Towards the development of a conceptual framework for Complex interaction between environmental changes and rural-urban migration

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Article

Keywords: Environmental Migration, Climate Change, Hydro-Climatic Disasters, Human Mal-Activities

Posted Date: April 12th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1521503/v1

Abstract

Dealing with environmental migration is a complex problem that may transform into a wicked problem. To investigate the environment-migration nexus, it is necessary to develop a conceptual model that considers the complexity of environmental changes as a cause of rural-urban migration (RUM). This paper provides such a model, focusing on the decline of agricultural lands and products and relevant economic consequences. It links the three leading “push factors” of RUM—climate change, human mal-activities, and hydro-climatic disasters— and migration. Also, it incorporates the pull factors in cities and intervening factors, such as governmental plans and individuals’ characteristics. The model contributes to bridging the knowledge gap on the effects of migration policymaking on the one hand and environmental and climate change on the other hand. It increases understanding of the full range of human responses to environmental and climate change and can be used for policymaking through sustainable management plans.

1. Introduction

Migration policymaking is a multidimensional and complex process that involves and affects different spheres of society at the local, regional, national and international level and different socio-political actors[1]. Environmental change is likely to affect global migration flows in several ways, particularly by reducing livelihoods in regions where the economy is based on agriculture[2–4]. Environmental migration, more generally, is currently one of the primary concerns of policymakers[5,6]. It is mentioned as a looming security crisis in much scientific literature and many policy reports[7].

Environmental migration may take place within and between countries and can be temporary or permanent. Internal displacement is a predominant pattern of environmentally induced migration[2,8–10]. The Internal Displacement Monitoring Center (IDMC) reported 30.7 million internal displacements induced by natural disasters in 2020[11]. Therefore, future studies need to address internal migration, in addition to international migration[10,12]. Among internal migrations, rural-urban migration (hereafter RUM) is the most crucial issue for policymakers[13].

The increasing rate of RUM causes many villages to be abandoned, with several undesirable consequences, particularly in the international border area, where this may lead to security threats (e.g., increased drug trafficking). RUM can also exacerbate the competition and pressure over natural and economic resources and increase the burden on infrastructure and services in the destination area[14]. This is especially problematic when resources are scarce[15]. Moreover, contamination of water, soil, and agricultural products in urban areas due to rapid urbanization is a great concern of policymakers[16]. The effects of RUM depend on the policies of the authorities for managing the issue. Accordingly, RUM as an important issue should be appropriately managed.

Environmental migration, in general, and RUM, in particular, are rarely caused by ecological factors alone and it is usually the result of a complex interaction among socio-political, economic and ecological

factors[17]. Environmental migration is inherently complex and may become a “wicked problem”[18] due to bad governance and lack of wise management and preparedness plans. RUM may be the result of political, economic, or social challenges. However, recently, environmental changes have been a principal cause. It is also predicted that the rate of environmental migration will increase in the next few decades[19] due to more frequent and severe climatic events arising from climate change[20]. Predictions of the number of environmentally displaced people by 2050 are up to one billion [12,21–23]. Although these numbers are uncertain and debated, they highlight the importance of the interlinkage between environmental changes and migration and the need to properly understand this interlinkage[7]. It is for this reason that a new conceptual model is needed to support effective policies for dealing with environmental migration and understanding the full space of human responses to environmental and climate change, particularly the interlinkage between environmental change and RUM.

The effect of environmental changes on migration has been investigated in several studies that consider climate change as the key driver of environmental change[24–28]. Some experts believe that the contribution of climate change to migration is considerably growing in comparison to political, economic, and social causes[29,30]. Others, however, argue that migration is a consequence of multiple factors[31,32]. El-Hinnawi (1985) noted that environmental migration is the result of natural or anthropogenic disasters, of drastic environmental changes (such as dam construction), and of gradual environmental deterioration[33].

Notably, nature and society are coupled and inseparable[34], and both contribute to the resilience and vulnerability of each other[35,36]. If environmental changes are ascribed to nature only, the role of human activities (society) is ignored[37], allowing the decision-makers to avoid their responsibility for dealing with migration issues[38]. Yet, climate change is not the only cause of migration, and human mal-activities should be considered as important drivers as well. Climate change and human mal-activities may gradually degrade the environment of rural areas, threaten people's lives, and, consequently, lead to mass RUM. These signals are embedded in the background noise of (increasingly frequent and severe) hydro-climatic disasters. Together, these factors can lead to displacement in the affected areas.

RUM has been increasing due to modernization, mechanization in agriculture, and land reforms in many areas worldwide. However, in some regions, RUM has become a sign of failure to adapt to environmental changes due to mismanagement, lack of appropriate preparedness plans, and bad governance. Undoubtedly, policymakers have to focus on dealing with change through proper strategies for supporting migrants and those who stay behind. A conceptual model can help policymakers to identify the linkages between environmental changes and RUM in specific cases. Accordingly, this paper aims to provide such a conceptual model, focusing on deteriorating agricultural lands and products and relevant economic consequences.

2. Environmental Rum: Problem Or Solution?

To develop the conceptual model of environmental RUM, it is firstly necessary to develop an in-depth understanding of migration and processes leading to migration. The first step is to clarify whether migration actually is a problem or a solution to a problem.

Several authors consider migration as an important form of adaptation to environmental change in some situations (e.g., Mcleman 2013; Hallegatte et al. 2016; Luetz 2019; Chhogyel et al. 2020). It can reduce pressure on ecosystems[2,41]. This is especially important when the environment's carrying capacity is decreasing due to, for instance, degradation and climate change and when increasing the local population or changing lifestyle leads to higher demands for water, food, and other vital requirements. In these situations, migration can help to fulfill basic needs and enhance long-term stability, and therefore constitutes an adaptation strategy to environmental changes [42]. Mendelsohn et al. (2007) suggest that in areas where people are unable to support themselves because of environmental impacts on local economics, migration is an undesirable but necessary adaptation strategy. In contrast, Adger et al. (2007) believe that migration leads to enormous social costs and unacceptable impacts related to human rights and sustainability, and thus, it is not a good adaptation strategy. Other authors argue that forced migration reflects limited adaptation plans[10,45] or indicates that the previous adaptation strategies have failed[46,47]. Economic problems may be dealt with by other adaptation options rather than migration. This is why Finan and Nelson (2001) argue that providing some adaptation strategies by the government convinces young migrants to return to the countryside. Since migration may increase conflicts in both areas of origin and destination areas, it can be seen as a security threat. However, conflict may be a cause of migration in the origin area. Accordingly, whether migration is a problem or a resolution depends on factors such as capacity and/or preparedness of individuals, communities, and countries for coping with environmental changes[49].

To find whether migration is an adaptation option, it is necessary to clarify the definition of adaptation[10]. In the context of climate change, the most popular definition is presented by IPCC: “adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities”[50]. Meanwhile, Fussel and Klein (2006) defined adaptation as “to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences”. Moreover, the term “coping” is used interchangeably instead of adaptation. However, some literature defines coping as an immediate and short term response to environmental changes, while adaptation is a strategy that involves planning for long term actions in a sustainable approach[10,20,52–54].

In this paper, we define coping capacity as the capacity of a system or actor to deal with natural disasters at a specific moment in time and adaptation as a process of increasing coping capacity. Some species have a natural mechanism to adapt themselves to new situations during the adaptation process gradually. In every step of the adaptation process, they have a specific coping capacity or can increase their capacity to a higher level. Sudden changes may have unpleasant consequences because they

exceed the coping capacity of the system, whereas slow changes allow the system time to adapt and increase its coping capacity. “Adaptive capacity” refers to the capacity to adapt to (fast) change.

In addition to defining adaptation, it is also necessary to delve deeper into the migration process. We suggest RUM has three main causes. First, there is modernization and structural change from agriculture to industry. Mechanization in agriculture results in a significant decline in agricultural employment, whereas industrial development increases employment in cities[55]. Secondly, overpopulation and growing demand for land can change land-use patterns, and available natural resources do not meet increasing population requirements. Thirdly, environmental changes, including prolonged drought, flood, dust storms, are another critical reason for RUM. In these three cases, migration may re-establish an appropriate balance between available resources and population size or demand for and supply of labour and reduce environmental pressure. It is not necessarily a problem or adaptation failure[42] or a strategy of last resort[56]. Still, it may be an appropriate voluntary response as a long-term strategy for dealing with unfavourable conditions (cited in Gemenne and Blocher (2017)[42]).

In contrast, migration can also be undesirable. It can result from anthropocentric environmental changes, poor infrastructure, mismanagement, a low level of adaptive capacity, a massive gap between urban and rural lifestyles, and a sense of relative deprivation. In such cases, RUM is a way to escape from difficult conditions in rural areas. It brings more newcomers to immigrant receiving cities, usually with no appropriate jobs, leading to many economic and social difficulties. Additionally, it leads to an unsustainable form of urban growth and consequently creates various problems for urban management (Abdul Rashid and Ghani, 2009). Martin (2013) argues migration is a high challenge for the destination areas because there are often few resources, complicated legal structures, and weak institutional capacity to meet migrants’ requirements. This migration can also have unpleasant consequences in the area of origin, such as a change in sex and age structures and security threat for the remaining people. People who stayed behind may also be encouraged to migrate, following their family members and neighbors. It can lead to a low level of interest in investments in these regions.

3. The Conceptual Model

The linkage between environmental changes and migration might be presented through a “common sense” approach[58], which simply says people are forced to leave their homes if environmental changes occur. However, people who are most vulnerable to impacts of environmental changes do not necessarily migrate[10,59]. It indicates that migration response to environmental changes depends on some other factors, such as political, economic, social, and demographic issues[60]. The common sense approach does not include intervening factors, especially the human reaction to environmental changes[41]. This requires a more developed conceptual model[61].

The proposed conceptual model is based on the model of Perch-Nielsen et al. (2008), developed to understand the linkage between climate change and migration. Perch-Nielsen et al. (2008) considered

two mechanisms: flood and sea-level rise. Drought, another influential mechanism, is investigated in an earlier study by Perch-Nielsen (2004). In this study, both drought and flood are included in the proposed framework as hydro-climatic disasters. One main weakness in Perch-Nielsen et al. (2008) is that human mal-activities, such as upstream development, are not included in their models. Such activities are common in many watersheds, resulting in severe environmental degradation and migration. In the model, the influential factors are classified in three categories: 1) leading causes (environmental changes, including climate change and hydro-climatic disasters, and human mal-activities), 2) pull factors in the cities, and 3) intervening factors (governmental plans and individuals' characteristics) (Fig. 1). Below, the causes and factors are described in more detail.

3.1 Environmental Changes

3.1.1 Climate Change

Earth's temperature has had an increasing trend during the last century[19]. This temperature change leads to changes in the global, regional, and local climate. Warmer winters, shrinking winter snowpack, reduction in renewable water, change in types and growth stages of crops, increasing evaporation, a decline in soil moisture, and changes in rainfalls have had adverse effects on agricultural products and rural living and have led to a long-term decrease in the resilience of the communities, to economic problems, and to migration. In addition to these gradual effects, climate change increases the frequency, intensity, and amplitude of extreme events (here flood and drought)[19,63–65]. Finally, less precipitation and higher temperature can also result in drying out of lakes and severe dust and salt storms. In some watersheds, human mal-activities are more contributed to drying the lakes and resultant dust/salt storms.

3.1.2 Human Mal-Activities

Human mal-activities are divided into activities upstream and downstream. Unsustainable development upstream, such as water diversion through reservoirs and canals and deforestation, can increase water scarcity and flood downstream, and sometimes both. Combined with overgrazing, inappropriate irrigation, and over-abstraction downstream, this may result in a decline in groundwater quality and quantity, in increasing soil salinity, and generally in land degradation.

3.1.3 Hydro-Climatic Disasters

Drought and flood are the main hydro-climatic disasters threatening agricultural products and rural living. Drought can be classified as meteorological, hydrological, agricultural, and socio-economic (Wilhite and Glantz 1985). Meteorological drought arises from a low amount of precipitation and may lead to a decline in soil moisture (agricultural drought) and in water resources (hydrological drought). Hydrological drought can reduce fisheries and irrigation, thus contributing to agricultural drought and a loss in agricultural production.

While drought is a slow-onset event, flood is a sudden-onset event. Sudden-onset events can result in considerable damage to infrastructure and property and loss of life[66]. It often makes people evacuate the region before, during, or after the event. Often, displacement is temporary as people try to get back home after the flood. Displacement in response to slow-onset events is typically temporary too, at least initially, because people may believe the situation to be temporary[66]. However, if they are not able to cope with the event and its economic aftermath (with no alternative livelihood), people may decide to migrate permanently.

In many parts of the world, migration in response to sudden-onset events captures the most media and scholarly attention than slow-onset events; however, the latter cause even more people to leave their home at early or more advanced stages of the events[67,68]. In 2016, over 24 million people were displaced in response to sudden-onset events, while it is not clear how many people migrated due to slow-onset events[69]. Moreover, Zetter (2010) suggested that, in the case of slow-onset events, it is more complicated to distinguish between voluntary or forced migration than in the case of sudden-onset events: people may migrate voluntary in the early stage of drought, they might be prohibited from returning when the drought continues.

3.2 Agricultural Consequences

A reduction in agricultural production due to unreliable rainfall and flooding can lead to more hunger and poverty and cause of migration[71]. Agricultural production can decrease due to a reduction in the yield per hectare and a loss of agricultural land. Flood directly reduces agricultural products, and causes intense erosion and strong sedimentation, making agricultural lands to be infertile. Drought can reduce both irrigated and rainfed agriculture, as well as fisheries. The decline in the quality and quantity of groundwater arising from overdraft and soil salinity from mal-irrigation leads to soil degradation.

3.3 Economic Consequences

Due to the environmental changes, reduction in agricultural products, and loss of agricultural lands, the economic efficiency of the agriculture sector has become low, resulting in low-income levels for rural people. Consequently, they encounter food insecurity in their homelands. They usually have no alternative jobs other than farming. At this point, they are in doubt for making a challenging decision, i.e., migration.

3.4 Decision to migrate

Most of the residents typically do not respond to unpleasant situations at the early stages, because they expect that situations do not last for a long time. Thus they usually try to adapt to unpleasant consequences at different stages[72]. They only leave their home if they cannot tolerate severe conditions or do not have any other alternative for subsistence. In the conceptual model, factors that encourage people to migrate or stay are classified into three groups: fears, hopes, and pull factors, which are described as follows.

3.4.1 Fears

Economic consequences lead to increasing uncertainty in the future welfare of rural people. Some people leave their homes at the early stage of changes, causing a decrease in a community population. The decreased population may lead to security threats in the affected area as typically only the elder, women, and children stay behind. Severe dust/salt storms can exacerbate such situation. These factors result in frustration and dissatisfaction, which push the remaining people to leave.

3.4.2 Pull Factors

In addition to push factors, pull factors can motivate rural people to migrate to big cities. Urbanization and modernization, and structural change from agriculture to the industry can result in RUM, even in the absence of environmental changes. While mechanized farms lead to agricultural productivity increase and a significant decline in agricultural employment, large-scale urbanization and extending industries pull unemployed people to cities and motivate RUM[55]. Moreover, changing lifestyles and seeking better economic conditions in the destination areas are pulling people to cities. RUM mainly results from the uneven geographic distribution of welfare and better living conditions in cities[73]. Furthermore, a trustworthy social network or ethnic group (family, relatives or acquaintances) in destination areas, besides access to enough money, acts as influential pull factors. Since pull-migration usually is meant to be permanent, migrants need to be sure that they can afford their displacement expenses and support their families in the destination area. Therefore, people with a low level of resources (money and social networks) leave their homes later than the others. In some cases, early-stage migrants are forced to leave their homes and subsequently assist the remaining people in moving voluntarily[74].

3.4.3 Hopes

Fears which arise from the leading causes and pull factors can be mediated by some counter-causes, called “hopes” in the proposed model. Factors encouraging people to stay are governmental support, loss sharing, and social network in the area of origin or sense of belonging. Sense of belonging to land and neighbors is a powerful feeling for humans, chiefly when belonging to a particular tribe or caste. Therefore, it may be expected that in the early stages of environmental changes, hardly any people decide to leave their homelands unless some of their neighbors, family, or tribe members migrate too.

If hopes are stronger than fears and pull factors, individuals prefer to stay, but if fears and pull factors are stronger, rural people cannot bear undesirable conditions and migrate. Migration reduces the agricultural economy as it reduces the agricultural labor force and investments. This in turn worsens the economic situation of individual farmers, stimulating even more migration. Thus, the linkage between environmental change and migration is a cycle with positive feedbacks (D and E in Fig. 1).

The proposed conceptual model can be applied to each region, depending on their unique and special characteristics. In this paper, we applied the model to Iran, as such studies have not been conducted in the country due to few interdisciplinary research.

4. Application To Iran

4.1 Study Area

Iran (Fig. 2a) is a developing country in the southwest of Asia. It is the second-largest country in the Middle East, with an area of 1,648,195 km^2[73]. Iran is generally classified as a semi-arid and arid region (Fig. 2b), with a mean annual precipitation of about 250 mm $year^{-1}$. Mean annual temperature ranges from 10°C (in the west) to 35°C (in the center). There is no general prevailing climatic season in Iran. According to the Koppen climate classification, the south, east, and center of Iran have a desert and semi-arid climate. A hot or warm dry-summer continental climate is experienced in the west and northwest of Iran, and the coastal regions in the north of Iran have a Mediterranean climate. These highly variable climate characteristics are due to the location on the Caspian Sea, the Persian Gulf, and Sea of Oman and the mountain regions Albors and Zagros[75].

Statistical Center of Iran (2016) reported that currently, more than 74% of Iran's population live in cities and only 26% in rural areass[76]. The current urban population is much higher than in the 1950s and 1970s (27% and 44%, respectively)[73]. Statistics show that during 2011–2016 about 30,000 villages across the country were abandoned[76]. The population growth in the rural areas in Iran is negative, e.g., -0.73% during 2011-2016[76].

4.2 Climate Change

The World Meteorological Organization reported that Iran became warmer by about 1°C during 2001-2010[78]. Due to the increasing trend in mean annual temperature and the decreasing trend in mean annual precipitation, aridity has been increasing during 1966-2015[77], indicating an evident change in climatic conditions in the country. It is also predicted that during 2020–2100, Iran will become even drier and hotter[79].

4.3 Human Mal-Activities

Iran is considered one of the pioneer countries in the world in the construction of water resources and efficient water irrigation projects to successfully deal with limited water resources in a sustainable manner[79,80]. For instance, Qanats were widely used by ancient Iranians. However, by importing the first water pumps to Iran in the early 20th century, the importance of Qanats has become less due to the expansion of water wells. The number of wells increased from 45000 to 50000 in the 1970s to 764000 in 2011[81]. This considerable increase leads to overexploitation of groundwater resources, changes in the hydrological cycle, land degradation, and desertification[73].

The country is experiencing considerable challenges of environmental degradation, mostly related to water issues. As in the other countries in the Middle East, most of the water challenges are rooted in bad governance and mismanagement, to a large extent arising from an oil-based economy with remarkable social and economic changes such as urbanization, rising standard of living, high rates of consumption and infrastructure development[82]. Moreover, despite improving the social and physical assets in rural

areas during the last decades, their economy still depends on agriculture and water. Thus, based on its "Hydraulic Mission" strategy, Iran over-invested in water storage and distribution infrastructures to meet the increasing demand of water during the last decades. Overexploitation of groundwater reserves and over-investment in dams and inter-basin water transfer projects with minimum concern about environmental consequences have led to drastic environmental changes in some parts of the country. Besides, the lack of appropriate socio-economic and political plans for dealing with these environmental degradations as well as the current economic, power, and services inequalities between rural and urban areas, increase the rate of RUM[73].

Moreover, the construction of dams to provide water for agriculture and domestic purpose and generate electricity were the priority of the policymakers during 1955-1962[83]. This aligned with a global movement during the 1930s-1970s that considered dam construction as a sign of modernization, development, and economic growth[84]. Currently, there are 316 dams in Iran, 100 dams are under construction, and a further 300 dams being considered for development[79], while in the 1970s, there were only 12 dams in the country[85]. Notwithstanding their benefits, these dams have resulted in damages to the ecosystem, changes in land cover, human displacement, and more development and water use downstream due to the perception of water abundance[73].

After the Islamic Revolution and due to international sanctions, the policy of Iran was to be self-sufficient. Thus, the policymakers decided for rapid development by constructing the major infrastructures without considering long-term consequences and the complexity of the human-natural system. It has resulted in many environmental challenges, including “drying lakes and rivers, declining groundwater resources, land subsidence, water contamination, water supply rationing and disruptions, forced migration, agricultural losses, salt and sand storms, and ecosystem damages”[73]. Additionally, climate change, prolonged droughts, and frequent floods have exacerbated environmental degradation in some regions. These factors together have been led to massive RUM.

These activities result in drying water bodies in many watersheds [73] , many other environmental challenges, and migration. In recent decades, the implementation of different development plans and overexploitation of biological resources have affected the eco-regions of Iran [86,87] . According to the last available report, the World Bank reported that in 2002, the annual cost of environmental degradation in Iran was about 8.4 billion US$ [88] .

Dust storms are a big problem in Iran, especially in the southeast and southwest. In the Sistan area in the southeast of Iran, part of the Hirmand River Basin (HRB) (see Fig. 2.b), shared by Iran and Afghanistan, human-made infrastructures in Afghanistan and debilitating dust storms have brought life to a standstill. The Lake Hamoun in HRB (Fig. 2.b) has dried up due to conflict between Iran and Afghanistan over the utilization of the Hirmand River[89]. All research on dust storms in the Sistan area believes that the dry lake bed is the main cause[90].

Salt storms also occur, for example, in the northwest of Iran from Lake Urmia (Fig. 2.b). Lake Urmia, the largest lake in the Middle East, has shrunk significantly due to upstream human mal-activities as well as frequent droughts[91,92]. In addition to the direct consequences for the lake's ecosystem and regional economy, shrinkage of the lake also leads to salt storms in the surrounding cities and villages[73]. Both dust and salt storms cause many physical and mental health problems, as well as the loss of agricultural lands, forcing, in some cases, many people to leave their homes.

Groundwater is the primary source of water used for domestic, industrial, and agricultural consumption in Iran[93]. Increased water demand has led to overexploitation of groundwater in Iran[94], such that the country is one of the top groundwater miners in the world[95,96].

4.4 Hydro-Climatic Disasters

Iran is one of the disaster-prone countries in the world. However, flood and drought are the biggest concerns of the Iranian governments and play a significant role in migration.

Iran has several large rivers that flood in spring, causing considerable damages to agriculture. For example, in March and April 2019, precipitation with a 200-year return period occurred in most parts of Iran, especially in the west and north. During 16 days (17 March to 1 April), the amount of precipitation was about 72 mm, almost 29% of the average yearly precipitation, resulting in a runoff of 119 MCM [97]. This flood affected 3,899 villages and more than 2,100,000 people and in about IRR 38,528 billion (US$ 321 million) of damages to the agriculture sector.

In Iran, severe and long-lasting droughts occur regularly: in the last 50 years, the country experienced 27 droughts [98–100]. One of the severest droughts since the 1940s occurred from 1998 to 2000. In 1989–1999 alone, about 4.2 million head of livestock died and about 12 million hectares of agricultural lands were damaged. The damage to agricultural products during 1989–1999 was about US$ 4.3 billion [99]. Approximately 11 km^3 of groundwater was abstracted and many wells and Qanats dried up [99]. In 2000–2001, rangeland production was reduced by about 70%. About 80,000 tons and 40,000 tons of rangeland production have been lost in Kordestan and Guilan provinces, respectively [99]. OCHA (2001) reported that "based on the official estimates, this year's drought [2000] is directly affecting more than 2.6 million hectares of irrigated farms, 4 million hectare[s] of rainfed agriculture, 1.1 million hectare[s] of orchards and more than 75 million animals [101]". After a brief spell, the most severe, prolonged and extensive drought over the last 30 years has occurred since 2003, with undesirable consequences for many rural communities in the center, east and south of Iran [98]. Drought has caused many rural people in Iran to lose their jobs and income, especially people whose lives depended on water and agriculture, and forced them to migrate.

Accordingly, drought is a common phenomenon and a part of normal life in Iran; however, it is also predicted that the country would be hotter and drier due to climate change with more pressure on water resources [102] and agriculture [103]. Agricultural activities in Iran are susceptible to droughts: one mm of

rainfall below the historical average leads to approximately US$ 90 million losses in the agriculture sector [79].

4.5 Agricultural Consequences

Agriculture in Iran depends mostly on groundwater: in about a third of the country, more than 80% of the land is irrigated with groundwater[104]. During 1993–2007, the area irrigated with groundwater increased by 39%, while that irrigated with surface water declined by 15%[105]. Reduction in groundwater levels (with an average of 0.4 m $year^{-1}$ across the country[104]) threatens the agriculture sector in the country. Moreover, over-abstraction of groundwater has led to environmental degradation and water salinization[93]. Irrigating the crops with saline water results in the concentration of salts in the soil and decrease in grain yields[105,106].

It is estimated that soil salinization in Iran has led to an economic loss of more than US$1 billion [93]. Overgrazing and deforestation directly cause soil degradation, leading to both a decline in agricultural production and a loss of agricultural land. Soil degradation indirectly–through desertification–results in loss of agricultural land. In the case of climate change, it is predicted that with 2.7–4.7°C increase in temperature in Iran, the average yield reduction in rain-fed wheat crops will be about 18% by 2025 and 24% by 2050[107]. Currently, the total cultivated area in Iran is approximately 16,477,000 ha, of which 46% is irrigated [76]. However, due to environmental changes, it is becoming less, with considerable economic consequences in the rural areas.

4.6 Economic Consequences

The economic consequences such as unemployment, decline in income, and food insecurity have not been investigated in detail in Iran. However, few studies have provided some information about these consequences. According to the interviews conducted by Khavarian-Garmsir et al. (2019), especially dust storms have contributed to the economic downturn and unemployment in Khuzestan province, southwest of Iran (Fig. 2.b). The interviewees from Masjed Soleiman, a city in this province, indicated that unemployment is the oldest reason for migration. In Urmia Lake Basin in the northwest of Iran, environmental changes and recent drought cycles have led to a reduction in agricultural productivities, higher rate of unemployment, economic problems and migration[109]. In Sistan area in the southeast of Iran, people also believed that the economic problems arise from the water scarcity and prolonged drought in the area[110].

4.7 Fears, Hopes and Pull Factors

The majority of rural people in Iran are employed in the agricultural sector. Agricultural degradation and economic problems increase uncertainty in the life of rural people. Many rural people are in doubt whether to leave their home places and emigrate to the cities[76]. For example, according to the interviews conducted in Khuzestan, some unemployed people out-migrate to find a job in other cities and, some employed people are looking for better economic situations and indeed for a better future[108]. Studies in

Khuzestan province show that 35–40% of rural migrants changed their jobs over the last four census periods due to environmental and economic factors[111]. Seeking better economic situations in combination with cities' attraction and social network in the cities increase the rate of RUM. This migration leads to communities' population decrease, security threat, and consequently frustration and dissatisfaction.

The findings of Khavarian-Garmsir et al. (2019) in Khuzestan showed that in addition to environmental changes and economic decline, the market downturn is also affected by political factors. They also indicated that in some areas, basic facilities are not available, and uneven economic development and inequity in job opportunity and life quality may lead to mass RUM. One more critical issue in Khuzestan province is the effect of Iran-Iraq war and the government's weakness in rebuilding the damaged areas. This makes many people to be dissatisfied with their current situations. Accordingly, Khuzestan province is known as the emigrant-pole in Iran such that more than 50% of rural-urban migrants come from this province[76]. Such situations are also observed in Sistan area in the southeast of Iran, where 55% of the rural population depend directly on agricultural activities for their income[112]. During the drought in the early of 2000s, 124 villages were abandoned, and unemployment rose considerably [113].

Mass RUM in Iran shows that hopes are not so strong to keep people in villages. This could be due mainly to a lack of wise management and preparedness plans for dealing with the consequences of environmental changes and governmental supports, such as providing water, jobs, investment, and amenities, allowing border markets, and engaging local people, especially young people, in managing local challenges. Additionally, Mianabadi et al. (2021) showed that sense of belonging, or current place attachment, and thrustworthy social network in the villages in the Sistan area are key factors that encourage people to stay in their homelands[110]. However, unpleasant situations make rural livelihoods increasingly at risk and threaten the communities and households that are more dependent on natural resources[100].

Among the leading causes of RUM, climate change cannot be mitigated at the local scale, and hydro-climatic disasters cannot be avoided completely. The only manageable leading cause is human mal-activities; thus governmental policies to deal with the migration should focus on this issue. Satisfactory, reliable economic conditions encourage people to stay in their villages. These conditions can be provided in different stages of environmentally-induced migration. Factors encouraging people to stay in villages include investment in small businesses, supporting economic activities other than agricultural ones, such as greenhouse production and border trade and markets in rural areas near the borders, and engagement of all stakeholders in local governance. Policymakers can provide direct financial supports before and after the consequences occur. They can also focus on coping and adaptation strategies to avoid unpleasant consequences of environmental changes by increasing resilience and decreasing the vulnerability of individuals and communities. These strategies include sustainable development of the region through land-use planning, using the water diplomacy tools to meet environmental demands, especially for transboundary wetlands and lakes, considering the socio-political aspects of water

management and development projects and sustainable participation of local communities in policy and decision making. However, migration is a complex and nuanced problem that requires a complex solution. Thus, there is no single solution for dealing with mass RUM. Therefore, depending on their unique and special characteristics, a unique and special solution might be helpful for each region.

5. Discussion

Investigation on the linkages between environmental changes and migration is transdisciplinary research. It involves a variety of disciplines such as environmental and natural resources science, social science, economics, geography, and political science. Building linkages among various disciplines is a challenging issue for transdisciplinary researches, which need to integrate diverse concepts, methods, frameworks, and data for appropriate cooperation among disciplines[61].

Due to the multi-causal nature of environmental migration, lack of appropriate data is a key gap in developing this model in Iran as a developing country. It is even more evident for slow-unset events[70]. Insufficient data makes it unclear to what extent each factor (i.e., climate change, human activities, or Hydro-climatic disasters) is a key driver of migration. Collecting data is a significant challenge. For example, the data on the hopes, fears and pull factors are not sufficient to help the scientists to provide the physical model and the policymakers to provide the appropriate strategies.

Furthermore, individuals' reactions to environmental changes are not predictable. Their reactions to slow- and sudden-onset events differ, and the trend and pattern of migration are often not clearly identified. While humans are a central part of an ecosystem[114], some environmental or climate modeling techniques have failed to take into account impacts of individual choice, the potential for policy actions at both local and international scale, as well as the effect of human activities on a system. It is also difficult to distinguish between natural and anthropogenic changes.

Another challenging issue is the distinctive role of environmental changes on migration from other factors (e.g., economics, social, demographic, and political factors). It is not clear to what extent a migrant is pushed out by environmental changes or pulled away from their home by the promise of a better economic situation in the destination [29].

Other challenges, specifically in Iran, are economic problems and inflation, making it difficult for the government and policymakers to provide appropriate preparedness plans and financial supports for collecting data and conducting the research.

6. Conclusion

This paper aims to provide a conceptual model that helps policymakers identify and understand the complex interaction between environmental changes and RUM. The conceptual model proposed in this study serves this purpose. It was applied in Iran to test its usefulness in specific cases, and this did

provide useful insights. Policymakers should help affected people in a way that is not leading to more degradation in the rural environments. For example, when farmers lose all or parts of their livestock in some drought cases, the government helps them by subsidies, loans, or insurance. Farmers then buy more livestock and use more water and pastures for feeding them, leading to more degradation in natural resources and more livestock failure.

Since some RUM causes are inevitable, policymakers should focus on the components that can be manageable. Climate change cannot be mitigated at the local scale, and hydro-climatic disasters cannot be avoided completely. The only manageable leading cause is human mal-activities, and governmental policies to deal with the migration should focus on this issue. Human mal-activities can be managed by both governments and people. By changing natural resources use sustainably and increasing individuals' and communities' coping capacity, undesirable consequences can be avoided or reduced, and migration can be appropriately managed.

Environmental challenges are likely to become more acute due to climate change and the increasing severity and frequency of hydro-climatic disasters. Accordingly, future research needs to be more focused on environmental migration issue and its consequences. Important research questions include when migration is necessary and when it is undesirable; which strategies policymakers can use to manage both necessary and undesirable migration (for individuals and/or communities) in origins and destinations; whether strategies for slow- and sudden-onset events should differ; which areas are most vulnerable to environmental change; how migration rate will change in future climate; whether migration is more related to climate change or to human interventions; which group of people more prefer to migrate (i.e., investigation on age, occupation, gender, marital status); and finally clarifying the concept of mobility in comparison to migration. These researches should be conducted for each area and include tacit knowledge as well, because, while there is linkage between environmental changes and migration everywhere, response to these changes may be different for each region because of differences in the coping/adaptive capacity of communities, their knowledge, and governments' policies. For this purpose, researchers can adopt novel approaches, including contingent approaches. Finally, future work based on this conceptual model can be developing quantitative models using appropriate data for rural-urban mobility and providing appropriate and applicable plans for policymakers to deal with migration issues.

Declarations

Acknowledgments

This research has been supported by Institute of Science and High Technology and Environmental Sciences, Graduate University of Advanced Technology (Kerman-Iran) under grant number of 99/2490. The author would like to thank local people, administrative personnel, university professors and students for their kind help for collecting the required information.

Author contributions

A.M and K.D developed the conceptual model. A.M collected the required information, prepared the figures, and wrote the first draft of the manuscript. H.M, M.K, and E.M reviewed the paper and contributed to the discussions.

Availability of Data and Materials

The datasets used and analysed during the current study available from the corresponding author on reasonable request.

Competing interests

Te authors declare no competing interests.

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Figures

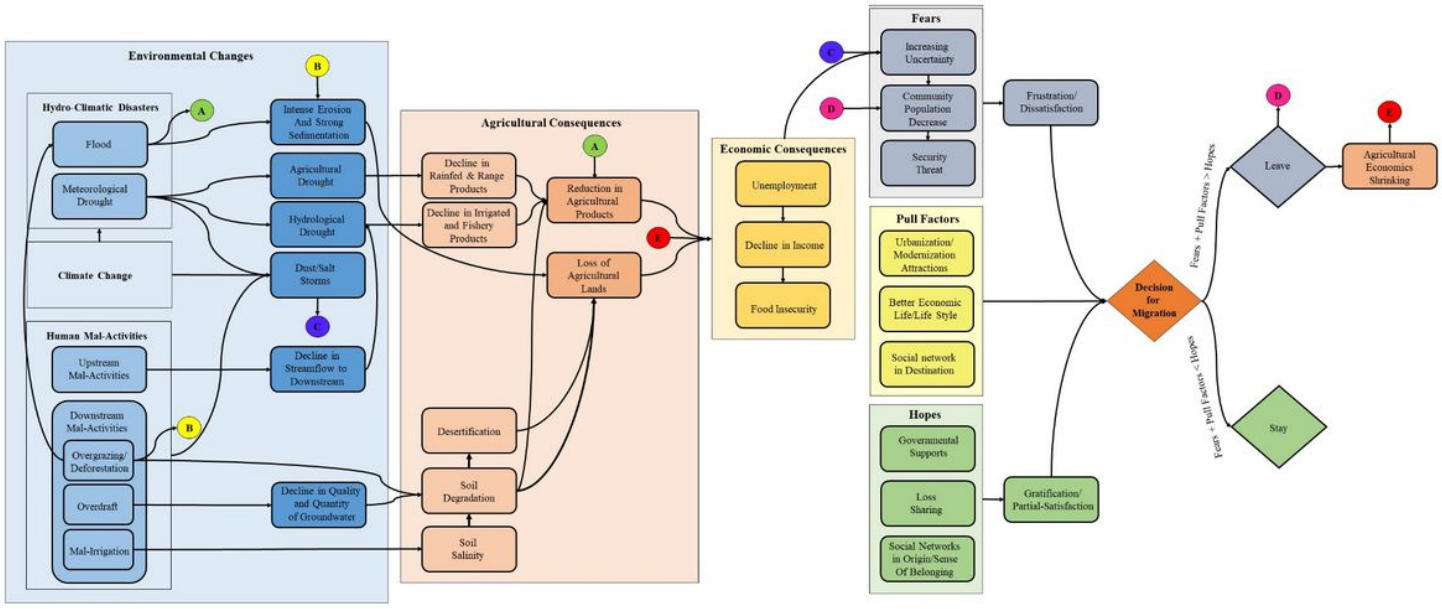

Figure 1

Conceptual model for linkages between environmental changes and migration

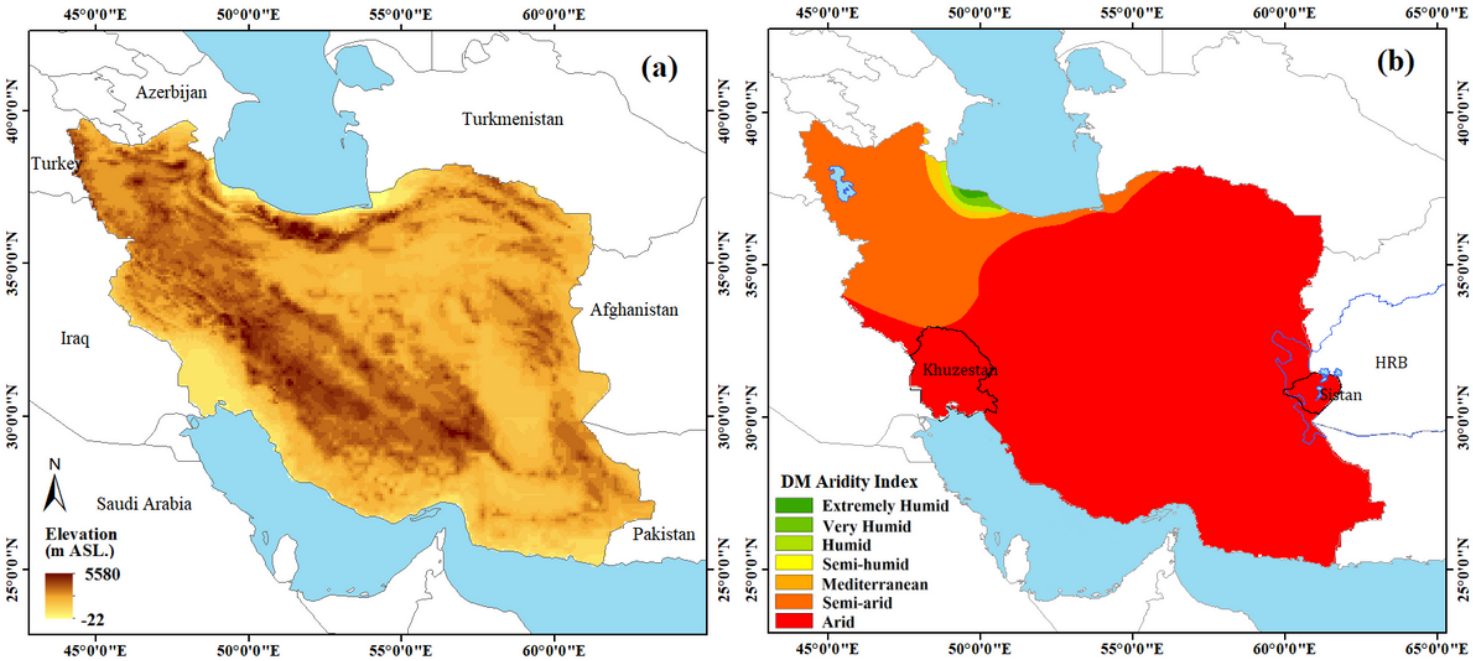

Figure 2

The geographical location of Iran with neighbours, elevation (a), and De Martonne Aridity Index (b) [77].