likely exert growing pressure to continue diverting stream flow before it reaches Lake Urmia. Over the last two decades, it was sharply dried and its surface reduced about 80% from 2003 [5]. The water table of Lake Urmia was decreased severely in recent years which caused serious socio-environmental consequences [4]. The dried lake bed is with a cover of salt, mainly sodium chloride, making a vast salty desert. The examinations for estimating the relative contributions of human activities as water resources development including agricultural development and dam constructions and climate change have been conducted by [9]. The results showed that the variability in inflow as a result of human activities is more prominent than the variability in precipitation. In addition, the flow origin from the Lake Urmia was decrease up to 40% due to the development of irrigated area which increased pressure on the water availability in the watershed. Shadkam showed that over 30 years annual inflow to Lake Urmia has thrown down by 48% which 3/5 and 2/5 of this change was caused by climate change and water resource development, respectively, as misconduct in human activities [9]. **Figure 1** shows the changes in water level and water surface in Lake Urmia within the last two decades.

Figure 1. The changes in surface and water level of Lake Urmia [4].

Amini and Hesami got the same results for two main subwatersheds of Urmia basin. They reported that the total irrigated area increased by ~20% between 1989 and 2000 and the net irrigation water requirement, NIWR, for a crop grown in the region in 2000 was slightly higher than that in 1989 as a result of global warming [4].

Hosseini-Moghari using spatial and hydrology and in situ data assessed the contribution of human acts to the decline of inflow water for the lake, the groundwater table reduction, and water storage in the lake reservoir [5]. They found that 50% of the total basin water loss is due to sectorial management of water resources in the region. The human interaction with the lake environment in Lake Urmia basin caused about 8 BCM of groundwater losses within 11 years. However, the climate change and drought are the causes for 40% of lake shrinking in the last two decades. Such findings may be used to support decision-maker in water sector to restore the Lake Urmia. It seems that there is no debate that the Lake Urmia diminishing was caused by a combination of water withdrawals for irrigation and climate change and global

Figure 2. The spreading of dams in Urmia watersheds.

warming [3]. The lake restoration was taken placed by local, national, and international organizations. However, the decision-makers inappropriately put the man-made infrastructures such as dams and interbasin water transfer, which are unsustainable projects in water sector, to increase the flow toward the lake. In fact, construction of numerous dams in the watershed has choked off water source from the mountains towering on either side of the Lake Urmia. **Figure 2** shows the existing, under construction, and under study dams in the basin of Lake Urmia. **Figure 2** shows intensification in diversion of surface water and water utilization further than current levels which at present appear to be unsustainable.

Reducing the basin's water consumption and demand-side plans must be considered immediately by the official organization. Moreover, the current projects for water transfer need drastic revision. Such projects have had harmful socioeconomic and environmental side effects in other parts of the basin. To maximize the welfares of the water resources, an integrated management of the water resources and agricultural development based on ecological potential of the basin including changing the rules of water pricing and recognition of cost allocation outlines as a prospect is required.

6. Need for adaptive management

The IPCC clearly confirmed in its Fifth Assessment Report that the climate change is existent and its primary cause is human-made especially through burning fossil fuels and other activities that release heat-trapping greenhouse gases into the atmosphere. There is no debate that the human needs to take actions to adapt and lessen the impact of climate change. In fact, there is a hierarchy of governor plans that can assist to protect population healthiness and welfare. The predictions of future climate change and global warming and defined scenarios by IPCC indicate that unless substantial and continued activities are taken to decline emissions of GHGs, world will continue to warm. Thus, we can reasonably expect that such changes are driving several related and interacting deviations in the environmental system and consequently the human life. In the case of Lake Urmia, a national committee in order to lake restoration was formed in 2013 called Lake Urmia Restoration National Committee (ULRNC). The ULRNC presented a road map and action plan based on integrated water resources/watershed management in cooperation with the universities in Iran and international organizations. The ULRNC reviewed 19 proposed programs and approved a 10-year program in three phases such as stabilizing the present status, restoration, and sustainable restoration. Although the provincial office claims that the restoration continues as scheduled, due to drying up the found and misconducting of management in water and agricultural sectors in the region, it seems that Lake Urmia will most likely fail to attain an ecological balance within a 10-year program by 2023. Although the specifics of how the upcoming impacts of Lake Urmia decline will unfold are not as well recognized as the main causes and mechanisms of lake shrinking, it is rationally expected that the avoidable consequences of lake drying will be more severe if activities are not taken to limit its level and adapt to its influences.

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