Chapter

Linking Land Use Changes to Policy Decisions: The Case of Northeastern Iran

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Abstract

Land use change is the most important cause of disturbances in the natural environment. It increases the severity of natural disasters such as floods, dust storms, etc. Moreover, it also leads to major unnatural events such as water, soil, and air pollution and land subsidence. Land use change can take many forms in different parts of the world. The vast majority of these changes are the result of erroneous and unscientific policies that may be beneficial in the short term, but have negative long-term impact on human societies and the environment. Wrong policies lead to erroneous and short-term development and, in the long run, irreversible socioeconomic and environmental challenges. In this chapter, the process of land use change, driving forces (political decisions, technological development, etc.), causes, and effects of changes were all considered in a socio-ecological system in northeastern Iran (As a representative of the hyper-arid, arid, and semiarid regions of Iran). The discussion is captured in a framework reflecting driving forces, pressures, state of affairs, responses, and impacts (DPSIR framework).

Keywords: land use change, policymakers' decisions

1. Introduction

Land use change is an important cause of disturbance in the natural environment as it increases the severity of natural disasters such as floods, dust storms, etc. It also causes significant unnatural events such as water, soil, and air pollution, land subsidence, and eventually, desertification [1]. Land cover changes occur naturally over time but are hastened by human activity. Land use and land cover changes have accelerated over the last three centuries, owing largely to the impact of technological advances associated with the Industrial Revolution. It is estimated that between 1950 and 1980, more forests were cleared than between the early eighteenth and nineteenth centuries combined. While forest cover has decreased by 20% since 1700, cropland areas have more than quadrupled [2].

Land use change can take many forms in different parts of the world, ranging from such factors as urbanization [3], deforestation [4], farming, overgrazing, and hydraulic terraces [5], coastal wind farm development [6], and mining [7]. The vast majority of these factors emanate from erroneous and unscientific policies that may be beneficial in the short term, but have a negative long-term impact on human societies and the environment. Wrong policies lead to erroneous and short-term development and, in the long run, irreversible socioeconomic and environmental challenges. Land use activities in developing countries, on the other hand, accelerated primarily during the twentieth century and continue to this day [8]. These countries are attempting to boost agricultural output while depleting their natural resource base. Over the last 50 years, most regions in Iran have continued to expand and intensify their land use activities [8]. Deforestation and agricultural expansion have been the dominant patterns of land cover change over the last five centuries [5]. Changes in land use practices, such as agricultural land management and urbanization, have, however, been significant drivers of change. In this chapter, the process of land use change, driving forces, or causes and effects of changes in northeastern Iran for two time periods (1977–2001, 2001–2016) are discussed.

2. Materials and methods

2.1 Study area description

Iran, with a population of 85 million people, is located in arid and semiarid regions of the world, and farming accounts for more than 30% of the people's income. The study sites are Taybad-Bakharz is an arid and semiarid region of Iran's Razavi Khorasan province (**Figure 1**). Taybad-Bakharz encompassed an area of 4800 km^2, with a current population of 160,000 people. Over 70% of rural people's income

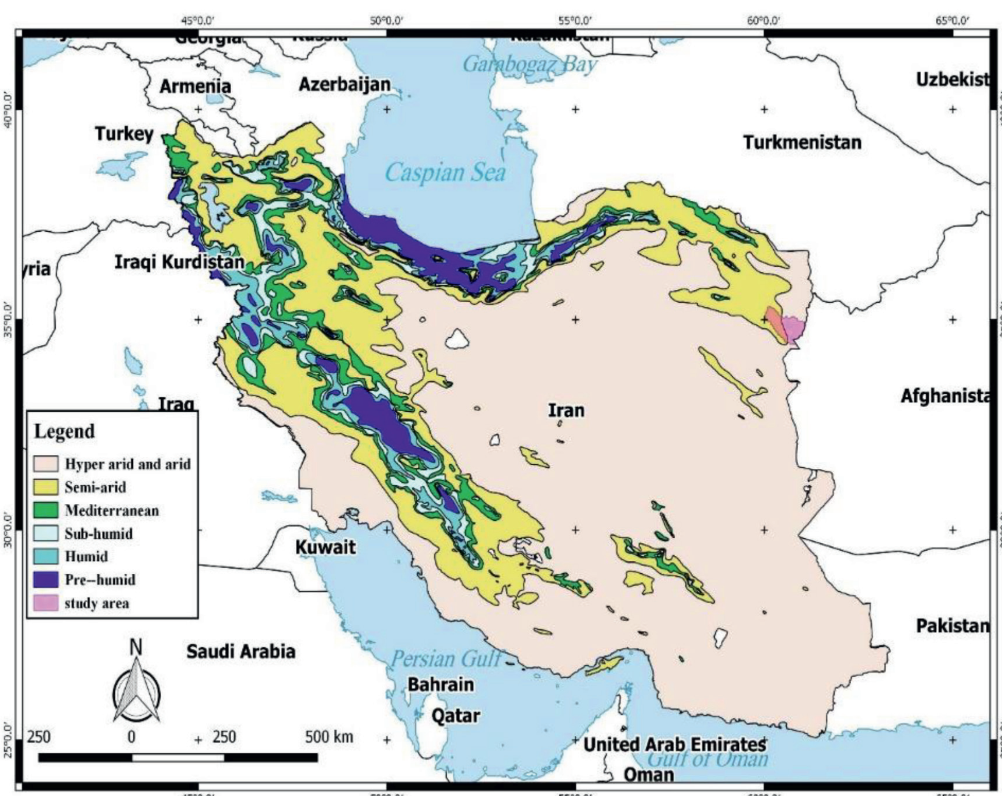

Figure 1.
The study area's location, as well as the spatial distribution of climatic zones in Iran.

comes from livestock, with the remaining 30% coming from farming. Precipitation ranges from 100 to 260 mm, with desert border areas receiving less. Rainfall varies greatly in both time and space. The average yearly temperature is around 16°C, but during the summer, the temperature can reach 42°C. In addition, annual potential evapotranspiration (PET) ranges from 800 to 2000 mm. Wind speeds range from 5.3 to 6.8 m/s, with the highest recorded in May at around 6 m/s. Furthermore, wind blows over 120 days per year [8, 9].

2.2 Factors influencing land use change in the DPSIR framework

Taybad-Bakharz region has experienced population growth over the last 50 years. This region currently has a total resident population of 160,000. Fifty percent of the population lives in rural areas and relies entirely on agriculture and animal husbandry for a living. Qanats used to provide water for agriculture and animal husbandry. However, since 1960, this region has undergone a significant transformation due to technological advancement and the arrival of the drilling industry, as well as Land Reform Law (the division of land among farmers), with a large portion of rangeland converted to agriculture. The Environmental European Agency's DPSIR (Driving force-Pressure-State-Impacts-Responses) framework was used to categorize effective information and identify a set of key indicators to better describe land use change, relationships, and feedback between factors. The PRESSURE indicators are associated with the hazardous effects tolerated by the environment under various types of pressure (physical, human, etc.). The understanding of pressures necessitates the estimation of determinant factors. DRIVING FORCES generate these indicators. This indicator category represents anthropogenic activities and the various processes that have an impact on land use change. They provide a general indication of the causes of changes in land use. In any case, they are primarily indicators of human activities such as intensive agricultural practices, overgrazing, population growth, tourism expansion, and so on. The IMPACT indicators describe the consequences of land use change, both onsite (soil loss, poverty, etc.) and offsite (flooding). The RESPONSE indicators are linked to the corrective actions taken to improve the STATE and lower the PRESSURES that influence it. These types of indicators are useful in land use change protection programs. They are in charge of "measuring" the actions and policies used to mitigate human pressures and other factors that contribute to the process of land use change.

2.3 Land use and land cover data

Initially, Landsat satellite imagery for the years 1977, 2001, and 2016 was downloaded from https://earthexplorer.usgs.gov using the following criteria (**Table 1**).

Year Produced	Satellite type	Image Date	WRS Path/ Row	Spatial Resolution	sensor
1977	Landsat3	13 May	158/36	60 m	MSS
2001	Landsat4	13 May	158/36	30 m	TM
2016	Landsat8	25 May	158/36	30 m	OLI and TIRS

Table 1.
Data type and technical properties of satellite images used in this study.

The quality of satellite images was then examined for geometric and radiometric errors such as striping, Atmospheric Interference, skewing on Scanline, and projection distortion. To accurately identify the Earth's surface condition, a false color composite (bands 7,4,1) was created for each satellite image [10]. A land use map was created for three different times to investigate changes in land use/land cover (1977, 2001, and 2016). The supervised classification method/maximum likelihood algorithm (using all spectral bands except the sixth band) was used to create the final land use maps. Topographic maps from the National Cartographic Agency (at a scale of l: 25000), aerial photographs at a scale of 1:20000, and regional land use maps were used for this purpose.

Groundwater depletion (GWD), electrical conductivity (EC), total dissolved solids (TDS), acidity (pH), and sodium adsorption ratio (SAR) parameters were used to assess groundwater changes over two time periods. The methods for calculating the aforementioned criteria are detailed in the following link: DOI: 10.1016/j.rsase.2020.100348

3. Results and discussion

3.1 Land use changes

Land use maps for 1977, 2001, and 2016 were obtained using Landsat satellite images, as shown in **Figure 2**. Given the maps, the study area's land uses were classified into five categories: (1) residential area, (2) cropland, (3) salty land, (4) rangeland, and (5) barren land. According to the findings, barren lands and rangeland had the highest percentage of area in 1977, accounting for 85.5% of the total area. In 2001, this percentage remained nearly constant, with a 10% decrease in the rangelands. In 2016, there are no significant changes, and this proportion is similar to that of 2001. The greatest

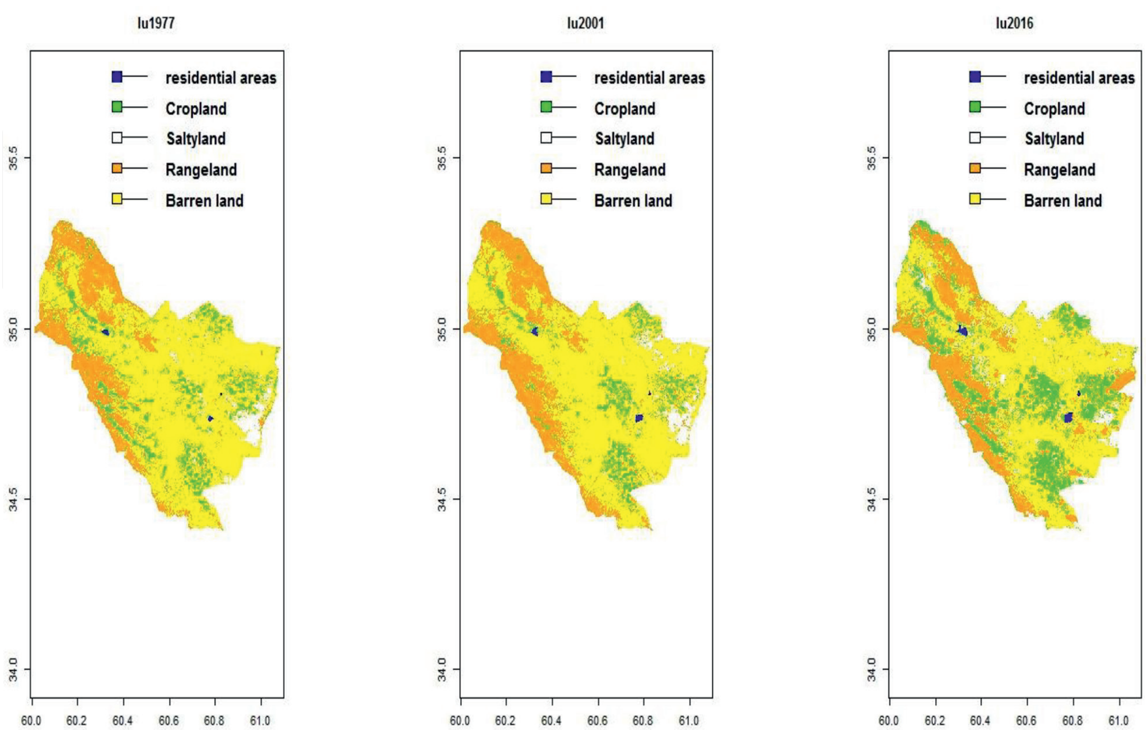

Figure 2.
Maps of land use changes.

percentage of change in barren lands and rangeland occurred between 1977 and 2001. The area of salty land remained constant over two periods, with a slight change in the second. This land use accounts for 6.5% of the total area. The proportion of irrigated and rain-fed agricultural lands increased in both time phases with 2 and 5% of growth during the first and the second phases, respectively. In fact, the percentage of agricultural areas experienced a steady rise from 7.8% in 1977 to 9.7% in 2001 and 14.3% in 2016. Due to the continuous growth in the population from 50,000 people in 1977 to 160,000 people in 2016, the growth of the residential area growth was dynamic during the two time phases with huge rise from 0.14 to 0.4% (**Figure 2**). The portion of rangeland areas decreased steadily from 42.7 (1977) to 32.2% (2001), and 29.3% (2016).

During these times, 288 deep and semi-deep wells were drilled in the area. These developments, combined with poor management of groundwater discharge, resulted in the cultivation of a large portion of rangeland. Given that barren lands had no productivity, and this land use included badlands, salty land, and rocky surfaces. Then, much of the rangeland was converted to agriculture. Most Qanats had dried. Because of these circumstances, the government and people were encouraged to drill deep wells to supply water for drinking, agriculture, and animal husbandry. As a result of these practices, agriculture reached its peak in 2016. Crops such as melons, wheat, barley, sugar beet, cotton, and crocus (saffron) were produced on a large scale as agricultural levels increased. This increase in production resulted in a decrease in groundwater level (**Figure 3**), so that the southern half of the region experienced 1.5-meter depletion per year during the second period.

Due to the close proximity of fresh and saltwater aquifers in this area, a sharp annual depletion, and high evapotranspiration, the possibility of displacement in the fresh and saltwater boundary is very high. As a result, some freshwater wells have been completely salted, and agricultural activities have been discontinued. This approximate displacement is irreversible. TDS and EC are increasing in the region's south. This movement is toward areas with the greatest water depletion.

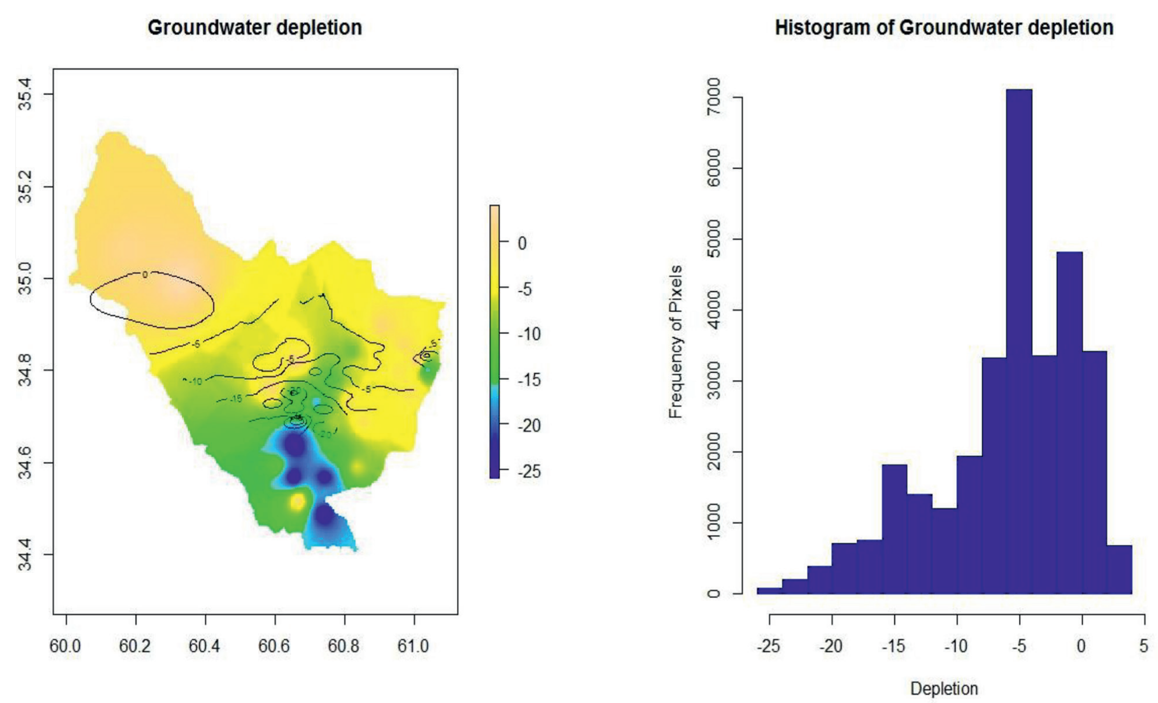

Figure 3.
Groundwater depletion.

Given that land use changes occurred at their peak, the most significant changes in this region will be an increase in residential areas. And this change is occurring in urban areas. It is predicted that as rural incomes decline and people lose their jobs, villages will become haunted and migration will begin.

It is obvious that a significant land use change has occurred in the Taybad-Bakharz region. Capable lands were converted to agricultural lands over a 40-year period (**Figure 2**). Technology and agricultural machinery entry, deep well drilling industry, and wet years that encouraged people to cultivate lands are three important factors that lead to increased agriculture areas. Currently, irrigated agriculture has reached its maximum potential and is entirely dependent on water discharge. Furthermore, farming and crop activities provide a living for many families. In recent years, regional management actions have been able to control discharge, digging wells, and land use conversion to some extent. However, these management practices have not been successful because aquifers have been depleted for many years, increasing the possibility of a disruption in people's livelihood conditions as precipitation decreases and aquifer recharge continues. Unless comprehensive management actions are taken at the local and regional levels, agricultural growth in the Taybad-Bakharz region is expected to slow and eventually stop, resulting in bare lands and dust storms. Due to ineffective policies in the past, the livelihoods of a large portion of the region's population have become dependent on agriculture, resulting in increased ground water extraction. The dependent population will be jeopardized as groundwater levels fall and salinity rises. To overcome the human-environmental catastrophe, policy-makers must develop alternative livelihoods at the regional level. Furthermore, the process of rehabilitating destroyed rangeland must be considered as soon as possible. Plowing poor rangelands in wet years should be prohibited because these lands can be a major source of dust in dry years. Furthermore, groundwater extraction should be minimized, and control policies should be tightened to reduce the severity of the risk.

3.2 DPSIR framework

The results of the case study in northeastern Iran are applicable to the Iran. The DPSIR framework was used to categorize effective information and identify a set of key indicators to better describe land use change, relationships, and feedback between factors (**Figure 4**).

3.2.1 Driving forces

Iran has changed over the years since 1960 as a result of population growth, technological development, and the Land Reform Law (the division of land between farmers). Population growth creates motivation for change. Water, food, and a place to live are just a few examples of basic human needs that can only be met by manipulating nature. Previously, the Iranian people were supplied with water via rivers, springs, Qanats, and rainwater. The traditional water supply could no longer meet the needs of the people as the urban population grew. The pattern of irrigation changed as land was fragmented. These cases were accompanied by technological and agricultural machinery advancements, resulting in abrupt changes in rangelands areas. During these periods, a large number of deep and semi-deep wells drilled.

These developments, along with mismanagement in groundwater discharge, led to a wide part of rangelands being placed under cultivation process. Then a large part

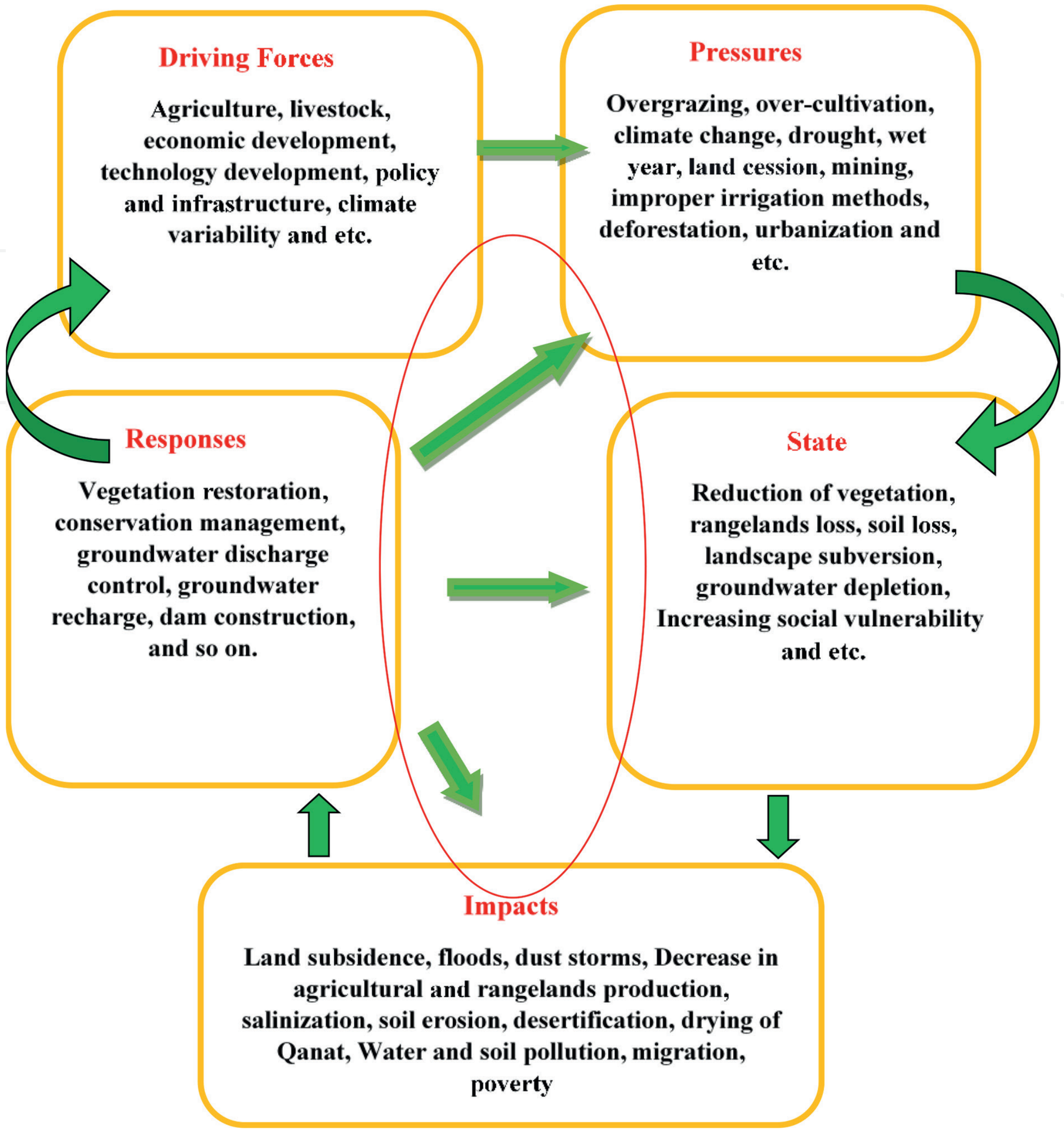

Figure 4.
DPSIR framework.

of the rangelands converted to the agriculture. Qanats dried in most areas. These circumstances encouraged the government and people to drill deep wells to supply water for the purposes of drinking, agriculture, and animal husbandry. These practices resulted in higher agriculture productivity. This increase in productivity has resulted in a decrease in groundwater levels, which are higher in arid and semiarid regions. Climate variability has also exacerbated the situation.

3.2.2 Pressures

The development of advanced agricultural machinery increased the amount of agricultural land available [8, 9]. Furthermore, during wet years, people are more likely to cultivate. Land cession policies, on the other hand, reduced the area of rangelands even further. Mining, industrial estates, and small industrial and agricultural units were all examples of land cession. These factors contribute to deforestation and the loss of rangelands. As a result, the phenomenon of overgrazing manifests itself. Overgrazing resulted from livestock concentration on a smaller area of land as the rangelands extent decreased (**Figure 3**). Improper irrigation methods (reduced crop and forage production) compound this pressure, as does the occurrence of drought.

3.2.3 State

Land use change begins in the rangelands as vegetation declines. Soil erosion starts, and soil nutrients are gradually depleted. Overgrazing, mining, and other cession activities are gradually causing landscape subversion (**Figure 5**). In addition, the shift in livelihood and complete reliance on agriculture based on groundwater discharge has created a shaky and unstable environment for human societies. Droughts, a lack of groundwater recharge, and declining groundwater levels expose the vulnerable socioeconomic system to destruction. On the other hand, as rangelands area shrinks, so do social conflicts among ranchers.

3.2.4 Impacts

Desertification, floods, dust storms, water scarcity and Qanats drying, air pollution, soil and water pollution, soil erosion, salinization, and the destruction of human communities, poverty, and migration are all examples of how land use change manifests itself.

3.2.5 Responses

There has been no positive response from policymakers in the face of widespread land use change. Until environmental disasters occur, policymakers will be unaware of the changes. Furthermore, the majority of responses concern when the environmental hazard occurred. When a flood occurs, for example, dam construction is proposed and implemented as part of a plan. Of course, programs such as vegetation restoration, groundwater management, and so on are proposed, but they are unfeasible due to a lack of water resources and a high reliance on local communities' livelihoods.

3.3 Policy decisions

Policymakers have made a variety of decisions over the years. The common denominator in these decisions is a lack of foresight. Paying attention to cross-sectional incomes while depleting non-renewable or low-renewable natural resources, regardless of the long-term outlook, has resulted in a failure situation. The first cause of the current crisis is embarrassment in technology entry and the implementation of inconsistent programs. The first blunder was digging deep wells and extracting groundwater, resulting in large dependent and vulnerable populations. Groundwater-based agriculture was a poor management decision in a country with arid and semiarid climates. The plains and hills were plowed as much as possible, so there was no plow able surface due to the slope and rocky conditions. Agricultural expansion, as well as land cessions for mining, military, sports, urban planning and settlement activities, parks, and other uses, gradually reduced the area of rangelands.

After agricultural development, mining is the most important factor in land use change, which is currently occurring at a rapid pace in high-quality rangelands. Mining activities are upturning the landscape in mountainous and steep rangelands where plowing is impossible. Heavy metal contamination in mineral residues quickly

Figure 5.
a: cultivation, b: mining, c: overgrazing (Source: Sarparast, M. (Photographer) (2022, April 20).

enters the soil and water, and over time, the energy cycle and animal and plant communities undergo changes and heterogeneity.

Agriculture expansion, mining, and other land cession have significantly reduced rangelands area. As a result, the number of livestock available is constrained to a smaller geographical area. As a consequence, overgrazing occurs, and the rangeland's tendency becomes extremely negative. However, it is always incorrect to believe that increased livestock numbers have resulted in overgrazing and rangelands destruction. Policymakers have created two vulnerable social groups in agriculture and animal husbandry by establishing cross-cutting and finite incomes with no regard for sustainable development. Unsustainable agriculture will result from declining groundwater levels, climate change (global warming), and climate variability (drought). Land use change is a multidimensional phenomenon with synergistic effects that eventually leads to environmental challenges such as desertification, land subsidence, floods, and dust storms, among others. Furthermore, a long-term drought, such as the one that occurred in the Southern Plains region of the United States in the 1930s (Dust Bowl), will result in extreme poverty and migration.

4. Future scenarios of land use change and management practices

The impact of human activities on the land has grown exponentially, changing entire landscapes, affecting soils, hydrological cycles, and climate, and in some cases leading to land use change. A variety of economic, technological, institutional, cultural, and demographic factors can be identified as the underlying driving forces of land use changes. Currently, in Iran, the process of land use change, particularly agricultural expansion, is at its peak, and environmental-human challenges are arising as a result of these changes. However, the wrong policies of plundering natural resources are causing a large, silent, and devastating change. This significant shift is the result of land cession to the mining industry. This industry exists despite the impact of topography on nature, landscape beauty, wildlife, and high-quality forage, among other things. Despite the enormous income generated by mining, no portion is distributed to local communities. This is regardless of the fact that the pastoralists have lost their pastures. This increases the vulnerability of local communities.

Management actions should be taken in two dimensions in response to land use changes:

1. Increasing policymakers' environmental knowledge and awareness

   Most management issues regard education and promotion among local communities as a means of reducing environmental damage. Meanwhile, local communities are open to all policymakers' decisions. Education and promotion among policymakers in developing countries, such as Iran, should be considered an immediate response to reducing environmental and human hazard. Because many of today's environmental challenges are the result of policymakers' lack of knowledge and awareness of environmental issues, as well as their poor decision-making. There should be two levels of training:

   A: Organizing courses and workshops for policymakers.

   B: Teaching environmental knowledge courses to university students from all fields of study who will be future policymakers.

   If training at these two levels is done properly, the conditions for sustainable development will be created. All humans on Earth require knowledge of water, soil, vegetation, and wildlife. This knowledge assists them in adapting their behavior to the environment. As a result, the life cycle is preserved, and man, as a component of the cycle, ensures his survival as well as the stability of the cycle's other components.

2. Identifying alternative livelihood opportunities to reduce local communities' vulnerability.

The next issue that requires immediate attention is reducing local communities' vulnerability by identifying alternative livelihood opportunities. Other uses, such as ecotourism, medicinal plants, sports activities, and so on, can be defined in addition to grazing livestock in rangelands. If ranchers are viewed as the primary stakeholders in the aforementioned uses, grazing pressure will decrease over time.

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