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AGRICULTURAL LANDSCAPE OF THE SANDY DESERT IN IRAN

Integrating green belts and productive landscape in the desert margin, for the sustainable development of residential areas

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In copertina uno schizzo di progetto dello studio Tezuka Architects per il centro Tokamachi di Ikote. Crediti: Tezuka Arkitects

One of the most important examples of the artificial ecosystem is the agricultural ecosystem. Through the extent of land use, agriculture has become the main contributor to global environmental change.
About 2 billion rural individuals live in agricultural systems associated with a high amount of risk and low levels of yield in drylands of Asia, Africa, and Latin America.
In desert and semi-desert areas, the short rainy season provides a limited opportunity for plant growth. Apart from natural factors, human factors play an important role in desertification. With several centuries of poor management of natural resources and increasing pressures associated with the rapid population growth, degradation of natural resources, especially vegetation, has occurred desertification in the desert areas environment.
One of the causes of desertification is the shortage of water. Currently, in Iran, different methods are being used to exploit water resources for urban, rural, industrial, and agricultural uses, which is less consistent with productivity standards.
In dry and semiarid regions, which have very fragile ecosystems, soil degradation, due to human activities or climatic and natural conditions, is one of the most important and influential factors of desertification. This phenomenon has occurred in many regions of Iran, particularly the villages in the periphery of the central desert of Iran, and has made living in these oases so difficult that the number of abandoned villages is increasing every year.

Abstract

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Also, the incorrect use of soil will erode it, which would have many adverse consequences, including that it could turn agricultural land into desert, block the desert paths, reduce food production, pollute the air of the city and the countryside, cause flooding and accumulate soil in dams, lakes and water resources.
In the past that the livelihood of people was mostly based on agriculture and livestock, due to its salty soil and the lack of water resources, the deserts were the main factor of backwardness in the arid region. But today, with the advancement of science and technology, deserts can be considered to be one of the most valuable natural resources.
One of the most important models for achieving sustainable development in desert areas is population conservation in these areas. Therefore, this study aims to investigate and formulate a strategic model for adjusting spatial inequalities of population settlement in desert areas. Migration analysis in different countries, including Iran, shows that this rate in desert areas due to severe natural and climatic conditions such as lack of rainfall and water, salinity, etc. is higher than other areas and regions. The research tries to show that by using the existing potentials in the region and turning potentials into actual ones in the form of defining new oases, consolidating existing settlements, reviving abandoned villages, creating job, emphasizing cultural and social and natural attractions, etc. many of the migrations can be stopped, and even reverse them.

Introduction

Today, there is convincing evidence that shows humans are nearly changing the entire ecosystem of the earth. More than half of the freshwater in the globe is consumed by humans, about half of the lands are altered by human activities. Most atmospheric nitrogen is stabilized by human activities rather than the natural processes of the earth. Human activities are significantly reducing biodiversity. As a result of these activities, most ecosystems (if not all) can certainly be considered ecosystems dominated by humans, regardless of whether humans actually occupied them (or not). However, humans are also creating new ecosystems for habitation.[1]

One of the most important examples of the artificial ecosystem is the agricultural ecosystem. this is a natural system that transformed by men for food production. Agriculture, including rangelands, now covers roughly 40% of the world's terrestrial surface. Through the extent of land use, agriculture has become a main contributor to global environmental change.[2]

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[1] N. E. McIntyre, K. Knowles-Yanez, and D. Hope, "Urban Ecology as an Interdisciplinary Field: Differences in the Use of 'Urban' between the Social and Natural Sciences," in *Urban Ecology* (Springer, 2008), 49–65.

[2] J. A. Foley et al., "Global Consequences of Land Use," *Science* 309, no. 5734 (2005): 570–74.

About 2 billion rural individuals live in agricultural systems associated with high amount of risk and low levels of yield in Asia, Africa and Latin America. They mostly farm in poor soils, hillside slopes, or arid dry lands influenced by erratic rainfall and periodic drought.[3] Such lands therefore cannot be classified as agricultural lands.[4] Peasantry systems are the primary source of staple food in developing countries, and it is estimated that 1.5 billion people earn a livelihood from such activities.[5] [6] [7] The vast majority of this immensely large group of undernourished people depends primarily on agriculture to provide most of their own food supplies and any cash income needed to purchase goods and services. Even with dramatic increases in nonfarm economic activity, agriculture will remain central to secure livelihoods.[8]

In semi-desert areas, the short rainy season provides a limited opportunity for plant growth. With several centuries of poor management of natural resources and increasing pressures associated with the rapid population growth, degradation of natural resources, especially vegetation, has

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[3] P. Gubbels, "Promoting Integrated Approaches to Rural Development for Poverty Eradication and Sustainable Development: The Critical Role of Smallholder Agricultur," *International Program Director*, 2000.

[4] F. Göltenboth and C.-P. Hutter, "New Options for Land Rehabilitation and Landscape Ecology in Southeast Asia by 'Rainforestation Farming,'" *Journal for Nature Conservation* 12, no. 3 (2004): 181–89.

[5] R. Chambers, *Challenging the Professions: Frontiers for Rural Development.* (Intermediate Technology Publications Ltd (ITP), 1993).

[6] P. Rosset, "Genetic Engineering of Food Crops for the Third World: An Appropriate Response to Poverty, Hunger and Lagging Productivity," in *Proceedings of the International Conference on Sustainable Agriculture in the New Millennium—the Impact of Modern Biotechnology on Developing Countries*, 2001.

[7] H. Van Keulen, M. K. van Ittersum, and P. A. Leffelaar, "Multiscale Methodological Framework to Derive Criteria and Indicators for Sustainability Evaluation of Peasant Natural Resource Management Systems," *Environment, Development and Sustainability* 7, no. 1 (2005): 51–69.

[8] Gubbels, "Promoting Integrated Approaches to Rural Development for Poverty Eradication and Sustainable Development: The Critical Role of Smallholder Agricultur."

occurred in the desert areas environment, while desertification is largely a natural occurrence. These phenomena have been exacerbated by human factors, especially agriculture, grazing and cutting. As outlined in Chapter 12 of Agenda 21 in the Rio Declaration on Environment "Land degradation in desert, semi-desert and semi-humid areas cause by various factors, including climate change and human activities (UNCED,1992).

In the absence of vegetation, rainwater is mostly lost as a runoff due to low penetration rate. It results into reducing plant growth and productivity and even influence plant long-term life. Trees and shrubs, over the next few years, typically face an intolerable challenge for survival. Vegetation as a protector will disappear, the risk of flooding will increase, and further degradation occurs. Therefore, in general, desertification can be strengthened.[9] Desertification has dramatic effects on food security, livelihoods, and socio-economic and cultural activities in the area. In West Africa, and in particular in Nigeria, food insecurity has been created due to desertification (UNEP, 2008). This leads to significant socio-economic challenges, including the movement of the people from the desert environment and the reduction of food supply as well as disruptions in the economic and social activities of people living in semi-desert environments (National Action Plan, NAP, 2007).

Apart from natural factors, human factors play an important role in the desertification, as some researchers believe that most of the deserts today are caused by the collapse of ecological balance and ecosystem degradation. At the Nairobi Conference in 1977, it was emphasized that "the reduction or deterioration of Earths' biological capacity ultimately leads to a desert climate, which is a means of destruction of the ecosystem"

[9] F. A. Adesina and B. L. Gadiga, "The Role of Shelterbelts in Vegetation Development of Desert Prone Area of Yobe State, Nigeria," *Journal of Geography and Geology* 6, no. 4 (2014): 109.

One of the causes of desertification is shortage of water. Currently, in Iran, different methods are being used to exploit water resources for urban, rural, industrial and agricultural uses, which is less consistent with productivity standards. From around 400 billion cubic meters of annual rainfall, 270 billion cubic meters of it is released in various forms (like evaporation). The annual water consumption per capita worldwide is about 580 cubic meters per person per year, but in Iran, which is a country with water shortage; this figure is 1300 m^3 per person. In the industrial sector, due to contamination with toxins and chemicals and flowing from the wells into aquifers, water loses its quality and becomes less re-useable. Also, the incorrect use of soil, which requires more than a thousand years to form a centimeter on Earth, will erode it, which would have many adverse consequences, including that it could turn agricultural land into desert, block the desert paths, reduce food production, pollute the air of the city and the countryside, cause flooding and accumulate soil in dams, lakes and water resources.

Unfortunately, every year, million tons of soil is destroyed and turned into desert due to unnecessary human interferences like overgrazing, excessive exploitation of soil, poor plowing methods and plucking plants and shrubs to supply fossil fuels. However, with the increase in population and the higher demand for food, the maintenance of fertile lands becomes more important.

In dry and semiarid regions, which have very fragile ecosystems, soil degradation is a common phenomenon. With the implementation of modern agricultural systems, it is possible to minimize soil destruction. Agroforestry is an integrated management system that helps with fertilization and protection of soil through addition of organic and nutritious ingredients to the soil, the accumulation of carbon and organic nitrogen in the soil, and the reduction in greenhouse gas emissions. The role of trees in increasing the fertility of farms and protecting other ecosystems is brought

into attention in Agroforestry. Agroforestry is introduced as a system of land use that grows woody plants along with agricultural products, pastures and livestock.

In the past that the livelihood of people was mostly based on agriculture and livestock, due to its salty soil and the lack of water resources, the deserts were the main factor of backwardness in the arid region. But today, with the advancement of science and technology, deserts are considered to be one of the most valuable natural resources. So that correctly utilization of them on the basis of a thorough and comprehensive planning, has a significant impact on employment creation in different fields, the prevention of immigration and the improvement of the economic, social and cultural conditions of arid areas. "An appropriate use of natural resources such as water, soil and energy is made possible by using traditional knowledge that establishes the harmony of architecture with the environment, the symbiosis of the techniques of organization of space with the traditional, the social habits, the spiritual values and the fusion between practical aspects and beauty."[10]

Importance and necessity of research

In the past, people's livelihood, especially inhabitants of the provinces of central desert of Iran, was agriculture and livestock. Desert people, those who lived permanently in the desert not the Bedouin, with the use of water resources, and in particular the invention of the Qanat system, they created agricultural civilizations.

With the increasing population and the need to produce more food, increased water using; And with the deepening of wells and the use of salt water for agriculture, the soils also

[10] P. Laureano, "Traditional Knowledge and the World Databank for Safeguarding Ecosystems," in *The Future of Drylands* (Springer, 2008), 123–43.

became saltiness. As a result, plants that were sensitive to salinity (such as wheat) were less produced and their planting was no more economical justification. Finally, due to high irrigation with salt water in saline lands, soil fertility was lost, and farms became desert. As a result, residents of these areas forced to leave the village and migrated to more favorable locations.

Thus, agriculture civilization, which was circular around the central desert, was destroyed in most places and what is remained, today is being destroyed by inattention or poor management. And especially with climate change, in recent years, we are faced with the problem of increasing the number of immigrants from arid and desert areas to temperate regions.

Research question

How does planning green landscapes on the outskirts of deserts outside the city affect the distribution and balance of the population and the resulting problems?

Research purposes

Considering that in recent years in Iran we have encountered problems in the implementation of comprehensive development plans, as well as the failure to comply with urban development plans followed by the rural plans, we were forced to consider the root causes. The causes and factors of this issue were as the guarantor infrastructure for implementing the projects, which they were the issues in terms of improving the quality of environmental indicators, and in particular desertification in the cities and provinces around of desert. Therefore, it was tried to find ways to solve the problems caused by these environmental issues through a precise study of the desertification and lack of water resources in the deserts of the central Iran plateau.

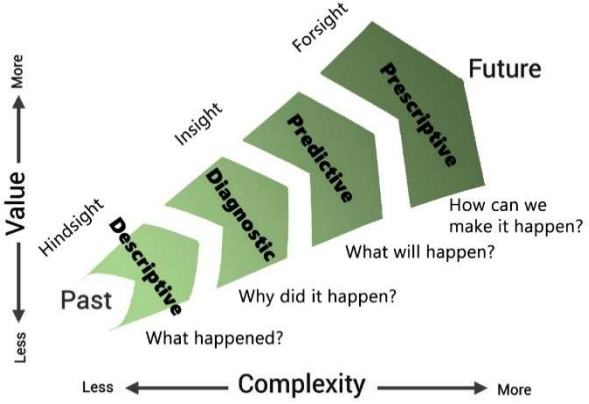
Research Innovation

Today, numerous researches are being done on environmental issues, and in particular desertification and drought management, and each of them presents solutions to the dilemmas caused by these environmental issues. This research, with a wide-ranging and comprehensive approach, tried to find the new form of agriculture landscape (based on the assessment of the ecological potential in the area of case study for agricultural activities), so that the issues of environmental protection and desertification posed as the main and effective issues in sustainable Development. It will review the consequences caused by the lack of attention to this area in urban dilemmas such as suburbanization, compulsory migration of villagers to the city, the concentration of poor people in different urban areas, demographic imbalance and so on. In general, it can be said that most studies have been conducted concerning the impact of artificial ecosystems in the desert on the sustainable development, and with a new look can consider the interaction of natural and artificial ecosystems and their impacts on the urban system.

Research methodology

Given the importance and breadth of the subject matter of the research as well as the widespread scope of the research due to its interdisciplinary nature, the implementation of descriptive-survey research can lead to a better awareness of existing conditions and assist in the decision-making process.

In other words, this research examines the status quo and introduces the systematic description of its current state (descriptive-analytic) and examines its features and attributes, and the relationship between variables (diagnostic-analytic). Then it tries to propose ways to solve the problems (prescriptive-analytic) by future modeling scenarios(predictive-analytic).



In this method, in order to obtain the necessary information and to get acquainted with the concepts of research, first, the focus is on the descriptive method. In this regard, books, articles, and previous studies are dealt with and after reviewing the methods used in previous studies, the basis of the implementation of this research will be formed.

The main achievements of this phase are a deeper knowledge of the desert and settlement system in the margin of the desert, that it is called, in this study, as H.S.O. (Hierarchy System of Oasis) and also, recognition of existing agricultural systems.

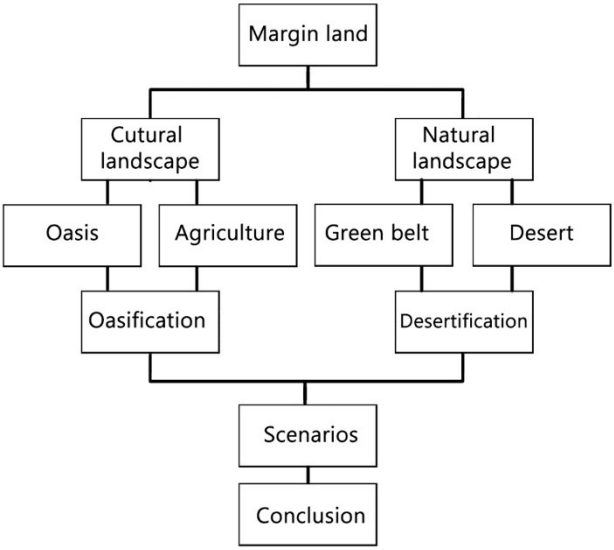
Meanwhile, in order to implement a survey method, based on the studies, it is used the IMDPA model (Iranian Model of Desertification Potential Assessment). The basis of the IMDPA model is the MEDALUS model (Mediterranean Desertification and Land Use, presented by the European Commission in 1999).

In this research, it is focused on soil and water data. Those relating to the soil are the result of 3 indicators: Electrical Conductivity (EC), depth, the texture of the soil; while those related to water are the result of the following indicators: Electrical Conductivity (EC), SAR, Reduction of groundwater level. Data were prepared and evaluated according to the IMPDA score table. The results obtained were integrated and processed in the ArcGIS software as an information level. The corresponding maps were synthesized using the medium geometric method, producing a final desertification map of the Kashan plain based on the IMDPA model. Using ArcGis, Excel, Autocad, Photoshop software, the data was analyzed to determine the severity of desertification in the study area.

Due to results of these two past phases, it is modeled in 3 scenarios to finding what will be happened. The scenarios are based on confronting and controlling desertification by

oasification and creating the new oases or strengthening and reviving existing oases.

Finally, with looking at the future and the past at the same time, also with respecting the existing culture and tradition, the new spatial configuration based on using modern-traditional methods is proposed.



DESERT

FROM FANTASY TO REALITY

Biaban in literature and myths

Desert has a special role in Persian literature, and it appears as the main subject of travelogues or the main background of novel events and stories. In this section, relying on ancient Iranian literature and especially Ferdowsi's Shahnameh[1], one of the world's longest epic poems, the desert is recognized as the main context of research. In ancient Persian literature, there is no reference to the creation of the desert, but the desert is shown as a result of nature destruction by humans.

In this regard, we refer to the story of Feridoun and Zahhak in Ferdowsi's Shahnameh:

".. Now it came about that the mother of Feridoun feared lest the Shah should destroy the child if he learned that he was sprung from Jemshid's race. So she hid him in the thick forest where dwelt the wondrous cow Purmaieh,...

.. Zohak[2] had found the beauteous Purmaieh and learned of Feridoun, and when he heard that the boy was fled, he was like unto a mad elephant in his fury. He slew the wondrous cow and all the living things round about and made the forest

[1] The ***Shahnameh*** (The Book of Kings) is written by the Persian poet Ferdowsi, between 977-1010 AD

[2] The correct name is Zahhak

a desert. Then he continued his search, but neither tidings nor sight could he get of Feridoun,..."[3]

In the literature and beliefs of the ancient Persians, the cow is a symbol of fertility[4], growth, and "the testicle of the heavenly Cow which makes the earth fertile and also the milk of the heavenly Cow which is people's aliment"[5]. In fact, Zahhak destroys the fertility of creatures by killing the cow. Then he burns the mansion and destroys the forest. What remains is a plain without plants, animals, and humans; that in the Persian language it is called the *Biaban*.

The *Biaban* (desert) in Shahnameh is always the scene of numerous conflicts and wars between good and evil, demon and man, death and life. Belief in the presence of demons, evil spirits, and jinn in desert areas is not limited to the *Shahnameh*, the reference to this issue is often seen in other ancient Iranian literary works such as *The Bustan of Saadi* [6] and even in the folk tales such as *One Thousand and One Nights*.

These beliefs have influenced all aspects of Iranian life, including architecture and urban planning and landscaping, not just literature. In Iran's desert, there was no human life as a Bedouin or living in a tent; and even, in traveling and crossing of the desert, they stopped in caravanserais. They lived on the edge of the desert, often in the castles with high walls, and with agriculture and animal husbandry around the houses or castle, they created a green and livable place in contrast to the desert. This complex, regardless of its size, is called "*Abadi*".

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[3] H. Zimmern, *The Epic of Kings: Stories Retold from Firdusi* (T. Fisher Unwin, 1882)., p.6

[4] A. Z. Alavijeh, "Representations of Cow in Different Social, Cultural, Religious and Literary Contexts in Persia and the World," *Asian Journal of Social Sciences & Humanities Vol* 3 (2014): 1.

[5] J. R. Hinnells, "Persian Mythology" (Chancellor Press, imprint of, 1997)., p.19

[6] The ***Bustan*** is a book of poetry by the Persian poet Saadi, completed in 1257 AD

Abadi and *Biaban*, two antithetical neighbors

The term *Abadi* is defined in the Dehkhoda Dictionary with the meanings of manufactured, architected, cultivated, and inhabited. It has been assumed to be a synonym for the village, town, and city and an antonym for ruined, ruin and deserted.[7]

In Persian, the word "*Abadi*" terminologically confirms this way of approaching it since the word "*Abadi*" in Persian is derived from the word "*Ab*", that it means water, and water refers to the prosperity of life, plenteous crops, and the life survival.

In a nutshell, one can say that in Iran, the areas turned into settlements due to human involvement in nature are called "*Abadi*".[8] This term is very much used especially in the central regions of Iran, which are in the vicinity of the Dasht-e Lut and the Dasht-e Kavir as almost the name of most of the villages of the desert and warm areas are at least composed of two parts that the second part is always "*Abad*" such as Noush-Abad, Ali-Abad Sofla, etc. The term "*Abadi*", meaning a place where water, life, and human habitation exist, is

[7] A. A. Dehkhoda, *Dehkhoda dictionary*, *Tehran: Tehran University*, 1998.

[8] M. Abbaszadegan, *Iranian Ruralscape* (Tehran: University of Tehran press, 2016). *P.13*

contrary to the word *Biaban*; "*Biaban*" in Persian language (desert in the English language) is a plateau or plain without water and herbs. The desert, meaning dehydrated and waterless land.[9] So it means a deserted place without living and housing conditions. However, despite the semantic contradiction in the terms of *Biaban* and *Abadi*, as both words are derived from the word "*Ab*"(water) in the Persian language terminologically, the landscape of *Abadi,* as a human-made and manufactured landscape, is not in conflict with the natural landscape of *Biaban*, but, it is actually derived from the *Biaban* and in response to the needs of the inhabitants of the *Abadi* for the climatic comfort.

Henceforth, for better readability, the English equivalent of these words will be used; Oasis and Desert.

[9] Dehkhoda, *Dehkhoda dictionary*. P.4462

Oasis as a cultural landscape

> *"Oasis is a human settlement that in arid geographical conditions uses locally available resources to create an amplification of positive effects and determine a self-sustainable vital niche and a fertile environment in contrast with the surrounding unfavorable desert."*[10]

Human settlement leads to the formation of a hamlet or an oasis. What is known as an oasis encompasses not only the village but also all kinds of human settlements, including houses, farms, villages, towns, and cities. That is the manifestation of the outer dimension of man's life and his connection with the environment, which is an interventional relationship to create proper conditions for human housing and settlement.[11]

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[10] P. Laureano, *Sahara,Giardino Sconosciuto*, II edizion (Firenze: Giunti, 1989).

Italian text: "Oasi è un insediamento umano che in condizioni geografiche aride usa le risorse disponibili localmente per creare una amplificazione di effetti positivi e determinare una nicchia vitale autosostenibile e un ambiente fertile in contrasto con l'intorno sfavorevole deserto"

[11] Abbaszadegan, *Iranian Ruralscape. P.13*

Due to the OG [12] and its definition of the cultural landscape, an oasis can be known as a cultural landscape:

> *"Cultural landscapes are cultural properties and represent the "combined works of nature and man" designated in Article 1 of the Convention. They are illustrative of the evolution of human society and settlement over time, under the influence of the physical constraints and/or opportunities presented by their natural environment and of successive social, economic and cultural forces, both external and internal."*

What we call cultural landscape today may be a new word in terms of vocabulary, but it has a long history of existence. Since nature forms all the fields and foundations of human activity, human beings have always influenced their surroundings and, by manipulating and interfering with the intact natural landscape, have created new landscapes that we now see them as designed landscapes. These designed landscapes in different periods have been created in various forms from agricultural fields to gardens, ornamental gardens, hunting grounds, religious complexes, biological complexes, etc. in different parts of the world, such as Southwest Asia, East Asia such as India, and Europe. So the relationship and interaction between humans and nature have a long history.

This concept is currently used for specific purposes of the World Heritage. The phrase "cultural landscape" exactly in this way, was first introduced in the United States in 1925 by Professor Carl Sauer. He argues that the cultural landscape is a phenomenon shaped by the natural landscape by cultural groups. Culture is considered as a factor, the natural landscape as a background, and the cultural landscape as its outcome and consequence.

According to this definition, cultural values shaped by social groups, traditions, beliefs, and different valuation

[12] Operational Guidelines for the Implementation of the World Heritage Convention (WHC.19/01 - 10 July 2019)

systems form human needs. These needs are processed through the significant interaction of humans with their surroundings and their perception of nature. Thus, cultural landscapes are formed.

In another definition, a cultural landscape refers to the section of land where significant modifications have occurred by humans. These modifications are designed to distinguish these sections from the intact nature, in such a way that in which no traces of human intervention can be seen. This definition is somewhat ambiguous, due to the lack of a common understanding of significant modifications and general agreement on what is natural and intact.

Mathews & Lennon define the cultural landscape such as a mosaic composed of:

1. Natural elements and features
2. Details and physical components of the modifications made to the characteristics of nature by human activities during several historical periods
3. Patterns are created in these landscapes over time. These are layers within or on the landscape.[13]

The following definition of the cultural landscape is presented by the Cultural Landscape Foundation of America[14]:

A cultural landscape is a geographic area involving cultural and natural resources associated with a historical event, activity, or person. Sometimes cultural landscapes are derived from the activities of a person or group on the ground. At other times, they are the result of the ideas of individuals or groups on the ground and created in a period.

The cultural landscape is a concept that discusses both the relationship between man and nature in the past, and the life

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[13] J. Lennon and S. Mathews, *Cultural Landscape Management: Guidelines for Identifying, Assessing and Managing Cultural Landscapes in the Australian Alps National Parks: Report* (Australian Alps Liaison Committee, 1996).

[14] https://www.tclf.org/

of today, and the interaction of historical places with the locals. Cultural landscapes are a symbol of the sustainability of the spiritual and material values of land. They are the intersection between nature and culture, tangible and intangible heritage, and the biological diversity and the essence of the culture and identity of the people of the land.

The intrinsic values of a place, including ecological and cultural ones, shape the value and importance of a cultural landscape. Cultural values are related to people who have lived in this land throughout history to date and have influenced the environment through their thoughts and actions and transformed it.

An important point to be taken into account in relation to the cultural landscape, in particular, and landscape, in general, is their constant change and dynamism over time. Since the term cultural landscape involves the interaction between humans and their natural environment, emphasis on the participation of people as the best means to protect the land authenticity, the continuation of authentic ways of life and indigenous experiences, along with new innovations and initiatives in order to make the life dynamic, and also paying attention to different aspects of the landscape, especially its multidisciplinary, are key issues of the cultural landscape.

Cultural landscapes often reflect the specific techniques of sustainable land use, and in this way, they consider the characteristics and constraints of their "mother" natural environment, as well as the special spiritual relationship with nature. Supporting landscape can improve modern land-use techniques and increase the natural values of the landscape. The continued existence of traditional forms of land use supports biological diversity in various regions of the world. So, the protection of traditional cultural landscapes is also useful for preserving biodiversity.

A cultural landscape has different characteristics that distinguish it from other landscapes or legacy sections. The

World Conservation Union has identified 16 characteristics of a cultural landscape in its guidelines and programs as follows:

"A cultural landscape:

1. is concerned with both people and their environment;

2. is concerned with a range of natural and cultural values;

3. focuses on areas where people/nature relationships have produced a landscape with high aesthetic, ecological, biodiversity and/or cultural values, and which retains integrity;

4. is both a type of protected area with combinations of special qualities, and a management process to guide change;

5. reflects a visionary and pro-active approach, aiming to enhance values rather than simply to maintain or protect existing assets;

6. views communities, and their traditions, as fundamental to the success of the approach: therefore, stakeholder and partnership approaches are required, e.g. co-management…;

7. recognizes the value of, and the need to support, the stewardship role of the private landowner or manager (including that of Land Trusts or similar bodies);

8. usually involves management arrangements that are determined by local circumstances and needs, and resolved through decision-making at local government or community levels;

9. places a special emphasis on effective land-use planning;

10. depends therefore on the presence of transparent and democratic structures which support peoples' active involvement in the shaping of their own environment;

11. brings social, economic and cultural benefits to local communities;

12. brings environmental, cultural, educational, and other benefits to a wider public;

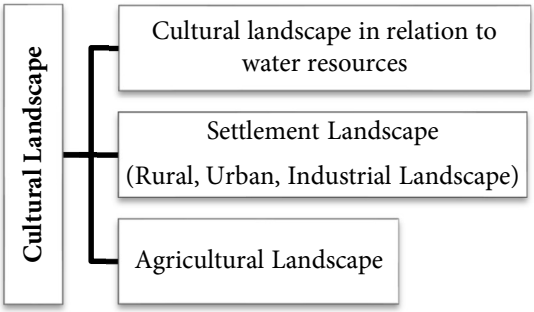
13. requires that all management activities be integrated, and promote sustainability;

14. can be used to help resolve conflicts over resource management;

15. can offer models of sustainability for wider application elsewhere in rural areas;

16. like all protected areas, requires effective management systems, including the setting of objectives, planning, resource allocation, implementation, monitoring, review, and feedback."[15]

In the following, we focused on a general review of the cultural landscape in the arid and semi-arid regions in Iran and recognizing the characteristics and elements shaping such a landscape. For a better review, these landscapes are divided into 3 categories:



[15] V. Coleman, "Cultural Landscape Charette: Background Paper," *NSW Heritage Office*, 2003.

QANAT, TRADITIONAL INFRASTRUCTURE OF WATER TRANSFER SYSTEM

Qanat is a subterranean tunnel-well originating in pre-Achaemenid Persia[16]. Throughout history, the Qanat or Kariz has been the most important and widespread water supply and transfer system in ancient Persia and more than 34 other countries.[17,18] The term Kariz is Persian; also it calls Kariz, Kahriz, Qanat, Canat, Foggara, Falaj.[19]

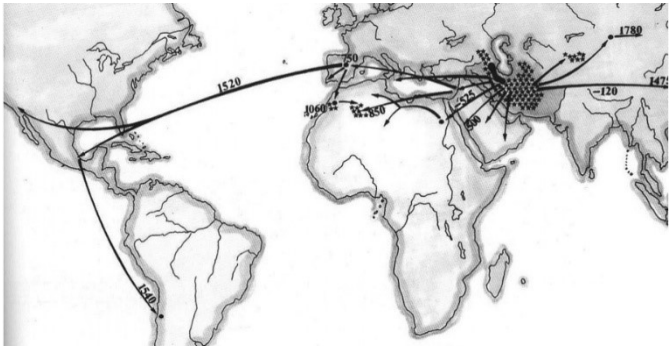


FIGURE 2
Distribution of qanats in the world[20]

Based on available resources, the idea of constructing Qanats came to the minds of miners in the northwest of Iran thousands of years ago. During the search for copper ores in the mountains and by constructing a drain on the floor of the mine galleries and accidentally got to the technique of the creation of the aqueduct. The construction of such Qanats

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[16] P. W. English, "The Origin and Spread of Qanats in the Old World," *Proceedings of the American Philosophical Society* 112, no. 3 (1968): 170–81.

[17] M. Jomehpour, "Qanat Irrigation Systems as Important and Ingenious Agricultural Heritage: Case Study of the Qanats of Kashan, Iran," *International Journal of Environmental Studies* 66, no. 3 (2009): 297–315.

[18] S. A. Naghibi et al., "Groundwater Qanat Potential Mapping Using Frequency Ratio and Shannon's Entropy Models in the Moghan Watershed, Iran," *Earth Science Informatics* 8, no. 1 (2015): 171–86.

[19] G. B. Cressey, "Qanats, Karez, and Foggaras," *Geographical Review* 48, no. 1 (1958): 27–44.

[20] M. Khansari, M. R. Moghtader, and M. Yavari, *The Persian Garden: Echoes of Paradise* (Mage Publishers, 2004). pp.26

dates back to the first millennium BC, but the use of Qanat water in agriculture was common a few years later. The first source pointing to supply the water of a settlement by a Qanat was the inscription of Sargon II, the king of Assyria in 700 BC. [21]

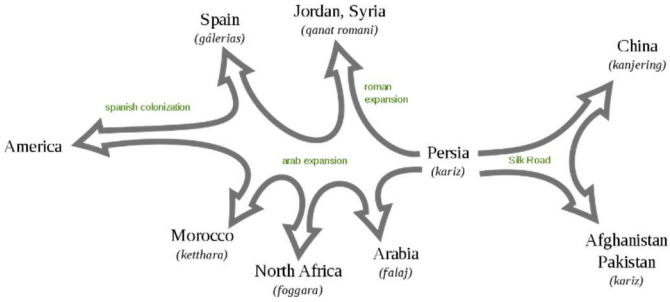


FIGURE 3
Qanat technology diffusion model and its various names in other countries[22]

The structure of the Qanat is a set of two major parts:

-A low-sloped underground horizontal channel from the foothills to the plain, which directs water from the groundwater table to the surface.

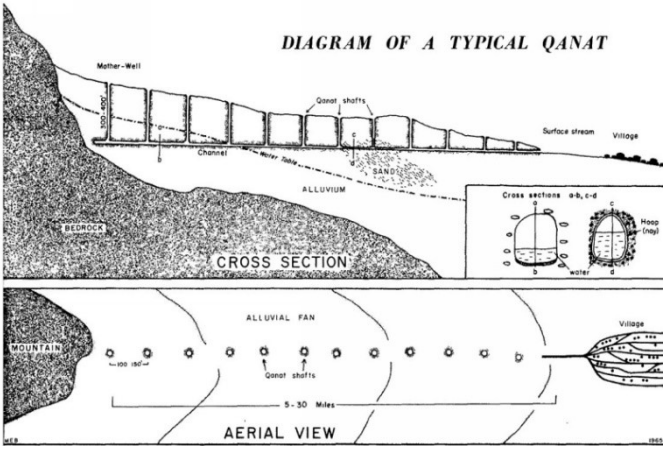
- The series of vertical wells that are used to ventilate the horizontal channel and also remove the excavated soil during the Qanat construction from the underground, as well as repair and restoration of the Qanat. (Figure 4)

There are many reasons for the spread of the Qanats in Iran, the most notable of which is the climatic conditions of a large area of Iran. This water extraction system was invented following the climatic and environmental conditions specific to arid and warm, and semi-arid regions of Iran and expanded to other countries.

[21] H. Goblot, *Les Qanats: Une Technique d'acquisition de l'eau*, trans. M. hossein Papoli Yazdi and A. Mogadam, vol. 9 (EHSS, 1979).

[22] M. Taghavi-Jeloudar et al., "Review of Ancient Wisdom of Qanat, and Suggestions for Future Water Management," *Environmental Engineering Research* 18, no. 2 (2013): 57–63.

FIGURE 4
Section and aerial view of Qanat system[23]



In the contemporary era, the number of aqueducts was increasingly diminished, and the digging of the well was replaced by Qanat using modern technologies. Before the land reform in 1962[24], there were about 50,000 Qanats in Iran, but subsequently, the development of Qanats stopped and their destruction began. During less than a quarter of a century, with the loss of more than 20 thousand Qanats with 100 thousand kilometers in length, an endpoint was founded in the era of Hydraulic Civilization in Iran.[25]

The role of Qanat in the formation of Iranian civilization

The completion of Iranian civilization is linked to Kariz, a link that lasted for several thousand years and established a bilateral relationship between Iran's history and geography. In the past, a vast range of Iran was known as the Hydraulic Civilization.[26] The ancient civilizations of Iran from Kashan

[23] English, "The Origin and Spread of Qanats in the Old World."p.171

[24] D. Craig, "The Impact of Land Reform on an Iranian Village," *Middle East Journal* 32, no. 2 (1978): 141–54.

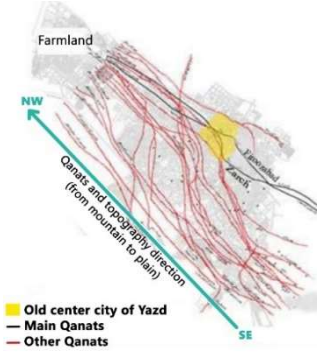
[25] M. Ahmari, "An Interpretation of Exclusions of Land Reforms in Iran," *Http://Pahlaviha.Pchi.Ir/Show.Php?Page=contents&id=18126*, 1990.

[26] Goblot, *Les Qanats: Une Technique d'acquisition de l'eau*.

Silk, Damghan, the Burned City of Zabul, and Shahdad in Kerman in arid lands to historic cities such as Rey, Yazd, and Kerman, could not be built without Qanat. The Qanats are still considered to be a major source and in some cases the only source for agricultural and drinking water supply in some villages of those civilizations. Up until about 40 years ago, the cities and villages of the arid and warm region of Iran continued to exist by Qanat water distribution network as infrastructure.[27]

The impact of Qanat on the form of cities and villages

The form of cities in the arid and warm region was affected by the entrance of the Qanat and the extension and distribution of water on the ground[28], so that the transit network and the form of division of land in these desert towns were completely in line with the water supply network of Qanat. Among them, Kerman, Meybod, Ardakan, Mehriz, Yazd, and Bam can be noted.



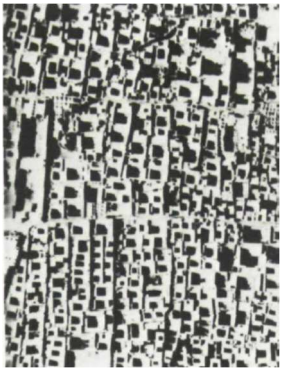


FIGURE 5
Left: Direction of Qanat in Yazd[29]

FIGURE 6
Right: Linear street and linear rows of open courtyard in Yazd[30]

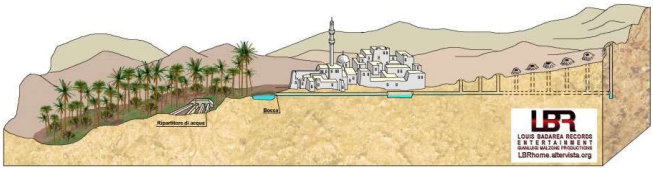
[27] M. R. Haeri, "Qanat in Iran," *Cultural Research Bureau, Iran (in Persian)*, 2007.

[28] M. E. Bonine, "The Morphogenesis of Iranian Cities," *Annals of the Association of American Geographers*, 1979.

[29] N. Ashrafi and G. Safdarian, "THE IMPACT OF QANATS AS SUSTAINABLE URBAN INFRASTRUCTURES ON THE PROCESS OF FORMATION OF URBAN STRUCTURES AND ARCHITECTURE," *Indian Journal of Fundamental and Applied Life Sciences* Vol.5 (S1) (2015): 892–901.

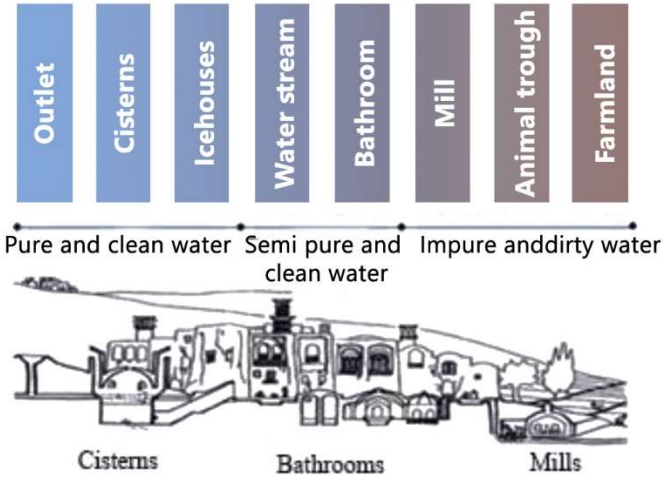
[30] Bonine, "The Morphogenesis of Iranian Cities."

FIGURE 7
Section of Qanat system and prioritization of the passage of water through residential areas and farms[31]



In the formation of these settlement landscapes and the choice of land use, the route of the water of the qanat has played a decisive role. Functions such as cisterns of water, drinking and sanitary purposes were closer to the outlet of Qanat (Mazhar), to using pure water of underground tunnel. The livestock and traditional industries were in the second rank of importance with using of water of the ground surface channel. Finally, the flow of water, after passing through the urban or rural texture, was directed toward the farms.[32,33]

FIGURE 8
The range of uses of qanat water based on water quality requirements



[31] http://lbrhome.altervista.org/antichi-acquedotti-qanat-e-foggara

[32] P. W. English, "Qanats and Lifeworlds in Iranian Plateau Villages," *Yale F&ES Bulletin* 103 (1998): 187–205.

[33] M. E. Bonine, "Qanats and Rural Societies: Sustainable Agriculture and Irrigation Cultures in Contemporary Iran," *Canals and Communities: Small-Scale Irrigation Systems*, 1996, 183–209.

The social dimension of the Qanat

Agricultural production in the arid and warm climate and therefore human habitat of these areas was based on the Qanat water supply system. Various types of Qanat-centered ecosystems had been generated from the optimal gathering of several households in low rainfall conditions for the optimal utilization of land and coexistence with their habitat. Qanats utilization and protection management in arid and warm regions of Iran were quite popular. The traditional system of water sharing has brought coexistence and cooperation between people in the region throughout history to date. Collaboration in society is considered an intangible social capital that increases the potential for development in that region.[34]

Qanat and agriculture

Each village is a sustainable human complex that has continued based on the exchange of generations' experiences and their continuity in interacting with the environment. In this case, and in particular, in the livelihoods of villages and cities, which are largely responsible for agriculture, the Qanat balances the amount of rainfall and groundwater harvesting. The type of annual cultivation is also different based on the experience and amount of annual water of the Qanat. Water supply by the Qanat from the depths of the earth to the gardens and farms can be considered as the most important role of the Qanat in "Hydraulic Civilization"[35]. The following diagram shows the hierarchy of connecting nature to the lives of villagers through the Qanat.

The Qanat irrigation system has three main advantages:

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[34] Haeri, "Qanat in Iran."

[35] A. Ashraf, "Historical Obstacles to the Development of a Bourgeoisie in Iran," *Iranian Studies* 2, no. 2–3 (1969): 54–79.

- Underground canalization reduces water waste and evaporation
- Since the flow is based only on gravity, there is no need to use a water pumping system.
- In the groundwater extraction system by Qanat, groundwater resources are renewable.

Qanat as a technical and engineering achievement

Due to limited tools and slight growth of technology in the ancient world, the Iranians brought water from the hillsides overlooking the low and drylands to Iran with the advent of the smart technique of Qanat. Most major cities in Iran located on mountain slopes were developed following this technology. In general, the balance between the arid nature of the desert and the man can be considered as the highest aspect of the Qanat. Qanat is a consequence that has wide and complex dimensions while being simple. The most prominent tangible and intangible aspects of the Qanat are expressed in the following table.

Intangible aspects	Tangible aspects
Qanat construction technology and Qanat water distribution and management system	Supplying drinking water to people
Cooperation and solidarity between people	Supplying agricultural water
Qanat literature	Influencing the form of cities and villages
Influencing people's customs and beliefs	The factor of the formation of civilization
The social organization of cities and villages	

It is necessary to take into account the importance of the intangible cultural heritage as the driving force and the main

motive for cultural diversity and a guarantee of sustainable development. The deep attachment between the intangible and intangible cultural heritage and natural heritage is also significant. Supporting the social structures of traditional knowledge and indigenous experiences and recognizing the substantial role of intangible and spiritual values for managing and revitalizing cultural landscapes is vital. In general, it can be said that the most complex layer of cultural landscapes is their intangible structure and heritage the continuance of which is of great importance and much attention should be given to the management of cultural landscapes.[36]

Human being as a part of nature's ecosystem

The Qanat-centered ecosystems were considered as part of the environmental cycle, all elements of which functioned in a systematic and reciprocal relationship, so that rainfall fitted with water stored in groundwater tables. So, the natural harvest from groundwater tables by Qanats kept their water balanced for centuries. The quality and quantity of the product and, consequently, population growth in these areas were directly related to the amount of water. Thus, the society set itself up with these resources in two ways: It changed the scale or crop of the lands under cultivation and the pattern of cultivation, due to the amount of Qanat water in that year, and the overflow of the population migrated in years of low water and low crop.

In the past, the Qanat was constructed coherently and considered as an element of social and environmental systems. So, there was always a stable balance between the Qanats, society, and the environment, and there was never a maximum efficiency at the cost of damaging the environment and society. This is a great lesson that can be learned from the Qanat management and applied in other areas.

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[36] M. hosein Papoli Yazdi, *The quassabeh quanat in gonabat a myth* (mashhad, 2008).

Qanat and landscape

There is a bilateral relationship between humans and the earth on which they live. In this relationship, human beings and the earth shape each other mutually, both physically, with goals such as agriculture and habitation, and mentally through the planning of imagination and dreams. In the past, civilizations also used the geographic features that would lead to the sustainability of life more deeply, and gradually organized the land-based on social relationships derived from the environment. As the strategy of civilization organizing and human settlement over time led to the formation of the landscape.[37]

Consequently, the Qanat place was to acquire water in a desert environment and establish a stable interaction in coexistence with nature. The human beings saw themselves as part of the ecosystem cycle and behaved in a manner consistent with the capacity of a desert environment, so that Qanat was the best response to the most basic human needs of human life, namely water.

Groundwater tables are almost the only source of water for desert areas. The choice of location for establishment and residence, the size of agricultural lands and their product types, population growth and migration, and the organization of social life were all based on the amount of water given by nature and transmitted by the Qanat. So from the past to the present day, Qanat has been considered as an infrastructural element for indigenous settlements in arid and warm, and semi-arid regions.

Qanat is an artificial landscape that is itself hidden in the ground. At the same time, Qanat has also considered a landscaping factor, so that the gardens of the crop, agricultural lands, and even Iranian gardens in the desert

[37] I. J. Robertson and P. Richards, *Studying Cultural Landscapes* (Arnold, 2003).

environment have been created only through the Qanat water and continued to exist.

Rural landscape

The landscape of the village consists of elements and qualities that nature and its natural environment form its most majority. In other words, the basic factor distinguishing the nature of the city from the village is the presence of nature in the rural environment.

The rural architecture of Iran encompasses a diverse set of settlement forms, which display different visual and physical qualities in each region influenced by various geographic, climatic, and cultural factors. Therefore, the rural landscape characteristic is influenced by physical variables (due to different geographic and climatic characteristics, etc.) and plays a major role in understanding and perceiving the environment.

The difference between rural landscape and urban landscape originates from further sequences and a variety of natural landscapes of the rural landscape compared to the natural landscapes of the urban landscape. The physical landscape of the village is mainly understood in the context of its natural landscape and only limited parts, including the collective rural spaces, have a completely human-made landscape. In other parts of the village, the natural landscape prevails in the field of vision. From the rural perspective, various cultural-historical and socio-economic factors along with natural factors form the activities and specific organization of production and determine the economic units. This process comes from the interaction between the apparent landscape and the internal image of the village, which will present a unique cultural landscape as an integrated set.[38]

[38] Abbaszadegan, *Iranian Ruralscape*. *P.14*

Studying the landscape of the village plays an effective role in the process of recognizing the identity of the village. In other words, the recognition of the elements forming the landscape confirms the quality and identity of the village since the landscape and image of the village is a response given to the set of existing economic, physical, and cultural factors over time, suggesting that how people have matched with different conditions and environments or how they coordinate the environment with themselves.[39]

Effective factors constructing the landscape of villages

The village is a united phenomenon that different cultural, social, and ecological factors cannot be separated from it because it includes people who have a particular job and production activity, live in a specific environment, and have special and determined relationships and communications with each other, have specific beliefs and values and live in a specific geographical context as well. Considering these, recognizing these factors contributes to providing the solutions and physical decisions in the village according to the realities in the village to be useful in improving the quality of the village. In this section, we examined the factors affecting the village landscape on different scales.

Natural effective elements

Every living complex (urban or rural) has been formed in a natural context. To assess the status quo and to achieve sustainable development, we need to identify the natural effective elements and clarify how to deal with them. The natural elements considered in this section include water resources, land characteristics, vegetation, and climate.

The water resources in the villages are diverse and each one somehow affects the village landscape. These resources include river, Qanat, spring water, well, pond or marsh, and the sea.

[39] Abbaszadegan, *Iranian Ruralscape*. *P.14*

a) River

The river, as the main source of water supply, can have a direct impact on the settlement landscape. The first effect, due to the easy access to water, is the probability of linearizing the texture of the village. In some cases, the rural life context is not formed beside this element due to the quality and natural shape of the river like rivers with spiral shapes, then under the conditions, there is a risk of flood. In such cases, due to the possibility of a flood, the village is inevitably located far from the river. In terms of the hierarchy of settling, the residential units are often built immediately after the embankment dam or the flood wall used as a suitable shield for a rural home to provide the access to the river for use of water for domestic use or commuting by boat. In the same way, public buildings and community spaces are often located in relation to the view of the river.[40]

FIGURE 9-10
The linear texture of Taft city, in Yazd province, along the river
Up: satellite photo from google earth
Down: © ISNA news agency

[40] A. Zargar, *An Introduction to Rural Architecture in Iran* (Tehran: Universiy of Shahid Beheshty Press, 1999).

b) Springwater and Qanat

Due to the spotting nature of the water of the spring water or Qanat, the texture of the villages relying on this type of water source is spotty and quite compact. The most important point is the issue of water constraints; however, the same amount of water may also reduce. For this reason, when the population of such villages reaches saturation in terms of exploitation of water, the people will face limitations in terms of physical development but will not change morphologically since they have not the capacity to accept more due to limited water resources as the main source of human and agricultural life.

Qanats and spring waters affect the whole rural landscape for the following reasons:

Due to the shape of the land, the Qanat outlet is often located in the upper part of the village. The texture of such villages is mostly shaped like a spot. The movement of water is from the Qanat outlet towards the village. Inside the village and in the texture traffic network, it is a function of the shape and slope of the earth. As a result, access to the streams directing the water of the Qanat or the spring water is seen as a value and the passageways are placed along the streams according to the direction of the water movement. In other words, the direction of the water movement has a direct effect on the morphology of the village. Naturally, due to the importance of the Qanats and spring waters in supplying water for the villages of the country, in the first place, the outlet of the spring water and Qanat is effective in locating; gradually, the center of the neighborhood is strengthened by increasing the population of the village. One of the notable points in this regard is the formation of the center of the neighborhood at the water division point of the spring water or Qanat. The outlet of the fountain or the Qanat affects the formations of neighborhoods of the village in addition to the center of neighborhoods and the hierarchy of habitation occurs based on the closeness or distance to the outlet of the

Qanats or spring waters. In these villages, following the establishment of residential units in the path of the spring water and Qanat, the main gateway is formed according to the direction of the water movement.[41]

In villages, where Qanat is the main source of water supply, traffic nodes and social hangouts are formed at the site of water division and its path deviation. Accordingly, the pattern of the passages network falls into a relative order and approaches the chess pattern. However, in the villages where spring water is the main source of water supply, irregular and non-geometric passages are formed due to adherence to the fountain path.

The presence of irregular and non-geometric passages in many villages can be due to the following of the movement of water. On the other hand, due to the cleanliness of the water in the Qanat outlet and its gradual contamination, the proximity to the outlet of the Qanat or spring water well is considered a valuable asset, and houses far from this point will be deprived of this certain advantage. Thus, the texture of the village can have a kind of physical-social hierarchy according to the distance to the outlet of the Qanat and its streams.

The following table summarizes the characteristics of the Qanat or spring water and their effects on the rural landscape.

Features of Qanat or spring water	**Impacts on the landscape**
The spot-like outlet of the water	The formation of buildings around the Qanat outlet
Water limitation	-Capacity limitations of the population -Texture compression -The limitation of the physical development of the

[41] Abbaszadegan, *Iranian Ruralscape*. P.23

	village
The formation of water transmission mainstream	-Organic formation of passages based on water movement -The formation of the hierarchy of neighborhoods
The outlet or location of water distribution	Places of assembly and nodes

c) Well

In areas where there has been no surface water in the form of a river or the water needed by the village has not been supplied by the spring waters or Qanats, wells and water harvesting from underground aquifers have been the most important elements of water supply either for drinking and domestic consumption or for agriculture. Some spaces were usually formed next to the water wells for stopping and taking water. The prevalence of pumps is a relatively new phenomenon that brings the water of wells from the lower layers of the earth to its surface and pours it into the pools, which will be then directed to the farms and the village. Also, the use of plumbing has increased the flexibility in the texture of the village since there is no longer any need to follow a specific waterway path with a specific movement and direction through the village.[42]

d) Pond

The pond is another factor affecting the spatial form of the countryside. In some areas of Iran, due to the salinity of the groundwater, the villagers supply their needs for fresh water through the gathering of rain-based freshwater in the ponds. This type of water source is seen in the highly deprived and

[42] Zargar, *An Introduction to Rural Architecture in Iran*.

remote areas, including parts of Hormozgan province and south of Kerman.[43]

FIGURE 11
Hootak: pond of water in *Sistan va Baluchestan* province

The methods of conservation and storage of water in villages lead to the emergence of several architectural spaces and components. Some examples of such architectural and spaces and constructions were mentioned in the following.

Attempts to prevent the water spillage in the streams' bed and/or its severe evaporation during the transfer from the source to a place of consumption have resulted in the development of multiple methods, each of which somehow affects the landscape of the village. In order to prevent surface evaporation, the villagers cover the streams or plant trees around the water streams. The evaporation of water is prevented by creating shadows in the village and preventing the direct sunlight. Also, the trees act as a type of windbreak and reduce the amount of water evaporation. Such methods for preventing water evaporation affect the village landscape.

e) Pool

It is very common to collect water in the pool for optimal irrigation of farms and storage of water. The stone or concrete beds are used in these pools for more productivity and preventing water spills or evaporation in addition to creating the necessary vegetation around them.

[43] Zargar, *An Introduction to Rural Architecture in Iran*.

FIGURE 12
Pool with a capacity of 500 cubic meters in Ghasem-Abad village (photo by Mahanz Sarlak-2018)

f) Cistern (Ab-Anbar)

Ab-Anbar or Cistern of drinking water is another water storage element. There are two types of storage water in the villages: Household and neighborhood water storage. Public water cisterns have a local bond type and are located next to the square or passage or somewhere that its neighborhood affiliation is known.[44]

Sometimes an open space can be seen in the center of the neighborhood, which has previously been the location of water storage. If a village has not been very large, it might have only one *Ab-Anbar* (water storage), which has been located in the collective space of the village. The general shape of the *Ab-Anbar*s (water storages) is rectangular or circular with a dome roof. Water reservoirs (*Ab-Anbar*s) are considered one of the highest points in the skyline of the village. Thus, this element is visible in the village's distant landscape (view). In some villages such as Fahraj village, Yazd, the size of the Windcatchers of the *Ab-Anbar* is very large and its dome is completely surrounded by the windcatchers. There are some *Ab-Anbar*s in Hormozgan,

[44] Zargar, *An Introduction to Rural Architecture in Iran*.

Bushehr, and Semnan provinces, which usually have very tall and wide domes with no windcatchers.[45]

Wind and its impact on the rural landscape

There are local winds in each of the desert districts and areas, which have a direct impact on the residents, architecture, and the landscape of the village. In a general classification, we can divide the winds into two useful and harmful groups. Certain physical solutions are considered for each group of these winds.

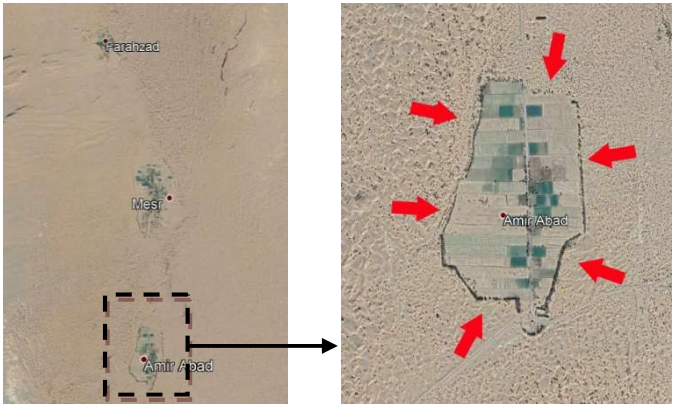

FIGURE 13
Amir-Abad village, in Isfahan province, and its farmlands are surrounded by trees as the windbreak (Google Earth)

In warm and dry climates, the following measures are taken to deal with the harmful winds:

- Planting trees, shrubs, and bushes specific to the low-water and desert areas in the sand deserts such as planting Haloxylon to prevent the invasion of running sands into the villages
- The creation of barriers against the movement of running sands, planting trees, or making walls adjacent to villages perpendicular to the wind
- Planting trees in the texture of the village
- Establishing the village in the shelter of a cliff or a valley
- Making a compact texture
- Twisting and narrow pathways

[45] Abbaszadegan, *Iranian Ruralscape*. P.27

- Pathways perpendicular to the direction of the wind
- Covering a part of the passages

Urban/rural landscape and architecture are also affected by wind in this climate. The construction of dome-like roofs provides a good performance in the face of winds and reduces the temperature of the roof. The landscape of most villages in the arid regions is as houses with dome-shaped roofs. These adobe and clay domes are more effective in reducing solar heat transfer compared to flat roofs since in this way, always and throughout the day, a part of the roof will be in the shade and the entire surface of the roof will not be under the sunlight. Also, these dome roofs increase the height of the ceiling of the lower room and provide more space for the rising of the internal warmth and its exit through the roof. This is especially true when a double-sided dome is used; the space between the two walls acts as an insulator. The circulation of the air between the two walls of the dome through the vents between them reduces the radiation-induced heat and keeps the space under the roof cool. This increases the airspeed flowing on these roofs and the air pressure in the pores on the dome decreases. As a result, the air inside the room flows into the vents, and thus, natural air ventilation takes place. Two other important features of dome roofs are their higher resistance compared to other types of roofs as well as the non-stop flow of water on them during the rain.

FIGURE 14-15
The effect of dome-like roof on skyline, Photo:
Left: Laar city ©www.kojaro.com
Right: Hossein-Abad-Kavir in Isfahan province ©Mahnaz Sarlak

Windcatcher[46] or wind tower[47] (*Badgir* in the Persian language) is also another component of traditional architecture in the arid areas, which has played a very important role in providing indoor climate and thermal comfort in the summer as a cooling system, "used to provide acceptable ventilation by means of renewable energy of wind"[48]. The windcatcher conveys the dominant wind of the summer through channels into the underground hall of the spring Waterhouse. When the air flows from the windcatcher tower to the spring Waterhouse, evaporation causes the interior space to cool. In addition to the functional aspect, according to the number and form of the outside valves as well as its height, the windcatcher plays an important role in the view and landscape of the warm and dry residential areas.

FIGURE 16-17
Windcatchers as the elements of identity in the urban landscape and their impact on the skyline, Photo: Kashan city ©//ICH.UNESCO.org

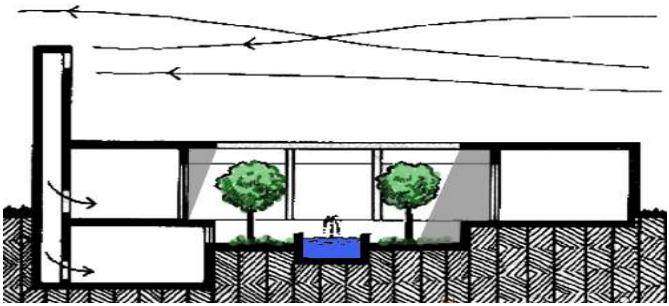

FIGURE 18
Wind catchers facing the prevailing winds to create a more moderate and humid microclimate in the central courtyard

[46] S. Roaf, "Wind Catchers, Living with the Desert," *Airs & Philips, London*, 1982.

[47] M. N. Bahadori, "Passive Cooling Systems in Iranian Architecture," *Scientific American* 238, no. 2 (1978): 144–55.

[48] M. M. Zarandi, "Analysis on Iranian Wind Catcher and Its Effect on Natural Ventilation as a Solution towards Sustainable Architecture (Case Study: Yazd)," *Eng Technol* 54 (2009): 574–79.

Vegetation

The vegetation appears to be an important factor in promoting the visual quality of the rural environment. The presence of plants in the human-made environment creates a pleasant contrast with the soulless lines of the buildings and other man-made structures, presenting different textures, patterns, shapes, and colors, and enhances the visual quality of the environment.

The sequence and diversity of nature perspective in rural landscapes are mainly much more than urban landscapes. Also, in rural tissues, the artificial and manufactured elements are quite organically combined with the broad vegetative cover, which has resulted in a visual and desirable diversity of the environment. Thus, natural landscapes and green space can be seen as one of the characteristics of the rural landscape. The presence of pastures, trees, etc. bring a special effect to the rural landscapes, and one can say that the physical landscape of the village is perceived by its natural landscape and limited sections can have a completely human-made perspective. In other cases, the role of the natural landscape and the green space prevail the field of vision. The meadows, pastures, different plant species, and their colors in different seasons have also increased this visual diversity. Hence, a variety of trees, shrubs, bushes, flowers, a variety of grass beside the water, and some elements of the floor have a great effect on the spatial quality.

In addition, plants play a very important role in space-making. In some cases, for example, the trees play the physical role and serve as a wall-covering, separator, space limiter, background, or foreground of the village as well.

Security

The security issue is another important point that is socially and politically reflected in the spatial structure of the village. The excessive scattering of villages in the plains and mountains has made them vulnerable to possible attacks, and

since they had to do the protection work self-sufficiently manner, they have inevitably thought of some architectural and constructional measures for this purpose. In other words, they have chosen the passive protection.

According to Abraham Maslow's hierarchy of needs (1954), the need for security has the highest priority after the need for water and food. Various measures have been taken to protect the security of villages due to various factors. For example, the risk of livestock robbery still exists in some villages, or in the past, there has been concern about the influx of the people into the house of the master or the risk of the invasion of the whole village by others. Therefore, the required predictions and measures have been made to deal with such attacks.

The castles are among the architectural elements that are responsible for providing security. In fact, one of the most important reasons for the emergence of castle villages has been insecurity. The castle villages in Iran are divided by A.Zargar[49] into three categories:

- Rural castles: Type I

In the rural castles, the collection of houses and the whole texture are inside the castle and with the relative provision of security, the villages have expanded to the outside of the fortress. The inner texture of the castle had been usually very tight. The infrastructure of the residential units had been considered as the minimum possible so that more people would be protected from the foreign invasion of the village. The examples of these castles can be found in the village of Hanjan in Natanz, villages of Fahraj and Aqda in Yazd province.

- Rural castles: Type II

In these fortresses, the castles were located next to the village and often in high and safe places. There has been no permanent residence in this type of castles; thus, no facilities

[49] Zargar, *An Introduction to Rural Architecture in Iran*.

and buildings are seen inside them. At the time of the occurrence of possible danger, the people used to go to these castles temporarily until the danger would be over.

- Rural castles: Type III

These castles had been built solely for the living of a few people and mostly played the role of safe houses for a class of villagers such as the lord of the village. These types of castles can be found in many ancient cities as the ruler residence section.[50],[51]

FIGURE 19
Left: castel type I, Mehrdanin village, Yazd province

FIGURE 20
Right: castle type III, Naeen, Isfahan province

The traditional Agricultural Landscape

In the literature of valuation and conservation of agricultural landscapes, the ecological approaches are the dominant approach, for example, in the report of Millennium Development Goals - UN Millennium Declaration - it is referred to support for agricultural technologies that protect and maintain natural habitats.[52] "European Innovation Partnership for Agriculture and Sustainability" also focuses on the genetic diversity of plant species and wild and domestic animal species,[53] and by changing the high nature

[50] Abbaszadegan, *Iranian Ruralscape*. P.65-69

[51] Zargar, *An Introduction to Rural Architecture in Iran*.

[52] S. R. Harrop, "Traditional Agricultural Landscapes as Protected Areas in International Law and Policy," *Agriculture, Ecosystems & Environment* 121, no. 3 (2007): 296–307.

[53] M. L. Paracchini et al., "High Nature Value Farmland and Traditional Agricultural Landscapes," *Europe's Living Landscapes. Essays on Exploring*

valued farmlands, supports the rural landscapes where agricultural practices support the rich diversity of species and habitats.[54]

In the Convention of Biological Diversity, there is an emphasis on the respect for traditional practices in rural communities, the presence, and continuity of traditional agricultural systems, and the various aspects of traditional agricultural landscapes. [55]

Traditional agricultural landscapes, however, are one of the most prominent types of the cultural landscape that display the balanced relationship between man and nature over time. Traditional agricultural landscapes are considered as multifaceted landscapes that are compilations of different ecological, socio-economic, historical, and aesthetic aspects and etc. In recent decades, identifying and supporting this valuable heritage has been on the agenda of international institutions. For example, ICOMOS named the year 2010 as the year of the agricultural heritage.[56] The Food and Agriculture Organization of the United Nations has supported the agricultural heritage in different parts of the world by emphasizing the importance of indigenous agricultural landscapes and by defining globally important agricultural heritage systems. This definition, introduced in 2002, includes land-use systems or landscapes that through the practice of traditional knowledge, which contribute to sustainability and biodiversity, deserve recognition and

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Our Identity in the Countryside. Landscape Europe. KNNV, Zeist, 2007, 21–34.

[54] Paracchini et al., "High Nature Value Farmland and Traditional Agricultural Landscapes."

[55] Harrop, "Traditional Agricultural Landscapes as Protected Areas in International Law and Policy," 2007.

[56] M. Luengo, "Looking Ahead: The Olive Grove Cultural Landscape," *Proceedings of the 17th ICOMOS General Assembly Symposium, ICOMOS, Charenton-Le-Pont*, 2011, 623–30.

support at the global level[57]. In the definition of GIAHS, the emphasis is on protecting human actions that contribute to the creation and conservation of agricultural diversity, to protect the rich diversity that results from the long-standing relationship between man and nature.[58] In this plan, the areas are selected based on the following criteria and are recorded as agricultural heritages:

- Food security and people's livelihoods
- Biodiversity and ecosystem functions
- Empirical knowledge and appropriate technologies
- Culture, value systems, and social systems.
- Special and unique landscapes and water and soil management systems.

There are hundreds of examples of such landscapes with countless cultures, languages, and social structures that can be categorized into ten groups in general:

1- Biological systems, (such as rice terraces farming, comprehensive forest, land and water use systems in East Asia)

2- Multiple cropping/polyculture farming systems (such as maize and root crop-based agroecosystems by the Aztecs in Mexico)

3- Understory farming systems (common in the tropical regions of Guinea and Pacific small islands)

4- Rangeland systems associated with nomadic (such range management and herding by nomadic Maasai in East-Africa)

5- Ancient soil and water management systems (such as water distribution systems by Qanat in Iran, Afghanistan, and Central Asian countries)

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[57] S. Okubo et al., "Land Use/Cover Classification of a Complex Agricultural Landscape Using Single-Dated Very High Spatial Resolution Satellite-Sensed Imagery," *Canadian Journal of Remote Sensing* 36, no. 6 (2010): 722–36.

[58] Harrop, "Traditional Agricultural Landscapes as Protected Areas in International Law and Policy," 2007.

6- Complex multi-layered home gardens (such as the home garden systems in China, India, the Caribbean)
7- Below sea level systems and agriculture with drainage (such as polder systems in Netherland and floating gardens in Bangladesh)
8- Tribal agricultural heritage systems (such as the Darjeeling system in the Himalayas and Zabo system)
9- High-value crop and spice systems (such as the saffron farming system in Iran, Afghanistan, Kashmir, and India)
10- Hunting-gathering systems (such as harvesting of wild rice in Chad and honey gathering by forest-dwelling peoples in Central and East Africa) (FAO, 2009)

Accordingly, all agricultural heritage systems – GIAHS - have seven significant elements at the local, national, and international levels:

1- A high level of biodiversity plays an important role in regulating the ecosystem's efficiency, as well as providing local and global ecosystem services.
2- Agricultural biological systems that have been fertilized with traditional knowledge and traditional farmers' innovations and technologies.
3- Systems and technologies for management and conservation of water and land resources that can be used to improve the management of new agricultural-biological systems.
4- Diverse agricultural and multi-crop systems that help local and international food security and livelihoods.
5- Reversible agricultural systems that show resistance and resilience to disturbance and changes (human and climatic-environmental changes) and reduce the risk through diversity.
6- Systems that provide ecosystem services at local, regional, and global levels.

7- Systems that are governed and controlled under influence of strong cultural values and by various forms of collaborative and group management.

UNESCO, with two conventions of "World Cultural and Natural Heritage" and "The Convention for the Safeguarding of the Intangible Cultural Heritage", also expanded its activities to promote sustainable agriculture, which indirectly improves economic, institutional, political and legal conditions, and provides a platform for supporting these landscapes by registering agricultural landscapes on the World Heritage list, as well as the Intangible Cultural Heritage of Humanity list.

An executive guide to the World Heritage Convention allows the inclusion of cultural landscapes in the World Heritage list, and the registration of landscapes under the title "World Heritage cultural landscapes" is broadly related to agricultural areas.[59] However, according to this convention, the main emphasis is on unique landscapes with high values on a global scale.

The World Heritage Convention recognizes the agricultural heritage as a multi-faceted heritage that includes different tangible, intangible, (spiritual) cultural and natural types,[60] and emphasizes the protection of all the natural and cultural components created by agricultural activities throughout history.

With this approach, the World Heritage Convention selects and preserves the agricultural heritages under the following titles:

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[59] Harrop, "Traditional Agricultural Landscapes as Protected Areas in International Law and Policy," 2007.

[60] I. Fuertes-Gutiérrez and E. Fernández-Martínez, "Geosites Inventory in the Leon Province (Northwestern Spain): A Tool to Introduce Geoheritage into Regional Environmental Management," *Geoheritage* 2, no. 1–2 (2010): 57–75.

- The "World Heritage" collection, which includes agricultural landscapes and high valued natural-cultural sites at the global level (WHC, 2013)[61]
- "Spiritual Heritage" that includes activities, skills, and traditions related to agriculture (CSICH, 2003) [62]

According to the World Heritage Convention guideline, agricultural landscapes are classified under the subset entitled "organically evolved landscapes", that is, the landscapes that have evolved in an organic way (WHC, 2013).[63] That is landscapes that are the result of economic, social, or religious actions, and their current form is a response to natural conditions [64]. The major parts of agricultural landscapes in the World Heritage list are considered as continuing landscapes, the landscapes whose active social role is preserved in the contemporary society, and traditional methods, as well as evolutionary processes, are still in progress in them, and simultaneously, they also exhibit evidence from the evolution of the past.[65] The intangible and spiritual dimension of agricultural heritage is important in two respects:

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[61] World Heritage Centre, "Operational Guidelines for the Implementation of the World Heritage Convention UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANISATION INTERGOVERNMENTAL COMMITTEE FOR THE PROTECTION OF THE WORLD CULTURAL AND NATURAL HERITAGE WORLD HERITAGE CENTRE," 2013.

[62] J. Blake, "Convention for the Safeguarding of Intangible Cultural Heritage (2003)," *Encyclopedia of Global Archaeology*, 2014, 1706–11.

[63] World Heritage Centre, "Operational Guidelines for the Implementation of the World Heritage Convention UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANISATION INTERGOVERNMENTAL COMMITTEE FOR THE PROTECTION OF THE WORLD CULTURAL AND NATURAL HERITAGE WORLD HERITAGE CENTRE."

[64] Fuertes-Gutiérrez and Fernández-Martínez, "Geosites Inventory in the Leon Province (Northwestern Spain): A Tool to Introduce Geoheritage into Regional Environmental Management."

[65] World Heritage Centre, "Operational Guidelines for the Implementation of the World Heritage Convention UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANISATION INTERGOVERNMENTAL COMMITTEE FOR THE PROTECTION OF THE WORLD CULTURAL AND NATURAL HERITAGE WORLD HERITAGE CENTRE."

- In the effects of intangible heritage such as traditions, rituals, and agriculture-related skills.
- In the spiritual concepts present in all the works and features of agricultural heritage landscapes, such as authenticity, integrity, identity, and cultural diversity (CSICH, 2003).[66] Currently, twenty-one landscapes have been registered on the World Heritage list for their unique agricultural values. The first agricultural landscape that achieved the title of world heritage was the rice terraces of the Philippine Cordilleras that was registered in 1995.[67]

It should be noted that in recent years, the value of all landscape species has become more evident, in such a way that for example, the concept of landscape in the European Landscape Convention covers all the landscapes, and not only landscapes with unique and specific values.[68] The definition of the European Landscape Convention seeks to draw attention to everyday landscapes too; so that any landscape that has been able to sustainably survive the passage of time and displays the harmony and balance between man and nature, deserves attention and protection, even if it lacks cosmological or historical values at the global scale.

The properties of traditional agricultural landscapes

Traditional agricultural landscapes managed under the influence of local knowledge and culture have similar properties: they have production cycles that have little input, they are ecologically and economically sustainable, bring together a variety of species and structures in time and place, and create sustainable cycles through effective recycling

[66] Blake, "Convention for the Safeguarding of Intangible Cultural Heritage (2003)."

[67] Fuertes-Gutiérrez and Fernández-Martínez, "Geosites Inventory in the Leon Province (Northwestern Spain): A Tool to Introduce Geoheritage into Regional Environmental Management."

[68] M. Antrop, "Why Landscapes of the Past Are Important for the Future," *Landscape and Urban Planning* 70, no. 1–2 (2005): 21–34.

measures,[69] and they are also associated with special and unique qualities, such as health, purity of ecosystem, peace and originality.[70]

Agricultural landscapes are one of the most ancient and comprehensive manifestations of the link between man and nature, and traditional agricultural landscapes are the result of certain cultural and natural evolutionary processes that result in a dynamic balance between semi-natural and cultural components.[71] Makhzoumi believes that rural landscapes, as much as resulting from geographical conditions and natural processes, they are the result of cultural modification and adaptation over time. He has portrayed the interaction between man and environment in rural landscapes in this way:

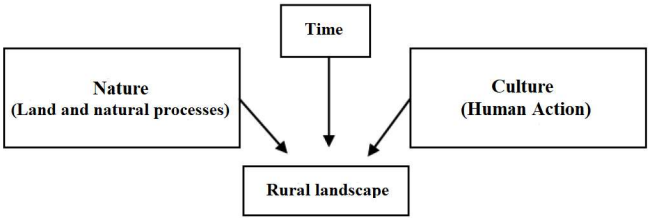

FIGURE 21
Interaction between human and environment in rural landscapes over time[72]

He believes all the spiritual, physical, and human aspects and processes and time sequences from past to present and future are involved in the formation of rural and agricultural landscape patterns (Figure 21), and by naming a rich and varied mosaic consisting of tree-spots, shrubs, and terrace

[69] T. Plieninger, F. Höchtl, and T. Spek, "Traditional Land-Use and Nature Conservation in European Rural Landscapes," *Environmental Science & Policy* 9, no. 4 (2006): 317–21.

[70] Antrop, "Why Landscapes of the Past Are Important for the Future."

[71] J. M. Makhzoumi, "Landscape Ecology as a Foundation for Landscape Architecture: Application in Malta," *Landscape and Urban Planning* 50, no. 1–3 (2000): 167–77.

[72] J. Makhzoumi et al., "Landscape Approach to Bio-Cultural Diversity Conservation in Rural Lebanon," in *Perspectives on Nature Conservation-Patterns, Pressures and Prospects* (IntechOpen, 2012).

farms and land farms, states that the rural landscape is a combination of natural and cultural ecosystems.[73] Agricultural and rural landscapes are one of the clear examples of cultural landscapes with many ecological and cultural values. The indigenous farmer, with the intermittent implementation of traditional agricultural practices, has been able to create a landscape in which his/her biological needs are met, and it also becomes a place for the continuation of the dynamic life of man in balance with nature. When looking for examples from a sustainable landscape, our attention is often focused on non-consumable cultures that have tested sustainable farming methods over a long period.[74] As mentioned, by valuing cultural landscapes, all landscape typologies, including the traditional agricultural landscape, were considered. The traditional agricultural landscape is a result of the survival and continuity of agricultural activities that have created a valuable cultural heritage, a heritage that needs protection and transfers to future generations. Research on traditional agriculture shows that most indigenous modes of production exhibit a strong foundation and base, which leads to the creation of a landscape with stable vital cycles.[75]

Empirical knowledge and indigenous management practices in traditional agricultural landscapes

Farmers who work regularly on the field have a sophisticated knowledge of ecological processes and have profound perceptions about the landscape properties that play an important role in the success of agricultural practices.[76]

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[73] Makhzoumi et al., "Landscape Approach to Bio-Cultural Diversity Conservation in Rural Lebanon."

[74] M. Amiri Ardakani and M. Shah Vali, *Foundations, concepts and studies of agriculture indigenous knowledge* (Tehran: Ministry of Agriculture Jihad, 2003).

[75] M. A. Altieri, "Linking Ecologists and Traditional Farmers in the Search for Sustainable Agriculture," *Frontiers in Ecology and the Environment* 2, no. 1 (2004): 35–42.

[76] P. H. Gobster et al., "The Shared Landscape: What Does Aesthetics Have to Do with Ecology?," *Landscape Ecology* 22, no. 7 (2007): 959–72.

These actions, in other words, "a particular way to do a job", are affected by many natural and cultural factors (Wagner, 2003), and the experimental farmer, with the help of empirical knowledge, is able to identify all of these factors. Examples of such actions are apparent in all landscapes that have ancient agricultural traditions.[77] Makhzoumi, who has been studying traditional Mediterranean agricultural landscapes, speaks of native management practices that cover a variety of issues, including: land shaping methods, terraces, species selection, irrigation systems, establishment of settlements, forming paths, etc..[78] Traditional agricultural landscapes are the elaborate solutions offered against social and environmental barriers, and the long history of management practices in agricultural lands has led to the formation of unique landscapes with rich cultural and biological diversity, that can only be protected under certain traditional management measures[79] because these measures are rooted in the empirical knowledge that is formed over time and based on the specific properties of each perspective. In this way, traditional agricultural practices are a rich source of information for ecologists who are interested in understanding the function of complex agroecosystems.[80] Thus, we refer to heritage activities that relate to past habits and traditions. It means that the empirical knowledge and actions resulting from it and patterns resulting from these actions can all be part of the heritage in an agricultural landscape.[81]

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[77] Antrop, "Why Landscapes of the Past Are Important for the Future."

[78] Makhzoumi et al., "Landscape Approach to Bio-Cultural Diversity Conservation in Rural Lebanon."

[79] Paracchini et al., "High Nature Value Farmland and Traditional Agricultural Landscapes."

[80] Altieri, "Linking Ecologists and Traditional Farmers in the Search for Sustainable Agriculture."

[81] P. Girardin and J. Weinstoerffer, "Assessment of the Contribution of Land Use Pattern and Management of Farming Systems to Landscape Quality: A Landscape Indicator," *Agricultural Impacts on Landscapes*, 2002, 193.

In recent landscape studies, landscape management practices, or the same human response to the current situation, have been in the spotlight. In the ECUALAND[82] project that classifies agricultural landscapes in Europe, instead of addressing the physical context such as geological layers, hydrology, and soil or climatic factors, the main focus and emphasis are on the human response to these components over time. The traditional farmer takes action with the exact knowledge of the needs, instruments, and properties of the environment and the landscape is a demonstration of his/her perception and actions, and as Leopold has said: "*every landscape is a portrait of its owner*"[83], and according to McHarg, a farmer is the guardian of exquisite landscapes.[84] Traditional practices and empirical knowledge are often specific to a particular landscape that has evolved over time and in the heart of a culture and a specific context[85], and is rooted in a deep and comprehensive understanding of the landscape. Traditional farmers generally have a clear memory and mentality about how to manage with traditional methods and they have full awareness of landscape changes.[86] Altieri refers to traditional agricultural practices with the term "ancient ecological heritage," and says that there is a need for more research before the disappearance of such heritages due to the expansion of industrialization. Due to the comprehensive view of the traditional farmer about his/her own living environment,

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[82] European Culture in Agricultural LANDscapes

[83] C. Meine, "The Farmer as Conservationist: Aldo Leopold on Agriculture," *Journal of Soil and Water Conservation* 42, no. 3 (1987): 144–49.

[84] I. L. McHarg and L. Mumford, *Design with Nature* (American Museum of Natural History New York, 1969).

[85] Altieri, "Linking Ecologists and Traditional Farmers in the Search for Sustainable Agriculture."

[86] M. S. Calvo-Iglesias, R. Crecente-Maseda, and U. Fra-Paleo, "Exploring Farmer's Knowledge as a Source of Information on Past and Present Cultural Landscapes: A Case Study from NW Spain," *Landscape and Urban Planning* 78, no. 4 (2006): 334–43.

his/her actions lead to the creation of a sustainable landscape that has diverse values and applications.[87] It is from this viewpoint that farmers are called not just a producer but the stewardship or supervisor of the land. According to McHarg, indigenous traditions may not be aware of the basics of science, but they have pondered on the existing relationships between events. Traditional knowledge is particular to a specific place, is highly detailed and experimental, and is learned by doing and over the long-term. It is due to this knowledge that farmers have a comprehensive awareness of their life and work context.

The research process in traditional agricultural landscapes

The process of recognizing, protecting, and restoration in rural landscapes is a complex research field that creates a link between culture, physical environment, and ecological systems.[88] In traditional agricultural landscapes, the separation of human and environmental aspects is not approved, since the formation of these landscapes has been remarkably associated with the formation of human culture.[89] Focusing on human action, or "responding to the circumstances of time and place," does not mean abandoning environmental and ecological aspects, but it means that ecological stability, biodiversity, and the attractiveness of agricultural landscapes stem from the man-made balance between different components,[90] and are the results of traditional uses, the ancient history of farming and the care

[87] Altieri, "Linking Ecologists and Traditional Farmers in the Search for Sustainable Agriculture."

[88] Luengo, "Looking Ahead: The Olive Grove Cultural Landscape."

[89] Paracchini et al., "High Nature Value Farmland and Traditional Agricultural Landscapes."

[90] J. Makhzoumi and G. Pungetti, "Landscape Strategies," in Mediterranean Island Landscapes (Springer, 2008), 325–48.

and handling of farmers.[91] The importance of farmers' empirical measures is to a degree that traditional agricultural landscapes have been considered as landscapes in which traditional sustainable practices are still in place.[92] Traditional agricultural landscapes whose values have been created through immemorial experiences of the people can be a model for sustainable land management,[93] and the conservation of all the heritage and natural properties of these landscapes, created over time through agricultural practices, is essential.[94] The preservation and survival of such landscapes primarily depend on the continuation of traditional measures in their original context, as well as the reinforcement of the landscape to respond to the pressures of new needs, with regard to the dynamic properties of the landscape, due to the presence of numerous factors and forces that affect the landscape, new conditions are created always over time, in which an appropriate response should be presented for these conditions. Because, as previously mentioned, the preservation and restoration of the landscape mean maintaining a dynamic and vivid landscape that all the components and aspects of it are alive and work.

The dynamism of traditional agricultural landscapes

dynamism is one of the most important properties of the landscape. The landscape is not a fixed, definitive, static concept, since, on the one hand, all the factors and forces involved in it, both natural and cultural, are constantly changing on different scales, and on the other hand, the

[91] Gobster et al., "The Shared Landscape: What Does Aesthetics Have to Do with Ecology?"

[92] S. R. Harrop, "Traditional Agricultural Landscapes as Protected Areas in International Law and Policy," *Agriculture, Ecosystems & Environment* 121, no. 3 (2007): 296–307.

[93] J. Stephenson, "Many Perceptions, One Landscape," *Landscape Review* 11, no. 2 (2007): 9–30.

[94] Fuertes-Gutiérrez and Fernández-Martínez, "Geosites Inventory in the Leon Province (Northwestern Spain): A Tool to Introduce Geoheritage into Regional Environmental Management."

human mentality and the way of perceiving the landscape by him/her are both dynamic and uncertain. That is, landscape dynamism means changes in time, as well as changes in location and observer. In addition, on a large scale, landscapes have a historical course that is affected by natural and cultural changes. For this reason, landscape studies are a combination of the study of humans, nature, and history, and we need to go beyond the static comprehension of the landscape and include movement and time in the conception of landscape. [95]

[95] Stephenson, "Many Perceptions, One Landscape."

Contemporary transformation of landscapes

Political, social, and economic changes have a strong impact on the transformation of rural areas. The result of these seemingly positive factors is the escape of young people (potential farmers) to the cities. This affects social behavior and activity, as well as the visual rural landscape. Today, rural and agricultural landscapes, are undergoing social and economic transformations.[96]

CHANGES AND DEVELOPMENT OF THE RURAL LANDSCAPE

Social factors have a great influence on the rural landscape. Rural settlements are complex phenomena; This complexity is due to the influence of different and various factors on the village, which is hidden in the heart of rural behaviors, cultures, and lifestyles. In the context of social factors, issues such as rural population changes, social stratification, family structure, and the security issue have a great influence on the

[96] J. Łach and B. Szczepańska, "Contemporary Directions of Transformations in the Settlement and the Landscape of Rural Areas in the Silesian Lowland," *Quaestiones Geographicae* 39, no. 2 (2020): 55–73.

rural landscape and the spatial perception and imagination of the village.

Population changes and their impact on the rural landscape

In today's world, one of the important and major issues challenged the man's as a matter of concern and dilemma is the population and its increasing growth. In addition to population growth, the issues of employment, environmental protection, and people's participation are among the most important issues and challenges facing the villages. In rural areas, the population pressure has been increasing on the developmental programs and the absolute magnitude of the rural population has continuously increased over the past decades despite the relative changes in the urban and rural populations. This increase in the population has brought important implications in these areas, the most important of which, can be referred to as excessive pressure on the natural resources and the production resources. The population growth in villages, in addition to particularly influencing the physical development of the village, leads to new constructions, and consequently, causes some changes in the countryside landscape. On the other hand, new needs that lead to the provision of new services have been physically manifested and these services have influenced the village landscape in different ways. The population changes affecting the landscape and view of the villages are:[97]

- The reduced young workers
- The increased migration rate to the city
- In some cases, the increased population of villages
- The joining and adjunction of some villages to cities due to an increase in the population of the city and adjacent villages and the urban and rural physical development

[97] M. V. Ghalfi, "Structure Review of Manpower and Employment in Rural Areas," *Quarterly of Housing and Revolution* 94 (2001): 32–40.

- Seasonal migration to cities
- Familiarization of villagers with urban culture and manufacturing technology due to increased interactions with the city
- The abandonment of residential and service-providing units and desertification a part of the construction context based on urban architecture criteria
- Enlargement of the village and creating new textures

Social stratification

Social stratification directly affects the physical texture and spatial organization of the village. For example, the social stratification affects the position of the lord's house in the village, access to water, appropriate landscape and perspective, and even the scale and size of the house.

The social structure of the rural community has a direct impact on the shape, size, architectural style, and the location position in the village. For example, the village lord houses are larger and located on the higher-height points and better land, and even sometimes, have more urbanized architecture. Many examples can be found throughout Iran, indicating that the social structure has a direct impact on the context and landscape of the village. Concerning the above, one can conclude that social stratification affects several important factors affecting the rural landscape:[98]

- Location of a settlement of different classes of the village
- Housing Scale
- Residential unit size
- Architectural style and material

Urbanization

In the study of landscape changes, the urbanization phenomenon of the rural area should be evaluated with a special focus. The urbanization process and level of rural

[98] Abbaszadegan, *Iranian Ruralscape*. P.66-67

houses affect the classification of these villages. The urbanization of a village house is in fact the landscape change, and the transformation means the transition from the rural state to an urban state.

Cities and villages are fundamentally different from each other. These differences are not merely limited to the population size, and thus, the density and type of buildings, but these differences are also seen in the behavioral patterns, lifestyle, daily activity calendar, cultural diversity, and the diversity of activities.[99]

"According to Antrop, urbanization is a complex process that transforms the rural and natural landscapes into urban and industrial".[100] The urban lifestyle, and consequently, the urban landscape also quickly penetrates the villages far and near the cities and the distance between the city and the village diminishes at least in form. [101]

FIGURE 22
Urbanizzazione in TaherAbad village Photo by Mahnaz Sarlak using an unmanned aerial vehicle- 2019

[99] I. Docherty, R. Goodlad, and R. Paddison, "Civic Culture, Community and Citizen Participation in Contrasting Neighbourhoods," *Urban Studies* 38, no. 12 (2001): 2225–50.

[100] Y. Murayama et al., *Urban Development in Asia and Africa* (Springer, 2017). P.198

[101] M. Antrop, "Landscape Change and the Urbanization Process in Europe," *Landscape and Urban Planning* 67, no. 1–4 (2004): 9–26.

The transformation models of the rural according to Antrop:[102]

- The villages in the shadow of big cities

The pattern of the development of large cities occurs based on stellar expansion. The development of cities is usually done along the roads and the required centers are being built along the roads. The remote rural areas remain rural among the branches of the stellar development of cities; however, the rural environments along the roads are directly and more intensively subjected to urbanization. This phenomenon is called an urban explosion. In a case that the cities are close to each other, this urban explosion will not leave room for the presence of the features of the rural environment. Under the influence of the urban explosion, the open lands of the villages are occupied in the beginning. Then, the villages are diminished by both the scale of buildings and their macro landscape versus the urban scale and lose their calm nature. Such villages are so-called occur in the shadows of the cities. It should be noted that some of the villages occurring in the shadows of the cities will host the urbanists in case of having a specific physical characteristic who come to visit these areas for tourism to satisfy the sense of returning to nature and the re-experience of the rural environment or to respond their nostalgia. There are villages in most large cities of Iran that host the urbanists who go there for rural tourism. These villages often lose their agricultural and horticultural performance in the long run due to the increased land prices in the favor of tourism and building villas. At this stage, the villages lose their visual features and genuine landscape, which the urbanists have been looking for.

- Urbanized villages

Many villages can be easily accessed on a daily basis by the citizens of nearby cities due to the development of fast

[102] Antrop, "Landscape Change and the Urbanization Process in Europe."

transportation lines. Therefore, in such conditions, some citizens tend to live in those villages for various reasons, including housing prices or the open and appropriate environment of the village. Following this population, the necessary facilities such as stores will be built in the villages as well. Most of the urban population brought to the villages use these settlements as dorms. In this situation, the countryside view turns into a suburb of a countryside landscape. Depending on the type of the village and its geographic location, the landscape transformation can associate the poverty-stricken urban landscape or an unfamiliar landscape belonging to the upper social-economic classes. In either case, the village will lose its native landscape. Obviously, if the village's landscape is considered as a value, then, these particular changes of the rural landscape should be given special attention.

- The urbanization of remote villages

Good, easy, and inexpensive access affects the remote villages as well. The remote villages with desirable tourism attraction features or vast and cheap lands for the development of industries, tourism facilities, and restaurants, and hotels as well as the villages on the way of roads with proper quality will quickly become urbanized. The demographic features and urban landscape quickly overcome the characteristics of the rural landscape and the cultural influences will also affect the people's lifestyle.

CHANGES AND THREATS OF THE AGRICULTURAL LANDSCAPE

The landscapes have historical continuity and unity, which means that despite the changes, their historical continuity is preserved unless the intensity or speed of changes is such that the landscape becomes disconnected from its historical

past.[103] The occurrence of these changes and the formation of historical periods corresponds to economic, social, and industrial changes on a macro scale.

Based on the kind of rapport between human and the environment over time, three periods can be identified about agricultural landscapes:

- The period of equilibrium and balance in the human-environment relationship that has emerged from traditional agricultural landscapes.
- The period of disturbances, turbulence, and environmental problems that arises with the advent of industrial agricultural landscapes.
- The period of return to equilibrium and balance with deliberate interference with the help of science and art and inspired by traditional landscapes.

Compared to traditional land management, which has been standing for centuries, modern development does not seem to be so stable.[104] With the onslaught of "industrial agriculture" and "urbanization" and with the spread of such phenomena as "land-use change" and "agricultural land abandonment", traditional agricultural landscapes and biological and cultural diversity associated with them are rapidly disappearing. [105]

In the study of traditional rural landscapes, Antrop considers contemporary changes as a threat, since recent changes have led to the disappearance of temporal and spatial contiguity in landscapes that have heritage value.[106] According to him, an important point in the current changes in the landscape is the speed and intensity of changes, as well as

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[103] Antrop, "Why Landscapes of the Past Are Important for the Future."

[104] Antrop, "Why Landscapes of the Past Are Important for the Future."

[105] Z Naveh, "From Biodiversity to Ecodiversity—Holistic Conservation of the Biological and Cultural Diversity of Mediterranean Landscapes," in *Landscape Disturbance and Biodiversity in Mediterranean-Type Ecosystems* (Springer, 1998), pp. 23–53

[106] Antrop, "Why Landscapes of the Past Are Important for the Future."

changes in perceptions of people's values and behaviors.[107] A break in the traditional agricultural landscape, in addition to eliminating the diverse aspects of the landscape, causes traditional patterns to be disturbed and the indigenous knowledge and technology disappear quickly. While this knowledge and technology and pattern resulting from it are a rich source of information, they can inspire future landscape planning and design.

Contemporary disruptions and threats of agricultural landscapes

An overview of the historical course of the agricultural landscape shows that the most pressures and threats facing these landscapes are:

- The expansion of industrial agriculture
- The expansion of urbanization
- The abandonment of agricultural lands
- The land-use change

Industrial agriculture: The dawn of agriculture, with the rise of civilizations in Mesopotamia and Egypt, started studying and collecting plants, improved production methods, and creating new tools in these communities. These advances made it possible to create vast plantations that produced food for humans. In the period before industrialization, the creation of traditional agricultural landscapes around the world was carried out according to the properties of the natural context and based on empirical knowledge. Since the seventeenth century in Europe, building agricultural machinery and tool and farming techniques have expanded.[108] But by the middle of the twentieth century, farming has benefited from a low trade-based system. Such a landscape, despite the presence of reproduction cycles, was in a sustainable balance with nature. In agricultural landscapes

[107] Antrop, "Why Landscapes of the Past Are Important for the Future."

[108] Cathryn J Long, The agricultural revolution, trans. by Mehdi Haghighat khah (Ghoghnoos, 2004).

with ancient cultural traditions, such as agricultural landscapes in Europe, measures were taken to minimize ecological degradation.[109] But since the 1950s, industrial agricultural landscapes have emerged, in which, with a profit-oriented approach, the emphasis is placed on a single goal, namely "production", in which all internal capacities and self-regulating cycles of traditional landscapes are eliminated.[110] According to Antrop, wherever there is no diversity, the ecosystem faces a risk of instability, while unifying and eliminating crop diversity, species diversity, and diversity of land farms are the main attributes of industrial agriculture. In industrial agricultural landscapes, the natural order and the self-regulating mechanisms of traditional landscapes disappear due to inputs and outputs of chemical substances and fossil fuel pollution[111]. In the industrial agricultural landscape, irrespective of the environmental conditions and the natural environment, and relying on machinery, fossil fuels, and chemicals, only more production is desired. While, as the amount of production becomes more and denser, the amount of waste is further increased and overcomes the recycling capacity of the environment, and thus the environmental problems become more acute.

The expansion of urbanization: The inharmonious development of the landscape eliminates its special distinctive features and creates a gap between people and their past.[112] The urbanization process not only tears up the agricultural and semi-natural landscapes to pieces, but it also eliminates the mosaic diversity of traditional landscapes. Today, rural and agricultural landscapes are shrinking all over the world

[109] Gobster et al., "The Shared Landscape: What Does Aesthetics Have to Do with Ecology?"

[110] Naveh, "From Biodiversity to Ecodiversity—Holistic Conservation of the Biological and Cultural Diversity of Mediterranean Landscapes."

[111] Naveh, "From Biodiversity to Ecodiversity—Holistic Conservation of the Biological and Cultural Diversity of Mediterranean Landscapes."

[112] Antrop, "Why Landscapes of the Past Are Important for the Future."

due to the threat of uncontrolled urban and suburban expansion. In addition to these visual changes, "*urbanization processes affect smaller settlements and even remote rural villages*"[113], so that the perception, empirical knowledge, and traditional management practices, all rooted in the deep link between humans and their living environment, gradually fade away.

Land abandonment: Strong tendency to urbanization has led many farmers to abandon their farms. The phenomenon of land abandonment is one of the greatest problems in agricultural landscapes. By reducing or eliminating conservation measures, new users and invasive species and weeds invade the agricultural landscapes and change the valuable properties of the agricultural landscape, which often result in the disappearance of the rich diversity in traditional landscapes. A diversity that requires human intervention, that is conservation. One of the results of land abandonment is the land-use change that breaks out the continuous mosaic of the landscape, and on the other hand, subsequently, new groups enter the landscape, who do not have enough awareness of traditional practices, therefore, the sense of belonging to the landscape is reduced and participation in landscape management also reduces.[114],[115]

Land-use change: The change in land use and the disappearance of landscape continuity occurs when a large number of users, without coordinating with each other, are taking action on their own, and this is a contradiction to the practices that traditional farmers do in their land in the same

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[113] M. Antrop, "Changing Patterns in the Urbanized Countryside of Western Europe," *Landscape Ecology* 15, no. 3 (2000): 257–70.

[114] D. Satterthwaite, G. McGranahan, and C. Tacoli, "Urbanization and Its Implications for Food and Farming," *Philosophical Transactions of the Royal Society B: Biological Sciences* 365, no. 1554 (2010): 2809–20.

[115] C. Queiroz et al., "Farmland Abandonment: Threat or Opportunity for Biodiversity Conservation? A Global Review," *Frontiers in Ecology and the Environment* 12, no. 5 (2014): 288–96.

way, which result in the creation of a contiguous landscape with a specific identity. [116] We are in an era that the rationality of commodity and profit-oriented relations tempt people to change the land use, even those who should be the guardian and supervisor of the land. Land-use change, which often occurs following the abandonment of land, shreds the unique traditional landscapes to pieces and ultimately destroys them.

[116] Antrop, "Why Landscapes of the Past Are Important for the Future."

ARAN-BIDGOL

SURROUNDED BY MOUNTAIN AND DESERT

The research area

The study area of this research is located on the periphery of the central desert of Iran that is called the *Dasht-e Kavir* or *Kavir desert.* It has been created such as a rain shadow desert due to the presence of two mountain chains (*Alborz* in the north and *Zagros* in the west), they block the passage of rain-producing weather systems and cast a shadow of dryness behind them.

FIGURE 1
Location of the Central Desert surrounded by the Alborz and Zagros Mountains (Iran's topography map, downloaded from www.maphill.com[1] edited in Photoshop)

[1] http://www.maphill.com/iran/3d-maps/physical-map/shaded-relief-outside/

The county of Aran-Bidgol is one of the counties of Isfahan Province and is located at the northernmost point of the province. The center of this county is Aran-Bidgol city. The county has two districts, 4 cities, 3 rural districts, and 13 villages, with a total population of over 100000 people.

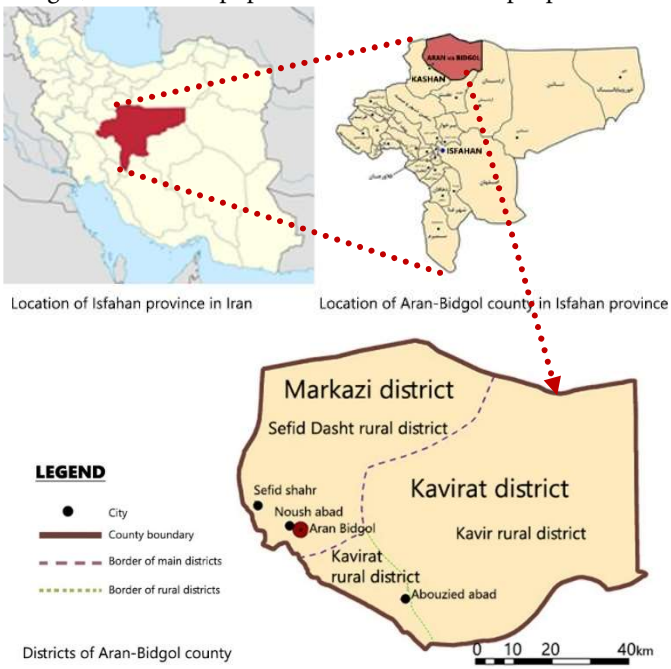

FIGURE 2-3
Location of the study area (maps based on google earth and information received from Iran National Cartographic Center, edited by Mahnaz Sarlak using GIS, Photoshop)

The city of Aran-Bidgol is located 5km from the historic city of Kashan, it is connected to Tehran and Isfahan via two main North-South roads and also a national railway. The city also has links with its subsidiary sections and villages with secondary roads (Figure 5). It is located on the southwest border of the central desert of Iran, its average elevation is 912 meters and the geographical coordinates are 34° 03'N, 51° 29'E.

The county of Aran-Bidgol is a large part of the alluvial plain of the southern basin of the Salt Lake, and its slope is from the south to the north. In its eastern and northern parts,

between Kashan and Salt Lake, there is Maranjab desert, one of the most sophisticated complexes of sand dunes that in the local term, it is known as Band-e Rig. It has a crescent arch that its conquest is toward the west. Sandy hills are drawn from the south-east to the north-west as a band with a length of about 120km, and an average width of 25km, and its height from the sea level is between 800 and 1000 meters.

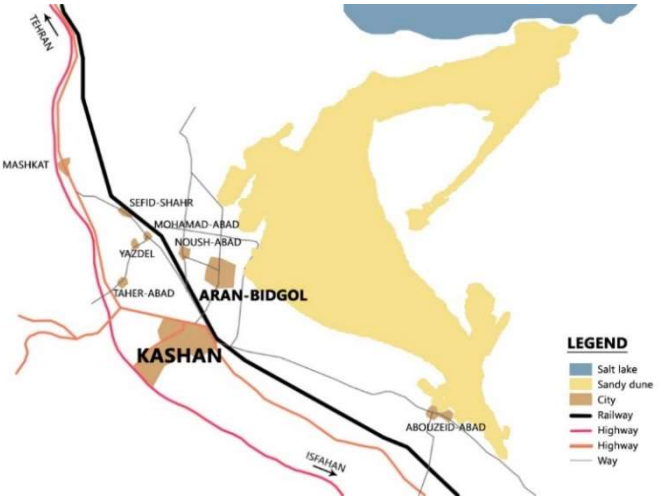

FIGURE 5
Location of cities, types of roads and natural elements in the study area and its connection roads with other cities (map by Mahnaz Sarlak using google earth, information received from Iran national cartographic center, GIS, Photoshop)

The most important features of the sand dunes are the dynamics and movement of the hills, which make them the center of the crisis and are problematic for urban centers, rural areas, industrial centers, etc. The dynamic process of wind erosion prevents the permanent fixation of these sediments and depending on the vegetation situation and the control mode, mobility, and displacement of sand dunes are considered such as a natural phenomenon.

In the south and southwest areas of this county, the plains of Kashan and Ravand are located, and between them, there are the dry rivers, which transfers scattered floods and the additional waters of the northern hillsides of the southern highlands of Kashan to the salt lake.

Brief History of Aran-Bidgol

Abdolhossein Sepehr Kashani (1869-1933) writes in the book, Brief Geography of Kashan: The construction of Aran, Bidgol, and Nushabad, which are called the triple villages, was before the construction of Kashan. He attributes the original construction of Aran to Jews, and points out that in these three blocks, there are many ancient works.[2] He states that instead of the desert there was sea several thousand years ago. The claim has been proven today, and according to geologists, the central desert of Iran has been a shallow sea in times past[3,4,5], which has dried up over time due to the warmth of the air and climate changes. The presence of layered deposits in the desert, as well as the presence of areas such as Fossil Abad in the National Park of the desert, which has fossil species called Marine fossils[6], many fossils of different marine organisms on the hill, can prove the validity of this claim (Figure 6-7).

FIGURE 6-7
A marine fossil in National park of the desert
©irandeserts.com

[2] A. Sepehr Kashani, *Brief Geography of Kashan*, 1919.

[3] J. Stöcklin, "Possible Ancient Continental Margins in Iran," in *The Geology of Continental Margins* (Springer, 1974), 873–87.

[4] A. null Gansser, "2. New Aspects of the Geology in Central Iran (Iran)," in *4th World Petroleum Congress* (Rome: World Petroleum Congress, 1955).

[5] H. V. Nasab and M. Hashemi, "Playas and Middle Paleolithic Settlement of the Iranian Central Desert: The Discovery of the Chah-e Jam Middle Paleolithic Site," *Quaternary International* 408 (2016): 140–52.

[6] "Fish Marine Fossils Region," 2014, at www.irandeserts.com.

Also, in Kashan History book, referring to the Aran alone has had more than forty subsidiary farms, which in this regard is superior to other villages in the region. Also, in this book, referring to the Bidgol village, the Bidgol subsidiary farms are fourteen numbers, some of which are still present.[7]

One of the attributes of Aran, Bidgol, and Nushabad is being at the lowest point of the residential area of the region, and on the path, there are rivers, which begin from the mountains and upstream. In the history of Kashan, there are several mentioned rivers, which on the way of Band-e rig and Salt Lake pass along these villages. Meanwhile, the Suk-i-Cham River, which starts from the neck of Naraq and the southwest mountains of the region, passes through the Middle of Aran and Nushabad.[8] This geographic feature, due to placement on the flood route, which usually flows from the mountainous and upstream parts of Kashan, has caused great damage to Aran-Bidgol throughout history. The flood, in addition to the destruction of agricultural products and trees, had blocked the way of the qanats, and as a result, the drying of the trees and farms, and the creation of famine, as it usually took one to three years for dredging qanats and preparing agricultural land.[9]

In the history of Kashan's book, a fearsome rain and flood have been mentioned, which occurred in 1964, and the flood flooded towards Aran, Bidgol, and Nushabad, caused the destruction of residential buildings and filled the qanats with mud and destroyed farms and gardens. Many people have died as a result of this flood, and many emigrated. In such cases, the houses of the city were vacated, and it takes years until the city or village returns to normal life again.[10]

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[7] A. Kalantar Zarrabi, *History of Kashan*, ed. I. Afshar (Tehran: AmirKabir, 1999). p.143

[8] Kalantar Zarrabi, *History of Kashan*. p.66

[9] Kalantar Zarrabi, *History of Kashan*. p.209

[10] Kalantar Zarrabi, *History of Kashan*. p. 208-210

Climate analysis

The climate is hot and dry, with hot summers and cold and dry winters. The maximum summer temperature is 48°C, and the minimum air temperature in the winter is -7°C.[11] In terms of the desert region, 1900km^2 (31% of the county's total area) is located on the sandy hills of Band-e Rig.

The region's climate is desert. The summer season is long and hot and burning, starting in mid-May, and ending in early November. Its winter season, which lasts from late November to late March, is cold and dry. The spring and autumn seasons are shorts. The frost period is 24 days in January and February.

In terms of climatic zoning, the city of Aran-Bidgol has a climate with relatively cold winters and very hot and dry summers. The number of very hot summer days: 60-70 (May and Jun.)

The rainfall in this region is low, and the highest rainfall season is from November to April, and snowfall is in December and January.

	Unit	Mar-Apr	Apr-May	May-Jun	Jun-Jul	Jul-Aug	Aug-Sep	Sep-Oct	Oct-Nov	Nov-Dec	Dec-Jan	Jan-Feb	Feb-Mar
Rainfall	mm	34.3	12.6	0.7	2.7	0	1	0.2	8.2	17.9	21.2	29.1	0
Humidity	%	43.4	34.6	27.6	24.5	22	25.7	31.2	47.5	64.8	68.7	69.8	39

FIGURE 8
Average rainfall and humidity by months of the year
Summary of annual statistics 2006-2015 received from Aran-Bidgol meteorological station

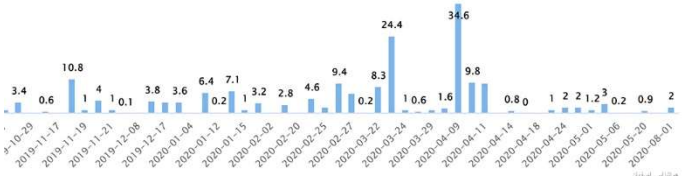

FIGURE 9
Date of rainy days and precipitation in 2020, downloaded from http://metservice.ir

The temperature difference between the north of the county and the southern highlands in Kashan plain leads to

[11] Iran Meteorological Organization, http://irimo.ir/

different air flows and the winds during the year; due to the importance of recognizing the winds, and their impact on the Landscape, they are explained in more details.

Wind flow is one of the climatic parameters that affect a region beyond a small area, also the general conditions of large areas affect it. In Aran-Bidgol, except for the two winds of the Shahriari and the north, other winds are considered as undesirable winds. The famous winds of the research area are as below:[12]

North wind and Shahriari wind: The direction of wind blowing is from the north. It is a cool stream, and it causes weather moderation in the summer.

Khorasan wind: This wind blows from the north-east, and its time is often in the warm seasons. This wind is accompanied by dust.

Sam wind: Its direction is from the east. The wind is dangerous, which, since its severity, causes damage to agricultural products.

Qibla wind: The direction of blowing this wind is south and southwest, and its flow, during the warm period of the year, increases the environmental temperature. The wind in the cold season causes weather modification in the area.

Lavar wind: It blows from the northwest and the Salt Lake. This wind is extremely hot in summer and has very adverse effects on all aspects of human life in this area.

Black-Storm wind: It is extremely dangerous and causes a lot of damage and accumulation of sand in the villages. This wind blows from the east, but its frequency is accidental.

[12] A. Shirehpaz, *Aran and Bidgol: jewel of Central Desert of Iran* (Maranjab, 2018). P.72

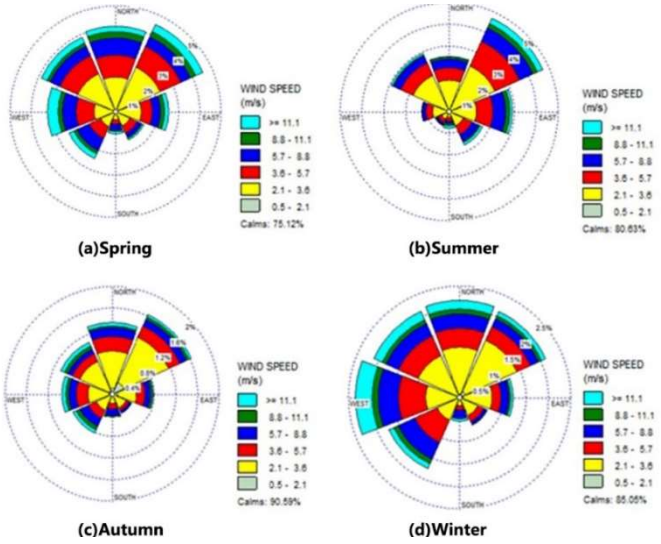

FIGURE 10
The seasonal wind roses (Source: Kashan weather station)

Geological studies

Geologically, Aran-Bidgol has a variety of igneous, sedimentary, and metamorphic units, indicating the history of complex evolution. Different orogeny phases, over time, have given the city a special view from the millions of years ago, which has high mountains on one side and, on the other hand, has plains and Salt Lake. The county of Aran-Bidgol is a large part of the alluvial plain of the southern part of the Salt Lake, and its slope is from the south to the north. In its eastern and northern parts, the Band-e rig sandy hills are seen from the south-east to the north-west. In the south and southwest areas of this county, Kashan and Ravand plains are located, and between them, there is a dry river, and scattered floods and additional waters of the northern slopes of the southern highlands of Kashan, are transferred to the salt lake.

According to the geological map of Aran-Bidgol, different geological periods can be observed, which in the following only the most influential geological period in the study area will be explained.

Quaternary: The largest part of the county of Aran-Bidgol is covered by sediments, which is related to the Quaternary period. Young flood alluvial deposits, including rubble, gravel, and sand, have covered a large part of the city. After that, the city's largest coverage is related to sand dunes.

The third quaternary unit with wide coverage includes salt beds, salt, and brine and is the southern part of the Salt Lake. The fourth quaternary unit with wide coverage is clay flat surfaces that include clay and silt, and flat salt lands and agricultural soils. Other Quaternary units include mud beds (salt and silt clay), new alluviums (gravel and sand), river sediments, alluvial fans, sandy sheets, and ancient alluvial Terraces.

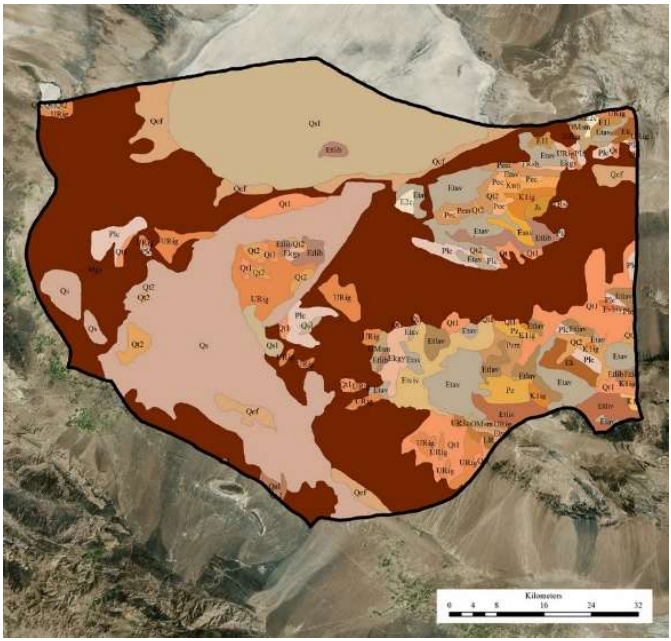

FIGURE 11
Geological map of the study area (Source: Geological Survey of Iran, map edited by Mahnaz sarlak using GIS, google earth)

The natural landscape of the area

"*The desert has a precise ecological equilibrium affirmed over time in specific climatic situations. Its landscape is healthy with aesthetic value, with laws, components, biological and cultural activities adapted to respond appropriately to thirst for plants, animals, and men.*"[13]

Natural elements

Sand dunes

Sand dunes or sandy hills and are the main elements in the desert landscape structure of the study area. The sand dunes are shaped by sands that flow through the wind on the surface of the earth, after reaching obstacles on their way (such as plants, stone pieces, or other natural effects) stop moving. The particles that are carried by the wind are accumulated around these obstacles, and they are gradually increased. Finally, the combination of these sand particles leads to the formation of sand dunes. Of course, as these barriers are larger, the sand masses may be in the form of larger hills. Sandy hills are not

[13] Pietro Laureano, https://ipogea.org/en/portfolio-posts/expo-agua-zaragoza-2008/

fixed in their place after their formation, but they are displaced by wind blowing. With the wind blowing, the sands go to the top of the slope against the wind and after reaching the summit they roll on the back of the hill and gather there. The displacement of sand masses in normal conditions reaches 10 to 20 meters per year. The height of the sand dunes varies and rarely exceeds 20 meters, but occasionally they rise to 100 meters. The Band-e Rig hill, with a height of 100m, is one of the most important elements in the natural landscape structure of the study area.

FIGURE 12-13
Nebka, accumulation of sands behind of Calligonum Polygonoides (©photo by Mahnaz Sarlak, 2018)

Left: side view
Right: top view

FIGURE 14
Nebka, accumulation of sands around the Tamarix tree (©photo by Mahnaz Sarlak, 2018)

Maranjab Salt Lake

The Salt Lake (also known as the Massileh Salt Lake) is one of the lakes in the central desert region of Iran, and the southern part of which is located in the county of Aran-Bidgol. The choice of this name is due to the high salinity of the lake, so that salt particles are floating on it in the summer. The lake with 80m long and 30km wide is tectonic subsidence, which is about 795m above sea level.

The land of this lake is covered with salt deposits, which are due to the accumulation of floods and surface waters over the centuries. The salt depth of this lake is between 5-54m, separated by clay layers. With each rainfall and evaporation of water in this lake, existing salts form beautiful terraces in the form of a polygon. The grounds around this lake are extremely marshy. Among the spectacular scenery of this lake, is Sargardan (wanderer) Island, located in the southern part of the lake.

FIGURE 15
Salt Lake of Maranjab desert, (photo: ©Mahnaz Sarlak, 2018)

Yakh-ab mountain

Yakhab, no-hunting zone, has a mountainous climate, alluvial plains, and in the western part in the form of flowing sand dunes. The climatic situation of the mountainous plain region is hot and dry. The range of altitude changes varies

from 800 to 2800 meters. Due to its proximity to Kavir National Park and the migration of national park species to this area, it is one of the supporting habitats of the national park. Since 1392, this mountain has been defined as a no-hunting zone.

FIGURE 16
Yakh-Ab Mountain and its vegetation. Photo: downloaded from https://seeiran.ir/

Physiography

Aran-Bidgol county is a part of the Kashan watershed, which, in turn, is a part of the central region of Iran. This area consists of three areas: mountainous and plains and desert, as follows:

- Its main mountainous part is located in the administrative district of Kashan.
- The desert section and its sandy hill are located in the administrative district of Aran-Bidgol.
- The plain area is also shared between the two counties.

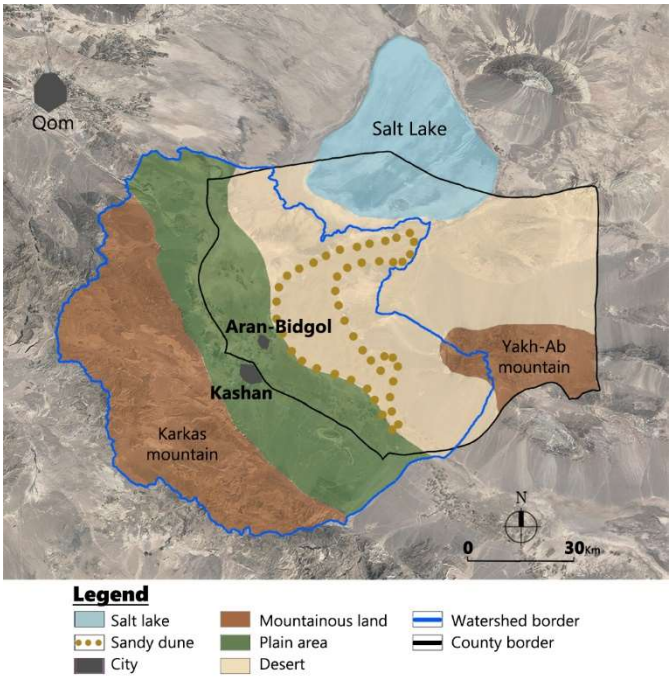

FIGURE 17
Main parts of the natural landscape. map by Mahnaz Sarlak based on the information received from Iran Water Resources Management company, and from Forest, Range and Watershed org Isfahan province, using gis, google earth, photoshop

Due to the dry weather and low atmospheric rainfall, the state of the county of Aran-Bidgol is very sensitive and dry; The condition of this area is very critical in terms of underground water, which will lead to an unfavorable future with a further drop in groundwater levels. It lacks large and permanent rivers, the flowing waters of this area, seasonally and periodically, flow from the altitudes of Karkas Mountains located in the county of Kashan, after passing through the watercourses, enter the plain and eventually enter the desert - the lowest point of the region- and get out of profit.

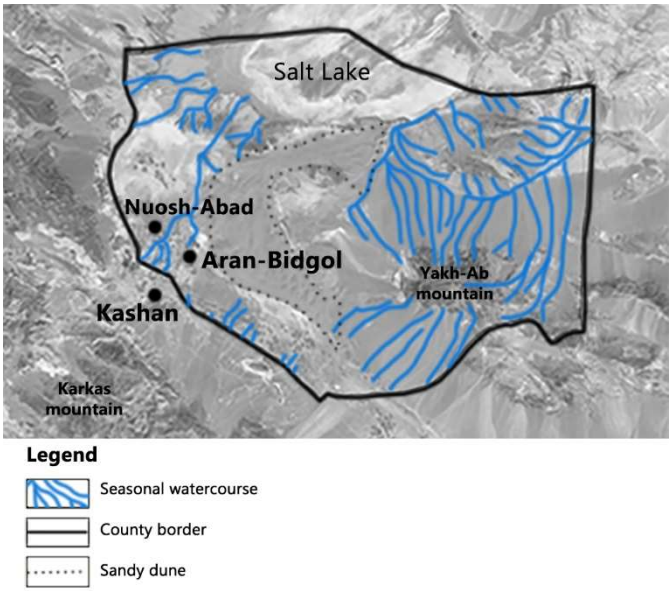

FIGURE 18
Seasonal rivers in Aran-Bidgol county from mountains to Salt Lake, (GIS information received from Forest, Range and Watershed org Isfahan province, map edited by Mahnaz Sarlak using GIS, google earth, photoshop)

Topography

The topography of the Aran-Bidgol region is a product of tectonic geological and geomorphological factors, it is divided into two major areas:

Aran-Bidgol plain:

This area is between the highlands in the south of the county and the desert margin in the east and north of Aran-Bidgol. From the south, it is limited to the highlands of Karkas and Kashan, and from the north, it is limited to the sand dunes of Band-e Rig. Most of the villages, Aran-Bidgol city, and Nushabad city are located in this plain. Aran-Bidgol topography with the mentioned altitude is a suitable region for the alluvial plain resulting from the mountainous stream and is also an embody of many of the qanats that fed in the highlands of the west and south of Aran and Bidgol. The presence of alluvial fans and soils formed from alluvial deposits is important in livelihoods for agriculture, and for this reason, rural settlements have been able to expand further into the plain.

Desert margin:

This area is located in the eastern and northern parts of Aran-Bidgol, with an average altitude of fewer than 1000 meters above sea level. The distances from the highlands and its proximity to the desert and the Salt Lake, as well as the lack of atmospheric drops, cause the dispersal of habitats and have led to adverse environmental conditions for the livelihood of its inhabitants. In the northern part, there is no mountainous, and there is only a complex of sand dunes in the area of Masileh, with an approximate length of 120 km.

Most of the villages and agricultural farms have been established in the eastern part of this area, between the sand dunes of Band-e Rig and the Karkas Mountains (Markazi district). Thus, the different conditions of topography and ripples in the Aran-Bidgol region create different perspectives in human and environment relations, including agronomic morphology, habitat texture, human livelihoods, and most importantly, the density and distribution of human beings.

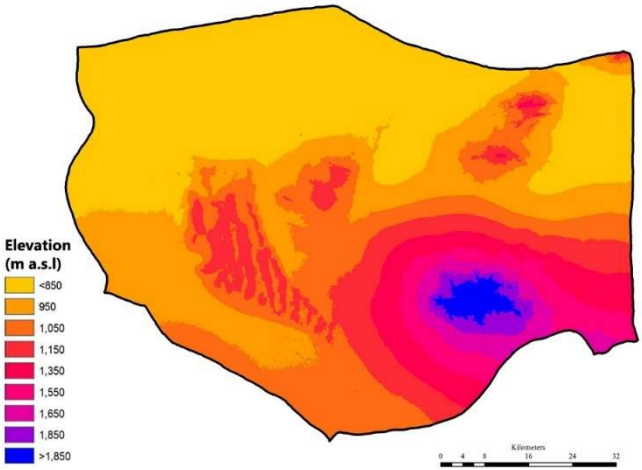

FIGURE 19
The topography of the county Aran-Bidgol (map by Mahnaz Sarlak using Autocad, GIS, google earth, information received from Iran national cartographic center)

Vegetation

Vegetation is largely influenced by geographical location, climate, topography, and the kind of soil and water resources. Variety, composition, distribution, and density of plant and animal species are also subject to topographic and other natural factors, including climatic factors. Aran-Bidgol is no exception. The county of Aran-Bidgol, especially its northern and eastern parts, is a desert. The soil and water in this arid and desert region are salty due to high evaporation. Most of the native plants of this region are halophytes, which are dedicated to arid zones and especially saline lands based on their ecological needs. The vegetation includes many species of needle-like leaves and thorny plants in the form of bushes and short shrubs, and there are few tree species.

Some of the most common species are listed below:

FIGURE 20-32
Common species of flora of the Aran-Bidgol county[14]

Artemisia Sieberi S.L.

Astragalus Squarrosus L.

Calligonum Polygonoides L.

Calligonum Comosum L'Her.

[14] H. Batooli, "Introduction of the Flora, Life Form and Chorology of Aran & Bidghol Deserts Area in Isfahan Province," *Journal of Plant Research (Iranian Journal of Biology)* 31, no. 2 (2018): 447–57.

Cyperus conglomerates L.

Ephedra Strobilacea Bge. ex A. Lehm.

Nitraria schoberi L.

Pteropyrum Aucheri Jaub. & Spach.

Stipagrostis plumose L.

Seidlitzia Rosmarinus Bge. ex Boiss.

Stipagrostis pennata (Triv.) De Winter

Alhagi maurorum Fisch. (Camelthorn)

CULTURAL LANDSCAPE

As explained in the first chapter, in the past, the presence of proper and reliable underground water resources had been the cause of emerging the initial core of the city as well as the factor of its physical growth and development.[15] The neighborhoods and settlements around the Qanats'axis have been in movement, dynamism, growth, and expansion, which have shaped their socioeconomic livelihoods and continued them in the context of time.

In the county of Aran-Bidgol, Qanat by transferring water from the mountain to dry areas has played a major role in the formation and development of the Hierarchical System of Oasis (H.S.O.) in the desert and semi-desert areas.

Having 118 to 150 strands of qanats and with an average length of 12km for each, Aran-Bidgol has encompassed over 1680km[16] of cavity and water tunnel below itself, which indicates the grandeur of the water system distribution and the use of land in the farming and livelihood activities of this territory.

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[15] M. E. Bonine, "The Morphogenesis of Iranian Cities," *Annals of the Association of American Geographers*, 1979.

[16] Shirehpaz, *Aran and Bidgol: jewel of Central Desert of Iran*. P.41

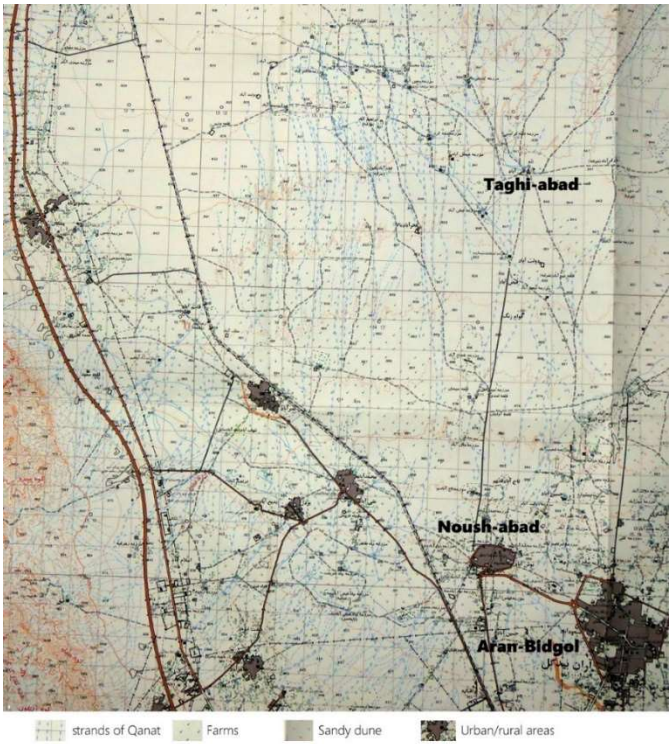


FIGURE 33
The dispersion of the Oases and water supply by Qanat (Source: Iran National Cartographic Center, the scale of original map 1:250000, the last update 2006)

The shortest Qanat of the county is called Moez-Abad Qanat, which has nearly 8km long; and the longest qanat is called Feiz-Abad Qanat, which is 42km[17] long originates from the mountainous part of Kashan and it has watered many villages and farms such as Taqi-Abad.

But there is another type of Qanats that is not started from mountains. Some of the qanats in the northeastern part of the Kashan have been of this type.

According to my interview with the native and old Qanat drillers, this type of qanat is called floor-generating (in the Persian language: *Kaf-za*[18]). This kind of Qanat that is

[17] Shirehpaz, *Aran and Bidgol: jewel of Central Desert of Iran*. p43

[18] I found no content regarding this type of qanat in scientific references. So personally tried to identify and understand this type of qanat by asking

unfortunately lost, it has played an important role in expanding the agricultural landscape and Oasis in this region.

The general system of the floor-generating qanat is similar to that of other qanats, as described in detail in the first chapter. However, two main points distinguish this qanat:

1. The mother well is not in the foothills, but it had been fed from the groundwater aquifer created in the upstream agricultural areas. In this area, traditional farming had been carried out using flooding irrigation method, in which, a large volume of water has entered the field at once and, given the sandy-gravel bed and the optimal soil permeability, the water penetrated well into the ground to the point getting to the harder layers, forming a new aquifer over time. With the construction of a new qanat from the site of the new aquifer toward the desert, the water was transferred to distant villages. Hence, the villages were built at distances far from the mountains and close to the desert.
2. In cases where the groundwater level is high or where the slope of the underwater flow has not much difference with the surface gradient of the earth, a greater part of the horizontal tunnel of the qanat is placed in water as if the water is coming out of the tunnel floor. Thus, it is locally called the floor-generating qanat. Most of the aforementioned qanats were fed from underground water-containing layers from the agricultural area of the upstream villages. They were of this type due to the fact that the beginning and end of the qanat were located in a plain with a gentle slope.

professors, the experts, the indigenous people, and the old diggers through field studies (Due to local language and dialect in the study area, I even asked for help from younger people as interpreters in a few cases during the interviews and conversations).

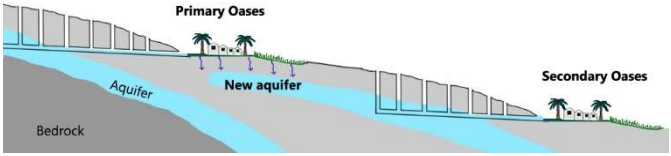


FIGURE 34
The schematic cross-section shows the role of Qanat in development of the secondary Oasis of H.S.O. (©Mahnaz Sarlak)

Therefore, the secondary Oases are dependent on primary Oases and usually, they have less physical development than the primary oases.

Secondary oases, although small or remote, play an important role in creating a cultural landscape, the most important of which include:

- **Cultural value and preserving the traditional knowledge:** Rural society has a "rural culture" that has its system of organization and transformation. In this view, culture is understood as the product of interaction with nature[19]. So, traditional agriculture is not isolated from rural culture. It affects and is affected by family and social relationships, how to divide the land and water, economic relations[20]. Also, local language and dialect, proverbs, songs, music, and dancing are a part of traditional knowledge in a rural area.

- **Environmental value:** Through agriculture and cultivating trees, creating natural filtering against hot and hazy winds of the desert, oases had an effective role in providing the climatic welfare of upstream oases. As a result, they enabled further development of the primary oases.

- **Security value:** Also, with the permanent settlement of the villagers, Oases are considered to be safe places on the desert periphery. They are reliable and welcoming shelters for exhausted travelers or those lost in the desert. They are also

[19] M. Castells, "The Urban Question, Translated by Alan Sheridan," *London: Edward Arnold*, 1977. P.120

[20] FAO, "Social and Cultural Factors in Extension," n.d., at http://www.fao.org/3/t0060e/T0060E04.htm#Culture.

the frontier places of resistance and fight against the enemy, so that the upstream oases have enough time for combat and defense.

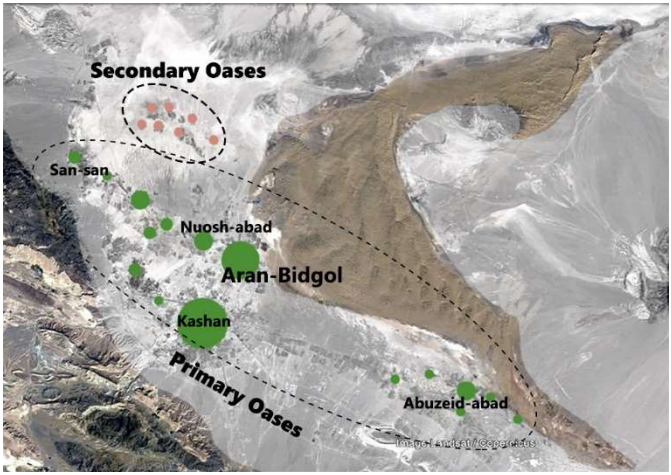


FIGURE 35
The hierarchical system of oasis (H.S.O.) Between mountain and desert (©sketch by Mahnaz Sarlak)

FACTORS AFFECTING THE DISPERSION, DEVELOPMENT, AND PHYSICAL CHANGE OF SETTLEMENTS

Different factors influence the formation and development of each settlement such as any other geographic phenomenon. The combination and impact of these factors will lead to a special structure and morphology in the settlements in every period of their life. This construct and development process do not follow a certain pattern to extend it to all settlements.

Geographic factors, both natural and human, play an important role in its physical development. The natural status of each region can provide favorable conditions for the expansion of the city or prevent its growth and development. By studying the topographic maps, we realize that the county is plain with a gentle slope, and in this regard, there is no problem for the development of villages in all directions. As

we approach the desert and the north, we get closer to flat conditions with the plain topography due to moving away from the foothills-mountainous area. This gentle slope and the earth's smooth terrain have provided a suitable ground for agricultural activity and building Oasis.

FIGURE 36
The cultural landscape between mountain and sand dunes (section and photos by Mahnaz Sarlak)

The sandy hills in the northeast and east can be seen both as an opportunity and a threat to the villages. As, on one hand, with a wind blowing from the east, a lot of sand and gravel are transferred to the villages and farms, causing some problems in the lives of the inhabitants of the area.

FIGURE 37
Abandoned villages due to sandstorms (© photo by Mahnaz Sarlak, 2018)

On the other hand, by creating a long wall, as if the settlements are enclosed in a plain between two mountains, they have created a microclimate, a bit milder than the vast desert on the east side of the hill of Band-e Rig. One can also say that, by creating a natural corridor, they lead a desirable but weak wind to the Oasis that blows from the north and northwest.

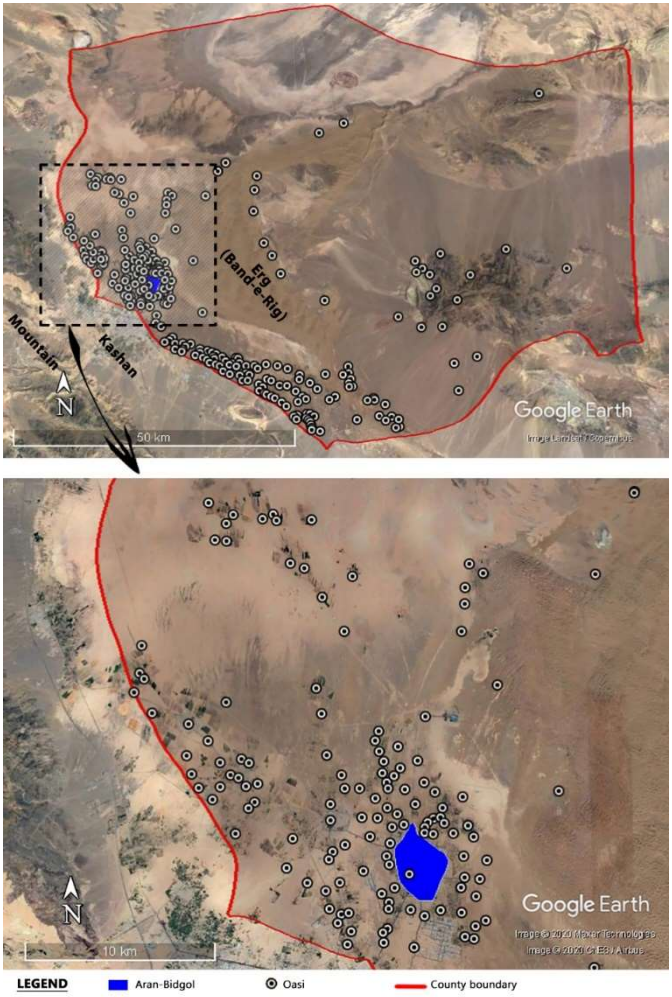


FIGURE 38
Distribution of Oases (map by Mahnaz Sarlak using GIS, google earth, Geographical coordinates of villages received from Forest, Range and Watershed Organization F.R.W.O.)

The presence of the sand dunes has defined a natural boundary and limit in the region, which has hindered the expansion of the hierarchical system of Oasis (H.S.O.) so that the residential areas are not seen in the eastern part of Band-e Rig.

In addition to natural and geographical factors, how to access water and the amount of water discharge have a direct effect on the dispersion and the rate of the physical growth of the oases.

As explained in the first chapter, until 1960, excavating wells was not common in rural regions of Iran, but with the start of modernity, besides implementing Shah's decree on land reforms and the independence of farmers, "It thus radically changed land ownership and resulted in a far-reaching socio-economic transformation"[21], the digging of wells started as one of the most important sources of drinking and farming water supply in these regions.

FIGURE 39-40
White revolution, land reform, 1963

Left: shah Mohammad Reza Pahlavi handing out the ownership document of agricultural lands to women, (https://commons.wikimedia.org/wiki/File:Mrplandreform2.jpg)

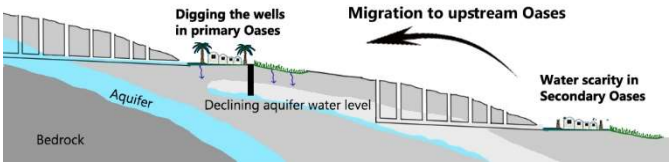
Right: Shah Mohammad Reza Pahlavi on tractor as a symbol of modern agriculture(A scene from a documentary in https://www.youtube.com/watch?V=4smqe3n2gng)

Downstream oases gradually faced flume dry-out and water scarcity, and they took two paths to survive: either migrating to upstream oases or excavating deeper wells. Due to the higher cost of excavating deep wells and the small size of the secondary oases, most of the villagers chose the migration option and settled in upstream oases. Over time, many secondary oases were abandoned, and the capillary system of oases, developed over thousands of years in accordance with the indigenous knowledge, had changed.

Today, unfortunately, it can be observed the severe desertification and the expansion of deserts in these areas.

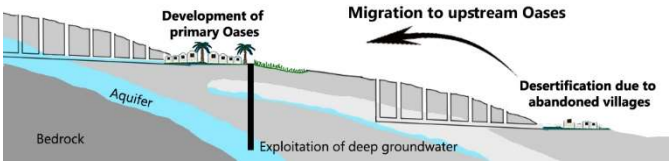
[21] M. G. Majd, "Land Reform Policies in Iran," *American Journal of Agricultural Economics* 69, no. 4 (1987): 843–48.

FIGURE 41
Schematic cross-section (not to scale) of the impact of digging wells on changes of H.S.O. (© Mahnaz Sarlak)



Few years after excavating semi-deep wells and the decline of water resources in these aquifers, farmers in the upstream villages had to excavate deep wells too. At first, villagers expanded farming and pastoralism activities as they had access to more water resources. With the increase of the migrant population from the downstream oases, these villages had the significant population and physical growth.

FIGURE 42
Schematic cross-section (not to scale) of the impact of deep wells on changes of H.S.O. (© Mahnaz Sarlak)



In desert areas, due to the low rainfall, high temperatures, and severe evaporation, the formation of groundwater aquifers and the natural recharge of the existing groundwaters, is a very slow process. In such a situation, in case the extraction of groundwater is more than its recharge, the groundwater level of the aquifers will obviously be lowered[22] and the result will be the water salinity. The reason is that as the freshwater in the underground aquifers declines, salty water will enter the wells. The salinization of these well waters and using them for irrigation not only does not benefit the farmers but also prepares the soil to get even saltier. In these situations, if the extraction of groundwater continues in an inappropriate trend, the water in deep wells will certainly become a factor in accelerating the desertification into the

[22] T. Gleeson et al., "Groundwater Sustainability Strategies," *Nature Geoscience* 3, no. 6 (2010): 378–79.

farmlands and pastureland[23]. Therefore, excavating deep well impinges irrecoverable expenditure on the environment in addition to heightening the economical expenses for the farmers.

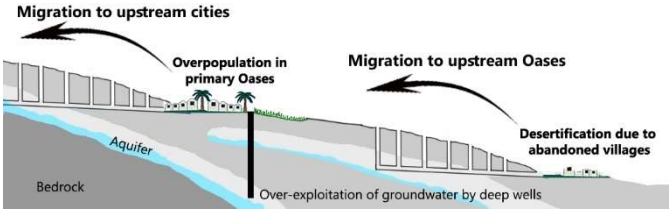


FIGURE 43
Schematic cross-section (not to scale) of the impact of migration and urbanization on changes of H.S.O. (© Mahnaz Sarlak)

Based on the current statistics from 1960 to 1976, about 50 thousand wells are excavated in Iran, but after 1976, the digging of the well was banned in the plains with the risk of groundwater resource decline.

According to the general director of the Bureau for Conservation and Exploitation of Groundwater Resources of Iran's Water Management Company, on the sidelines of the 15th International Exhibition of Iranian Water Industry and Water and Wastewater Installations at the meeting of "Forbidden Plains and Groundwater Resources Crisis in Iran," held in October 2019 in Tehran, among 609 plains in the country, 408 plains are banned currently. Among the 408 forbidden plains of the country, about 135 plains have a more severe condition and face quality change and land subsidence because of the water resource decline[24]. Despite the ban on exploitation of underground water (see figure 44), due to the wasteful and immethodical excavation of deep wells and excessive utilization, strong damage has occurred to the level of groundwater so that most of the plain qanats have dried and the water yield of old wells has fallen sharply as well. At present, all the water needed for urban and rural areas, and

[23] P. Kardavani, *The problems of waters in Iran*, 10th ed. (Tehran: University of Tehran press, 2011). P.234-240

[24] Full text of the interview, in Persian language, is available on the site of Tasnim news:
www.tasnimnews.com/fa/news/1398/07/09/2109370

even agricultural uses, is provided by deep and semi-deep wells.

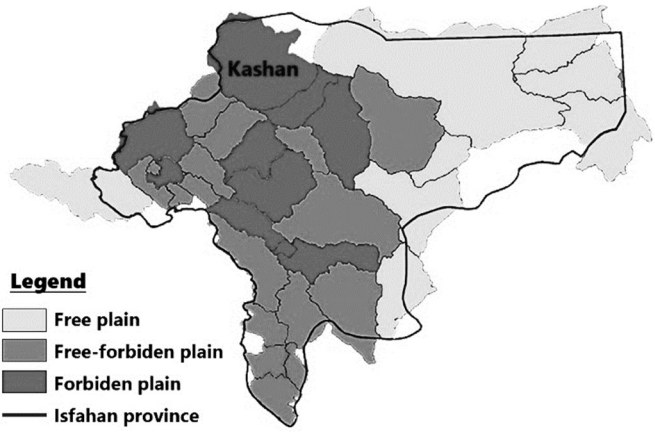


FIGURE 44
Isfahan's forbidden plain for drilling the deep well (Source: Regional Water Company of Isfahan, 2017)

As mentioned before, the county of Aran-Bidgol is located in a dry area adjacent to the Maranjab Desert and the Salt Lake, in which on one side, the rush of salty water and on the other side, the decline of atmospheric downfalls and the droughts in recent years have led to the reduction of recharging resources of aquifers, as well as increasing of the saltiness and the amount of EC in the water of this region (see analyses on the depth of agriculture wells and the quality of water). Unfortunately, in this region, due to the excessive use of salty water for Irrigation of farms in long term, many high-quality agricultural lands are converted into salty lands and are non-cultivable (see the analyses on the agricultural water and soil).

Land destruction, due to human activities or climatic and natural conditions, is one of the most important and influential factors of desertification. This phenomenon has occurred in many regions of Iran, particularly the villages in the periphery of the central desert of Iran, and has made living in these oases so difficult that the number of abandoned villages is increasing every year (see figure 45). Therefore, the H.S.O. is weakened, and the traditional agricultural landscape

and the existing rural landscape, along with the cultural, economic, and social functions, are diminishing rapidly. Thus, the desert replaces the lush land of small oases.

	2006	2011	2016
Village with inhabitants	49	45	41
Village without inhabitants	61	65	69

FIGURE 45
Quantitative growth of villages of Aran-Bidgol county, (Source: Statistical Center of Iran)

In addition to the aforementioned, other reasons have also contributed to the physical changes of these habitats and their spatial development. As these Oases, on one hand, are affected by the internal changes of their community that has formed based on the socio-economic and religious developments and the system ruling the economy and livelihood for a long time, and, on the other hand, the developments of the city of Kashan and its physical, spatial, and economic impact on its domains of influence have caused many changes in the cities and villages. Thus, the network of surrounding villages has turned into villages-cities in terms of appearance and physical dimensions without the opportunity of undergoing the stages of urbanization, which have neither an urban identity nor a rural identity. (The process of urbanization of villages has been completely described in the first chapter)

FIGURE 46
The rural structure that is changing in urban structure, Taher-Abad, 2019 (photo: ©Mahnaz Sarlak using an unmanned aerial vehicle)

According to this analysis, the number of residential villages is decreasing and at the same time, the number of non-residential villages is increasing, It indicates that the

villagers are migrating to the cities, and if this trend continues in the long run, most of the villages will be abandoned and the rural landscape in the county will be destroyed.

FIGURE 47
Population growth in urban and rural areas of Aran-Bidgol county, (Source: Statiscal Center of Iran)

	2006	2011	2016
Urban population	76438	82332	89022
Rural Population	13523	15077	14495
Total population	89961	97409	103517

Population growth analysis also shows that rural population growth is much slower than urban population growth. Most of the county's population growth is related to cities. In addition to migration from rural to urban areas, it can be concluded that the younger population has decreased in the villages. Usually, urban residents, especially young people, although coming from villages, have less interest in continuing agricultural activity and activities related to rural life. Therefore, in Aran-Bidgol county, the agricultural landscape is at risk of destruction and disappearance.

FIGURE 48
Age-based pyramid of urban zones of Aran-Bidgol county (Source: Statical Center of Iran, 2006)

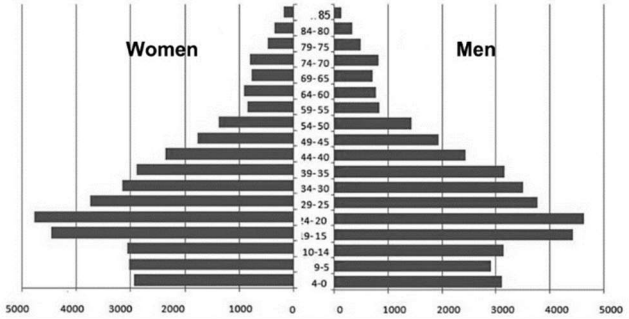
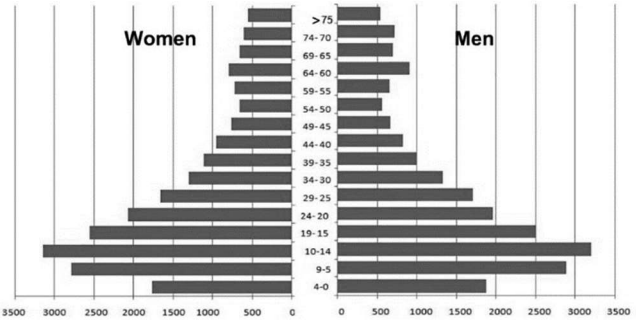


FIGURE 49
Age-based pyramid of rural zones of Aran-Bidgol county (Source: Statical Center of Iran, 2006)



AGRICULTURAL LANDSCAPE

As discussed in the Cultural Landscape section, the general landscape in the study area consists of a series of scattered Oases. Each Oasis consists of village and agricultural land that expanded according to the number and quality of available water resources. Due to the process of urbanization and industrialization, the agricultural landscape has undergone drastic changes.

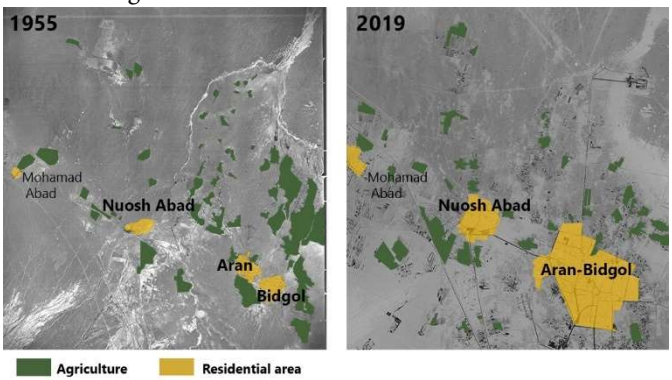


FIGURE 50
Changes in agricultural areas
Left: based on an aerial photo of 1955, received from Iran's National Geographical Organization (N.G.O.)
Right: based on google map
Edited by Mahnaz sarlak

The oldest aerial photography of this area dates to 1955. Comparing to the current situation, which is available from Google Earth. It is clearly seen that the area of agricultural land has been drastically reduced.

	2001	2006	2011	2016
Farming area	10227	11004	10397	8181
Orchards	1180	1561	2305	2256
The total area of irrigated agriculture	11407	12565	12702	10437

FIGURE 51
Quantitative changes of cultivated area of crops (in hectares) over time, (Source: Organization Agriculture Jahad Isfahan, www.agri-es.ir

Agriculture in these Oases is based on family farming, due to the scarcity of water resources and poor soil quality, the extent of the farmlands is often small, about the scale of a family's needs, or slightly larger. In the past, the subsistence in this arid and desert region, especially in some remote villages, continued with local produce. Throughout the centuries,

indigenous peoples have used specific crops and techniques for agriculture.

In short, the traditional agricultural products of this region can be divided into five main categories:

1- Cereals that are important for bread making. Due to the adaptation of barley to water deficit and soil salinity, barley has been one of the most important crops in the region.
2- Fruits and vegetables, especially juicy summer fruits for quenching thirst. It should be noted that in all warm regions of Iran there is a special type of farmland that is dedicated only to planting juicy summer fruit bushes of Cucurbitaceae family plants such as watermelon, Persian melon, cantaloupe, honeydew melon, cucumber, and et. This type of kitchen garden is called *Jaliz*.
3- Forage Plants for livestock (most livestock are Camels and Sheep)
4- Plants used in industry such as Cotton, Tobacco
5- Orchards, the main crops of this category can be noted pistachio and pomegranate.

Category	Main crops	Area (h)			
		2001	2006	2011	2016
Cereals	Barley	4000	4235	4700	3600
	Wheat	1900	1525	1400	800
Plants used in industry	Cotton	1148	1018	850	500
Forage	Alfalfa	700	350	600	919
	Forage corn	342	541	540	300
Kitchen garden	Cantaloupe	680	1169	1055	668
	Melon	385	347	350	177
Orchards	Pistachio	1100	1198	2065	1581
	Olives	30	123	-	-
	Pomegranate	-	97	235	195

FIGURE 52
Examples of quantitative changes of cultivated area of each main crops over time, (Source: Organization Agriculture Jahad Isfahan, www.agri-es.ir)

The agricultural activities that are in this area can be divided into two large groups:

- Traditional or subsistence farming
- Semi-modern or commercial farming

	Subsistence Farming (S.F.)	**Commercial Farming (C.F.)**
Purpose	personal consumption	purpose of trade
Character	Labor intensive	Capital intensive
Labour type	Family members	Hired workers
Size	Small area	Large area
Irrigation method	Traditional methods	Modern methods
Financial capital	Minimal	High
Type of products	Polyculture farming, use for own consumption	Monoculture farming, specialized products
Environmental effects	-Increased biodiversity -Tolerated the unpredictable environment	-Reduced plant competition -Reduced genetic diversity -Increased soil erosion
Landscape	Landscape homogeneity	Diversified landscape

FIGURE 53
Comparison of traditional and commercial agriculture

In the study area, each of these two major groups, include various agricultural systems. In the following, some of these systems which are capable to affect the agricultural landscape will be examined.

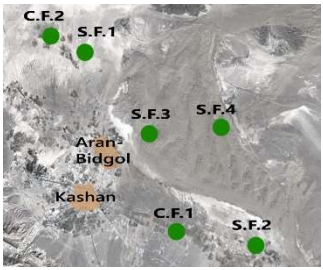


FIGURE 54
Location of the studied oases

S.F.1, Taqi-Abad Oasis

Taqi-Abad is one of the secondary oases of H.S.O. in this area and it may be considered the closest oasis to the desert which has still permanent inhabitants. It has been resisting abandonment for more than 10 years by having a population of fewer than three households. To reach this oasis, it is possible to move from NushAbad city toward the north for 13km. This trip is along to the qanats that transfer water to the secondary oases of H.S.O.; Feiz-Abad qanat, the longest aqueduct of the county, is visible in the west of the road.

FIGURE 55
The way toward Taghi-Abad, on the left of the road, see the Qanat, on the right of the road see the afforestation area (photo: ©Mahnaz Sarlak, using an unmanned aerial vehicle, 2018)

Another way to reach Taqi-Abad begins from the north of Aran-Bidgol city and arrives at the Kavir Steel Company after passing about 6km. This factory has been constructed with the aim of increasing employment and prevent migration, but due to the high extraction of underground water and also the entrance of wastewater of the factories to the water and soil, it has had a significant role in polluting the environment, reducing the agriculture and destroying the small villages. It has been turned into a factor for having immigration. (it will be fully examined in the industrial part). After the factory, the road changes to the northwestern route and after 6km reaches the village of Feiz-Abad, of which only one shrine remains.

Taqi Abad village has been located 3km to the Feiz-Abad from the north. In the east part of the road, there is a strip of about 350meters wide and on the west side up to aqueducts, there are many Haloxylon seedlings that are planted in the rows to prevent desertification.

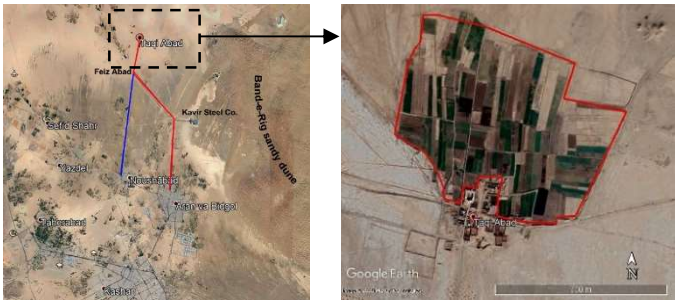


FIGURE 56-57
Location of Taghi-Abad and the access routes to the Oasis from the nearest cities.
Source: Google earth

Taqi-Abad oasis is built-up from two parts of residential and agricultural. The rural landscape consists of old texture and a new one. The old texture of the village consists of a cistern and an adobe castle that has an entrance and a watchtower on the southern front, a central yard, and small houses with domical roofs on the east and north, and the sheepfold on the west. Of course, today most of the houses are abandoned and outside the castle, buildings with modern materials have been built without any special order or complying with the old texture. The new texture is formed based on the needs and personal tastes of the permanent residents and also seasonal farmers and ranchers over time. The facilities of this area are limited to electricity and potable water and lack schools, medical centers, and shops. It is in the urban sphere of influence of Nushabad.

The small pomegranate orchard is in the west of the adobe castle, near of water stream. The vast agricultural farms can be seen in the north and east of the village. The water is directed to the fields based on the schedule. Surface irrigation methods (flood irrigation, basin irrigation) are used for irrigation.

FIGURE 58
The constituent component of Oasis:
- Old rural texture (adobe castle)
- The cistern of water
- New rural texture
- Farms
- Orchards

FIGURE 59-60
Oasis and the access routes to it.
The afforested area can be seen in the distance

FIGURE 61-62
Traditional architecture as the Eco-Friendly Architecture

All of above photos: ©Mahnaz Sarlak

In general, the water enters the basin and waters the plants by passing through the soil surface, and then the remaining water is directed to the next basin. This action continues until the entire surface of a farmer's farm is irrigated. In this method, only half of the water reaches the plant and the other half will be absorbed by the soil or evaporated. Due to the intense solar radiation and evaporation of the surface water, traditional farmers were not proceeding to irrigation at the hot times of the day to preventing water loss to some extent. In modern agriculture, they consider the amount of water which is absorbed by the soil as the water loss, but the same amount of time, recharge underground aquifers that in the context of the cultural landscape, its role in the development of oases was investigated. Choosing the type of crop is based

on the economic needs and price of crops, climatic conditions, the amount of precipitation each year, water, and soil conditions by farmers. Common agricultural products in Taqi-Abad usually include barely, alfalfa and legumes. Compared to these products, much less area is allocated to wheat and vegetable planting.

FIGURE 63-64
The water stream

FIGURE 65-66
The most diversity of flora in Oasis is on both sides of the water stream

FIGURE 67-68
The pomegranate orchard

FIGURE 69-70
The extensive agricultural landscape on a plain with a slight slope

All of above photos: ©Mahnaz Sarlak

S.F.2, Qasem-Abad Oasis

In the southern part of Aran-Bidgol county, a narrow and long plain has been created in the distance between Band-e Rig sandy hill and mountain. The width of the plain is divided into two parts parallel to the sandy hill and at about 10km from it by crossing the railway line. In a way that the oases, which are linearly formed according to the geographical form of the region, are located in the distance between the sandy hill and railway line, and industrial lands are placed in the distance between the railway and mountain. An asphalt road begins from Kashan and connects these oases with an approximate length of 40km. Approximately, in the distance of 35km of Kashan, in the southern part of the sandy hill of Ban-ed Rig, Qasem-Abad is located.

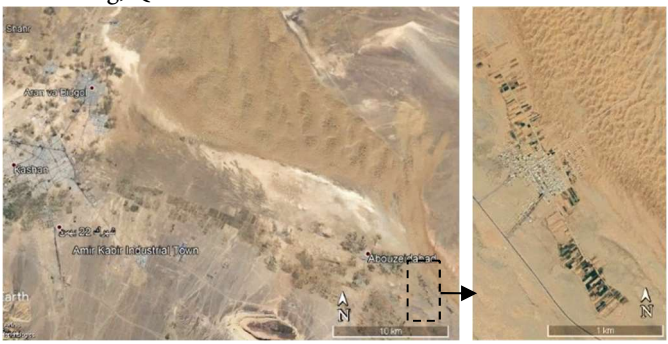


FIGURE 71-72
Location of Qasem-Abad
Source: Google earth

This village has a residential texture in the center and two agricultural parts on sides. The rural landscape includes a new checkered texture which is almost regular and modern. The residential area is located in a closer part of the road and the animal husbandry area is located in the last part of the village and near to the sandy hill. There are a few remnants of the previous texture of the village as the old castle has been buried because of sandstorms (Figure 73).

The agricultural landscape of Qasem Abad is strongly influenced by the eastern winds that have a higher speed due to the low height of Ban-ed Rig. The agricultural lands have been enclosed among the sands and the permanent struggle of

farmers with the desert is visible. Farmers must do some actions to stabilize sands as well as farming in the fields in order to reduce damages of sandstorms. Due to the weakness of some desert plant species to regeneration naturally[25], farmers proceed to plant climate compatible plants, bushes, and shrubs, on the sand dunes around the fields. To more protection farms from the wind, tall bushes and various trees have been planted on the border of the farms. The roots of the trees stabilize soil and the crown of the trees plays an important role as windbreaks. The basins are in the form of narrow, long rectangles. The first basin which is exposed to the wind, usually is dedicated to planting pomegranate and pistachio trees. The existence of trees decreases the speed of the wind and reduces the damage to crops by filtering and clearing the air from the sands.

FIGURE 73
Remnants of the old adobe castle

FIGURE 74-75
Vicinity of sand dunes and farms

All of photos: ©Mahnaz Sarlak

[25] K. G. Ramawat, *Desert Plants: Biology and Biotechnology* (Springer Science & Business Media, 2009)., P425

FIGURE 76
New rural texture regardless of climatic conditions

FIGURE 77-78
Agriculture landscape is surrounded by sand dunes

FIGURE 79-80
Orchards as a windbreak

FIGURE 81-82
Irrigation canals

FIGURE 83-84
More diversity of flora results in more diversity of fauna

All of photos:
©Mahnaz Sarlak

S.F.3, Chal Sombak Oasis
(planting watermelons in the middle of the sandy deserts)

Certainly, traditional agriculture is not possible without having access to water. In the previous parts, common methods of extraction and use of water from the ground in the form of well or qanat and their issues were checked. In the study area, there is another way of using underground water without the need to dig the well or even channel. In fact, underground water is directly using in agriculture without any facilities. In this traditional agricultural system, the roots of the plants grow and reach the underground water, so they are not directly watered. This traditional method has been common in some of the desert areas of Iran from ancient times, especially in the massive coherent sandy dunes of Band-e-rig in which the level of underground water is very high. According to the geology studies, it can be justified that the slope of the ground is from Kashan and the heights located in the south to the north and the Salt Lake. As a result, the flow direction of underground water and surface floodwater is from the south towards the north, that is, from Kashan to the sandy hills. Moreover, another characteristic of the sand is that it has a low capability to absorb and keep water. So, when it rains, the sandy hills guide the rainwater to the bottom. The existence of impervious layers in the lower layers of sandy hills causes the aggregation of water and the level of underground water rises[26]. This water is fresh and potable and in general, the study area has the lowest electric conduction. (see the analysis of water quality)

Some of the native farmers proceed to plant watermelons when they are aware of the presence of freshwater on the sandy hills. This method of cultivation is called Sombak (named after Sombak Plain of Ghazi area in Kashan). The farmers push back the wind-blown sands to reach the ground

[26] Kardavani, *The problems of waters in Iran*.

surface so that a flat plot of sandy land will be released in the middle and a sandy mass will be accumulated in the form of a high wall around it. In order to prevent these sands to move under the influence of the wind and not to cover the land surface which has been released, they place some dry bushes on these sands to create a windbreak in this way. In some cases, instead of dried plants, they plant *Stipagrostis pennata (Trin.) De Winter* which are the native plants of these sandy dunes[27].

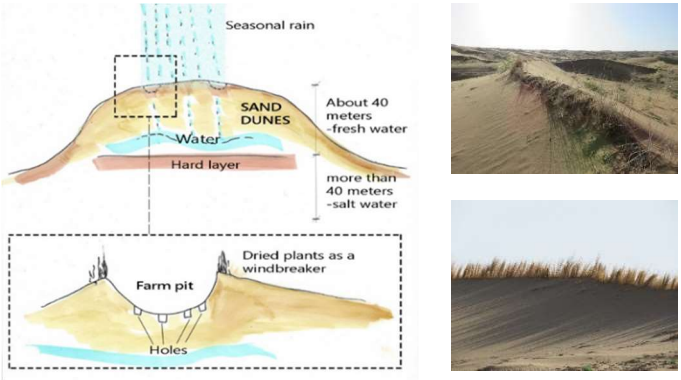


FIGURE 85-87
Left: a sketch of the farm pits on sand dune
Right: dried plants as a windbreak
©Mahnaz Sarlak

The farmers plant watermelon by digging holes that are 1m deep and 30cm wide and then cover them with different layers of soil and manure. The top layer of soil most heated by the sun is poured in first, then covered with 10cm of manure, and finally covered with the most humid layer extracted from the hole. They place the watermelon seeds inside the soil and prepare some kind of barrier against the moving sand and wind in the surroundings of the hole. The seeds develop and grow gradually while the water is captivated in the basin. Once the root reaches the layer with manure, there is no further need for irrigation.

[27] H. Batooli, "Studying the Ecological Properties OftheDesert Plant Stipagrostispennata (Trin.) De Winter in the Sandy Dunes of Rige-Boland in Aran AndBidgol," *Plant and Ecosystem* 11, no. 42 (2015): 107.

FIGURE 88
The farm pits in Chal-Sombak, (photo: ©Mahnaz Sarlak, using an unmanned aerial vehicle)

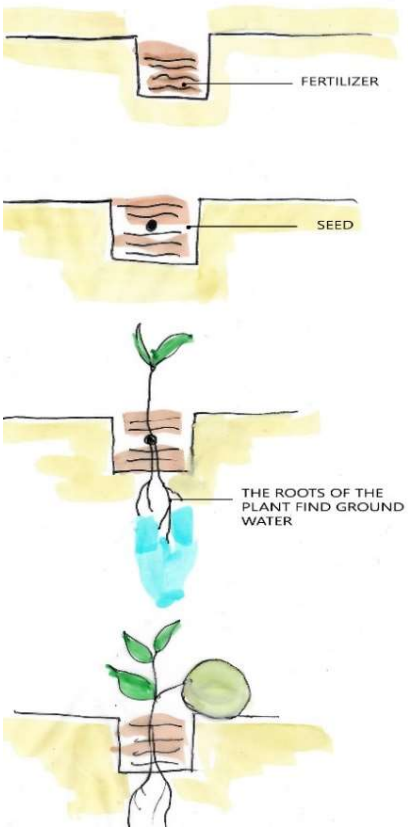


FIGURE 89-94
Agricultural steps from seed to crop
Sketch and photos: ©Mahnaz Sarlak

S.F.4, Chah Aroos Oasis

Chah Aroos (in the English language: Bride well) is the name of an oasis consists of a collection of farms, without residential part, on the eastern part of the Band-e Rig sandy hill. The agricultural system in this area has been common as well as the Chale Sombak, which has been explained. Due to the lack of roads and the problems to have access to the residential areas, all the farms have been abandoned. Only one farmer has kept his farm active with perseverance and initiative. Since 2006, he has decided to change the kind of his crop that was unique to watermelon. He proceeded to create a palm grove by planting about 800 seedlings in a completely organic way. Palm cultivation has been unprecedented in this area because, as F.A.O. confirms, "even though date palm is a thermopile species, it withstands large temperature fluctuations. Below 7°C growth stops, and this stage is called a resting period. When the temperature decreases for a certain period to below 0°C, it causes metabolic disorders which lead to partial or total damage of leaves."[28]

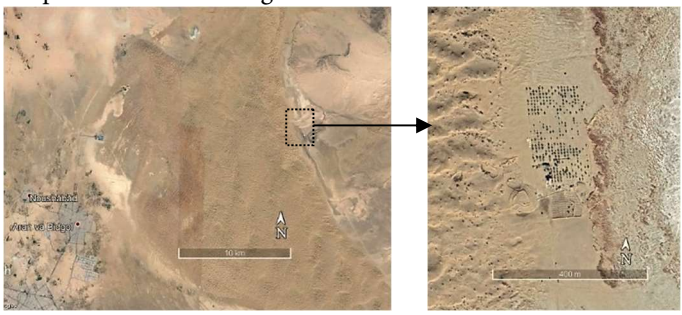


FIGURE 95-96
Location of Chah-Aroos Oasi
Source: Google earth

This farmer has done these actions to struggle with the current situation:

- He has created a suitable substrate for planting palm trees with a mixture of clay soil, sheep, and pigeon fertilizer.

[28] http://www.fao.org/3/y4360e/y4360e08.htm

- After planting trees, in order to protect tree trunks against the coldness of winter, he has buried them in the soil and just the upper part of the tree is visible.

The trees do not need irrigation in this method and the water table directly waters the roots of palms. As he said, some of the trees became fertile after 7 years and the first crop of the date was picked up. According to the statistics of 2016, the amount of his date harvest was 5tons[29]. Therefore, it can be said that his project achieved great success.

The presence of palm groves in the desert region, in addition to being important in terms of agriculture and food security, and economy, has positive environmental effects:

- In this method, the branches and crown of the trees have a short distance from the soil surface and can protect the soil against wind erosion.
- The large crown of the palm tree shadows on the soil surface and soil moisture increases.
- Over time, it can relatively improve the poor and sandy soil and create a substrate for growing other plants by mixing the leaves and dried components of the palm tree and finally increase the diversity of plant species.

FIGURE 97-98
The palm grove and its farmer

C.F.1, Pistachio orchard

Pistachio (*Pistacia vera* L.) is a plant that has been cultivated in different parts of Iran since ancient times. There are wild pistachio forests in the northeastern area of Iran particularly the border between Afghanistan and

[29] http://www.agri-es.ir/Default.aspx?tabid=1926

Turkmenistan[30]. It is supposed that the pistachio tree was domesticated and cultivated in Iran[31] since 3-4 thousand years ago[32]. Pistachio is one of the most important agricultural products in Iran due to "high potential in improving livelihood and food security due to the high international demand"[33].

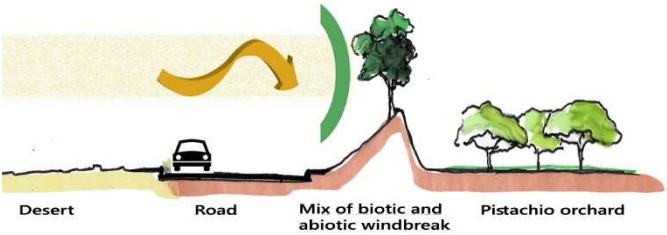


FIGURE 99
Schematic cross-section (not to scale) of the impact of Two-component windbreak on the protection of orchard
©Mahnaz Sarlak

The pistachio tree can be easily planted in most of the soils with different textures in a way that even in the salty lands, it is more resistant than the other trees. The best soil for the pistachio is clay soil with optimal drainage and low EC of water and soil.[34]

But pistachio trees are not suitable for windy areas because the wind blow disturbs the skeletal balance of the trees and causes damages. It is usually recommended to plant windbreaks perpendicular to the prevailing winds of the area and at a distance of 5meters from the first row. The most suitable tree windbreak for these areas is the male pistachio in which the distance between the male pistachio trees as windbreaks is 2-3 meters. Another benefit of this windbreak is

[30] O. F. Harandi and M. Ghaffari, "Chromosome Studies on Pistachio (Pistacia Vera L.) from Iran," *Cahiers Options Méditerranéennes* 56 (2001): 35–40.

[31] M. M. Jazi et al., "A Genome-Wide Transcriptome Map of Pistachio (Pistacia Vera L.) Provides Novel Insights into Salinity-Related Genes and Marker Discovery," *BMC Genomics* 18, no. 1 (2017): 627.

[32] J. Crane, "Pistachio Tree Nuts," *Westport: Avipublishing Company*, 1978.

[33] fao.org/fileadmin/templates/SEC/docs/PP_prez/Pistachio_ppt_en.pdf

[34] https://iranpistachio.org/fa/article/baqbani/1513-ehdas

the optimal cover of the pollen during pollination[35]. But in the study area, Khorasan and Sam winds (see p.89) blow sharply from the desert and it is not possible to protect the pistachio orchard just by planting a row of male pistachio tree and a stronger windbreak is needed. To this, farmers create an embankment, with a height of at least 2meters, perpendicular to the wind direction, and proceed to plant Tamarix trees on them.

- Stabilization of the sandy soil by the deep roots of Tamarix trees
- Increasing the height of the windbreak
- Maximum effectiveness by a mix of biotic windbreak (Tamarix tree) and abiotic windbreak (embankment)
- The contradiction of green vertical wall with the horizontal lines of the desert, makes a variety in the monotone landscape of the desert
- Indigenous materials and compatible with the environment
- Low implement costs
- Decreasing the speed of the wind and prevent wind erosion.
- Creating a local microclimate and increasing the function of the agricultural plants.
- Providing a good substrate for growing the plants. (as can be seen in the picture, over time, the seeds of the plants that are carried by the wind, have settled in the soil, in the side of the wind).
- Making diversity in the monotonous desert landscape, by contrasting green vertical wall to the horizontal lines of the desert

Creating pistachio orchard in large areas requires initial big funds which are not possible for a rural family. It usually is done through agricultural cooperatives and using bank loans or attracting investors. This type of agriculture tries to

[35] https://iranpistachio.org/fa/article/baqbani/1513-ehdas

increase exploitation by using technology, modern agricultural machinery, and chemical fertilizer.

FIGURE 100-101
Tamarix tree as a windbreak
Photo: ©Mahnaz Sarlak, 2019

AFFORESTATION

According to UNCCD "Afforestation is the planting of trees or forest cover on land which historically did not contain forests"[36].

"Afforestation increases biomass accumulation (both above ground and below ground), soil organic carbon accumulation, and the related increase in soil biological activity, ecosystem biodiversity (including soil biodiversity) and derived ecosystem services, such as soil and water conservation, carbon sequestration potential, and often aesthetic and cultural values."[37]

As it was discussed in the previous parts, the winds and the movement of sand are natural factors that play an important role in the erosion of soil, the expansion of the desert, and landscape changes. Various biological and chemical methods are used for soil stabilization and desertification control.

[36] https://knowledge.unccd.int/knowledge-products-and-pillars/best-practices-sustainable-land-management/identifying-slm

[37] M. J. Sanz et al., "Sustainable Land Management Contribution to Successful Land-Based Climate Change Adaptation and Mitigation," in *A Report of the Science-Policy Interface. United Nations Convention to Combat Desertification, Bonn, Germany*, 2017. P.62

Increasing vegetation by planting trees and shrubs that are compatible with the natural conditions of the desert is one of the biological methods that have a significant effect on soil stabilization.

Species such as Haloxylon Persicum, Tamarix spp. Zygophyllum spp. etc. are planted in arid and semi-arid areas[38].

In Iran, the project of biological stabilization of sand dunes began in 1963. For the first time, it was tested near the Abuzeid-Abad city and it had great success[39]. Today, following that project, planting the Haloxylon trees in sandy deserts is continued. In recent years, the creation of vast afforestation by the Haloxylon tree in the central desert of Iran has been a controversial issue and has many proponents and opponents.

Tamarix aphylla (L.) krasten (common name: salt cedar)

Tamarix tree is one of the important halophytes of the desert areas that is important in the vegetation of the desert. Tamarix is in the form of a tree that has small needy leaves. The most suitable soil for the growth of this plant is loam soil and mostly grows in the dry areas, near the salty waters and rivers. The Tamarix has different species. It is resistant the temperature changes and grows in every climate. In some cases, due to strong winds, the main trunk is bent on the ground, and consequently, the branches grow upwards. It plays a very important role in protecting the soil by creating the Nebka behind it.

Haloxylon persicum Bunge ex Boiss. & Buhse

Haloxylon persicum, as a resistant species in different habitats, forms scattered masses in some parts of the deserts

[38] www.fao.org/forestry/6170-0260d0070bf7a95927f12e9b6c02073b6.pdf

[39] P. Kardavani, *The great central Kawir of Iran*, 2nd ed. (University of Tehran press, 2008).

of Iran. The positive results of the primary biological stabilization increased the attention to the Haloxylon species.

This plant is in the form of a bush or small tree with a height of 1-8meters which grows well in the poor and salty soils. It is used as a windbreak in the desert areas and causes sandy soils to be less exposed to wind erosion. The Haloxylon roots penetrate the soil about 2.5 meters in the first years and about 16 meters in the next years[40].

FIGURE 102
The green belt of Tamarix and Haloxylon trees

FIGURE 103-104
Nest of savage animals such as rats and snakes

FIGURE 105-106
Irrigation systems of green belt

All photos:
©Mahnaz Sarlak

[40] http://ardestandoe.blogfa.com/post/16

Populus euphratica Olivier

In the stripe margin of the sandy hills, in the range of Siazga, Sonbak, Chahar Taghi in Aran and Bidgol county, there is the native habitat of Populus which are broad-leaf tree; While due to the lack of water, heat, and excessive perspiring of the desert plants, only the needle leaf tree can have a climate adaptation. Populus trees have an average height of 3-5meters and a crown with an average diameter of 2-4meters. One of the important features of this plant is the tolerance against the wide range of temperature and soil salinity[41]. The soil of Populus trees has light to semi-heavy texture including river alluviums. They are also seen in the salty soils and even at the edge of the salty well. Populus is the only tree with wide leaves in the field of sandy hills and margins of desert holes that is affected by the surrounding waters and stabilizes the fluent sands and prevent the soil erosion through the deep root system[42]. These trees often form dense communities and masses in areas of sandy hills that provide more moisture and can improve microclimatic conditions. One of the remarkable points about this species is that it solves the thirsty of birds and other animals in the burning Aran-Bidgol deserts by keeping water in the cavity of the tree trunk and helps maintain the biodiversity of the region.

FIGURE 107-108
The *Populus* tree on the sand dune, photo: ©Mahnaz Sarlak

[41] M. Viart, *Poplars and Willows in Wood Production and Land Use* (Food & Agriculture Org., 1979)., P.13

[42] M. Calagari, A. R. Modirrahmati, and F. Asadi, "Morphological Variation in Leaf Traits of Populus Euphratica Oliv. Natural Populations," *International Journal of Agriculture and Biology* 8, no. 6 (2006): 754–58.

INDUSTRIAL AREAS

Before the introduction of industrial carpet weaving, a significant percentage of families used to weave handmade carpets, kilims, Jajims, all kinds of cotton and silk fabrics, and make pottery and bricks along with agricultural and livestock activities. With the advent of the carpet weaving industry in the last few decades and increasing its revenue, even up to a few times the agricultural income, more than 85% of the families turned to this industry and its other occupations such as mapping, dyeing, wrap winding, etc. so that the carpet weaving and its related occupations have played an important role in the financial and economic situation of the people of this city and the region of Kashan.

FIGURE 109
Handmade carpet weaving by women (©photo by Mahnaz Sarlak)

In 1990, Sabahi-Bidgoli Industrial Town was established in a land with an area of 200 hectares in the east of the old road of Aran-and-Bidgol to Kashan; about 250 factories with office complexes, parks, sports complexes, and cargo terminal were predicted in its surrounding range. With the development of the industrial Town to 400 hectares, more than 400 units of factories are currently engaged in the production of machine-made carpets. Its other production units, including chemicals and hygienic material production units, home dishes and

appliances manufacturing units, and motor pumps making units, etc., supply and present their products to domestic and foreign markets. The number of people employed in this industrial town accounts for more than 7,000.

Helal Industrial Estate was established in 2003 with 57 hectares of land, and currently, more than 45 industrial units are active in this city, mainly working in the areas of machine-woven carpets, textile, and knitting industries.

Ansar Industrial Town in Noush Abad, Aliabad Industrial District in the Central District, and the industrial town belonging to the company of Aran-Bidgol industrial estates are among the industrial areas of the city.

Kavir Steel Co., one of the key industries in the county, built-in 2002; however, its official production started in 2007 with 400 employees and an annual production of 650,000 tons of rebar. With the company's development in 2015, its production capacity increased to 2 million tons a year. Various other industries are active in Aran-Bidgol sparsely. A total of 16,000 persons work in the industrial sector of the county.

FIGURE 110 Industrial landscape, the Kaivir steel company has replaced the agricultural fields near sand dunes (©photos by Mahnaz Sarlak)

Environmental features of the county

Considering the most important goal of today's world, i.e., the achievement of sustainable development, the excessive utilization of natural resources in order to meet the growing needs of human societies, and the return of waste, sewage, and the waste products arising from the consumption or production of necessary supplies to the environment have caused disturbances in the ecosystems, which in some cases lead to the threatening of the biological and non-biological communities (climate change, soil and water resources) and even their destruction. Thus, the regions with environmental value need to be identified in the development and civil studies of different regions and areas and the existing destructive and polluting agents should also be examined. Polluting and destructive factors generally have two natural and human origins. In the following, environmental problems and constraints have been investigated in each section separately and based on the source of pollution.

Environmental problems of natural origin

The rainfall regime, temperature, and wind status in the area are among the most important climatic indices.

Limitations in each of the indicators mentioned, directly and indirectly, influence the environment and the organisms living in that environment. For example, the lack of rainfall and its improper distribution during the seasons prevent the expansion and deployment of green spaces and, consequently, other life manifestations. This limitation is mainly seen in this county. The reduced rainfall and high temperatures during the warm seasons cause an increase in the evaporation from the soil surface, leading to the concentration of salts in the surface layers of the soil. The resulting conditions have prevented the establishment of plant species in the aforementioned area and only halophyte species, which are mainly herbaceous and bush, have grown with a very low density on the surface of the soil. The poor vegetation and soil texture properties in these regions cause the soil to be exposed to severe erosion, leading to the displacement of the surface layer of the soil and the formation of sand dunes and saline lands in the studied area. The movement of gravel particles causes damage to the urban facilities and equipment and also to agricultural lands in addition to air pollution and reducing visibility. Such areas mainly have fragile ecosystems and any exploitation and activity in the environment should be subject to the existing limitations.

Other climatic factors with certain environmental impacts are wind blowing and the movement of air masses. The movement of air masses significantly contributes to the movement of air pollution due to working, activity, and living in the urban environment. The calm weather rate can be a good indicator for determining the capability of each area for industrial loading. The statistics and data from the Kashan Synoptic Station indicate that there is a calm weather phenomenon in the periphery range with approximately 85% of annual observations in 85% of the year. Hence, the weather is calm in a significant part of the year and the displacement of air masses and their transfer may not occur. According to common international rules, the areas that have calm weather

in more than 50% of the year are not suitable for the expansion and development of industrial centers.

Acute environmental dilemmas of artificial origin

A significant part of the existing environmental problems is due to the pressure imposed by man on the natural resources of the environment. The pressure on water resources, discharges of wastewater and industrial wastewater in the environment, turbulence in urban road networks, and its disproportion with the development and expansion of the city, the failure to transfer of industrial factories and polluting workshops to the outside of urban environments are among these pressures.

The following section is examined the existing problems separately:

Excessive pressure on the groundwater aquifers

The increased water withdrawal from underground water tables is one of the acute environmental problems, which mainly threatens the lands area of the Kashan plain. This has led to a significant reduction in the level of groundwater aquifers. In addition to the free water level drop, the suction of saltwater into the water tables with optimum quality has led to a decline in the groundwater quality in some areas. Regarding the negative balance sheet of the plain, the digging of the well was banned for 3 years for the first time in 1979, and again in 1994, the ban on well-drilling in the plain was extended for 5 years. Due to the current situation, the ban still continues, and unfortunately, no evidence indicating the improvement of the groundwater aquifers status has been seen so far.

The set of conditions indicates that one of the environmental problems of the present and future settlements

of this county is the provision of water for various uses from water resources, especially the plain water table aquifers.

Disposal of industries wastewater and sewage in the environment

The sewage and wastewater of factories and plants are one of the most important environmental pollutants. Usually, the wastewater and sewage of factories must undergo the process of physical, chemical, and biological treatment before discharging into the environment and it must be disposed into the environment or recycled in the industrial and agricultural cycle after the output water meets the standards set by the relevant organizations and institutions.

Rangeland degradation

Rangeland degradation is also one of the issues that the studied area is facing. Picking and using the rangeland species as fuel and the excessive pressure of grazing on the rangelands are considered as two major factors in the degradation of pastures.

In addition to the above factors that threaten the environment of the county of Aran-Bidgol, the number of livestock in this county is close to twice the capacity of grazing land. Excessive and uncontrollable pressure on the rangelands leads to the compression of the surface layers of the soil and reduces the permeability of the soil in these lands in addition to removing the proper livestock species and replacing poor quality species. Hence, the soil permeability decreases during seasonal rainfalls, and the rains not only do not feed the aquifers but also exacerbate the soil surface erosions by creating floods.

Assessment of land degradation and classification desertification based on IMDPA approach

Obviously, determining of current desertification situation and its severity is very important for all projects and activities in the arid and semi-arid area. The IMDPA (Iranian Model of Desertification Potential Assessment) approach is one of the available approaches developed for desertification sensitivity assessment based on 9 main criteria, 35 indices, and 3 climates. The nine criteria include climate, geology, and geomorphology, soil, vegetation, water, erosions (fluvial and Aeolian), agriculture, socio-economy issues, industrial and civil development[43]. For the quantification of these criteria, indicators related to each criterion are used. Finally, such as MEDALUS[44] model, the geometric average uses for combining the data[45].

In this study, soil and water criteria were analyzed.

[43] M. R. Ekhtesasi, *How to Classify Desertification in Iran* (Tehran: Research Institute of Forests and Rangelands, 1996)., p.14

[44] Mediterranean desertification and land use

[45] M. R. Ekhtesasi, *Methods and Models in Assessment and Mapping Desertification* (yazd: Yazd University, 2011)., p.286

-The soil criterion consists of 3 indicators of electrical conductivity, soil texture, and depth.

-The water criterion includes electrical conductivity, SAR, and declining groundwater levels.

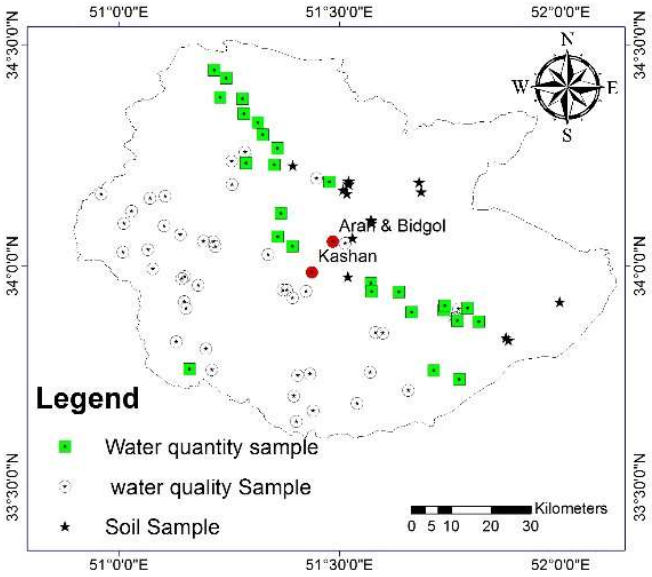


FIGURE 111
Location of water and soil sampling

Map by Mahnaz Sarlak using GIS

Qualitative analysis of water

To study the quality of water (EC and SAR[46] parameters), selected wells were sampled. Sample wells were selected according to the size of the study area, topographic conditions and based on agricultural use.

[46] The **Sodium adsorption ratio** (**SAR**) is an irrigation water quality parameter used in the management of sodium-affected soils. It is an indicator of the suitability of water for use in agricultural irrigation, as determined from the concentrations of the main alkaline and earth alkaline cations present in the water. It is also a standard diagnostic parameter for the sodicity hazard of a soil, as determined from analysis of pore water extracted from the soil. (R. C. Reeve et al., "A Comparison of the Effects of Exchangeable Sodium and Potassium upon the Physical Condition of Soils," *Soil Science Society of America Journal* 18, no. 2 (1954): 130–32., quoted from wikipedia)

First, it was done by the Kriging method for each intermediation index, then it was scored (figure 112), and finally, using the following relation, the water criterion map was calculated.

$$Q_W = \sqrt[3]{Q_{W1} \times Q_{W2} \times Q_{W3}}$$

Q_W : Qualitative water map

Q_{W1} : Electrical Conductivity (EC) map

Q_{W2} : Sodium Adsorption Ratio (SAR) map

Q_{W3} : declining groundwater levels map

FIGURE 112
The weight of water index in IMDPA model

Desertification Classes	<1	1-1.5	1.6-2.5	2.6-3.5	3.6-4
	Very low	Low	Medium	High	Very high
EC (µs/cm)	<250	250-750	750-2250	-5000 2250	≥5000
SAR (meq/l)	<10	10-18	18-26	26-32	≥ 32
Groundwater Decline(cm/year)	<10	10-20	20-30	30-50	≥50

The formula for calculating the sodium adsorption ratio (SAR) is:

$$\text{SAR} = \frac{Na^{+}}{\sqrt{\frac{1}{2}(Ca^{2+} + Mg^{2+})}}$$

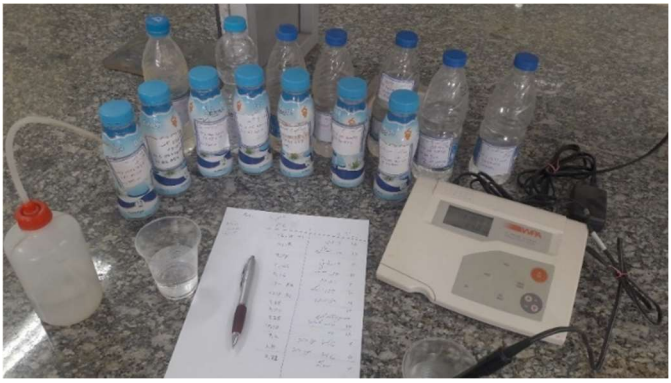


FIGURE 113
EC meters measure the electrical conductivity of water by EC meter (analyze and photo by Mahnaz Sarlak-June 2018)

FIGURE 114 - Summary of water quality test (analyze by Mahnaz Sarlak)

	Type of location	Na (mq)	Ca+Mg (mq/L)	**SAR** (meq/L)	**EC** (µs/cm)
1	Qanat of Maranjab caravanserai	228.44	10.4	100.18	9280
2	Rangeland	152.30	14	57.56	6180
3	Rangeland of camels	220.83	14.8	81.18	12100
4	Agriculture (depth=120m)	357.89	36.4	83.89	17100
5	Agriculture (Qasem-Abad)	186.14	34.4	44.88	9290
6	Agriculture (Chal-Sombak)	78.26	25.2	22.05	3960
7	Agriculture (Chahar Taqi)	82.49	27.6	22.21	3990
8	Pistachio orchard (depth=60m)	122.68	22.8	36.34	7310
9	Pistachio orchard (depth=20m)	93.07	6.8	50.47	3910
10	Agriculture (Chal-Sombak)	31.73	2	31.73	1200
11	Agriculture (Chal-Sombak)	76.15	4	53.84	2460
12	Agriculture (Taqi-Abad)	160.76	39.2	36.31	8720
13	Agriculture (Chah-Aroos)	95.18	4	67.31	3280
14	Agriculture (Chah-Aroos)	46.53	1.2	60.08	1310

Qualitative analysis of soil

The sampling of soil was carried out at 18 points of arable land in the study area including farms, abandoned farms, rangelands. After doing laboratory analyzes, it was done by Kriging method for each intermediation index, then it was scored (figure 115), and finally, using the following relation, the soil criterion map was calculated.

$$Q_S = \sqrt[3]{Q_{S1} \times Q_{S2} \times Q_{S3}}$$

Q_S: Qualitative soil map

Q_{S1} : Electrical Conductivity (EC) map

Q_{S2} : Soil texture map

Q_{S3} : Depth of soil map

FIGURE 115
The weight of soil index in IMDPA model

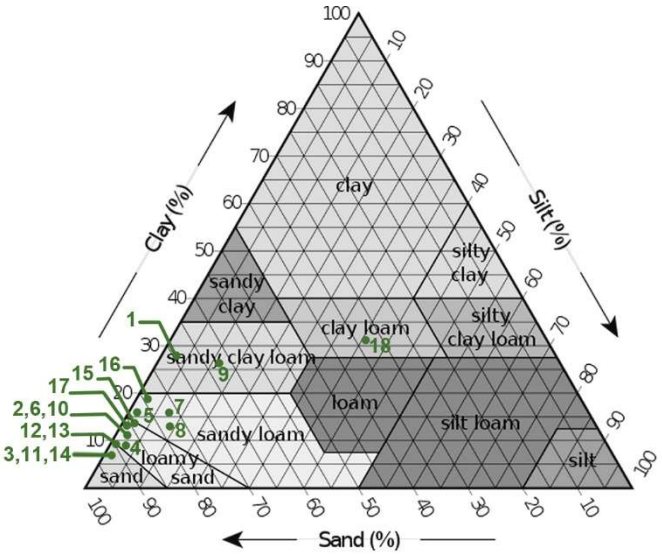
Desertification Classes	<1	1-1.5	1.6-2.5	2.6-3.5	3.6-4
	Very low	Low	Medium	High	Very high
EC (ds/m)	<2	2-4	4-8	8-16	≥16
Depth (cm)	>110	80-110	50-80	20-50	<20
Soil texture	clay	Clay loam	loam	Sandy loam	sandy

Soil Texture

Determining soil texture in this study is based on USDA[47] classification by Hydrometer Method and use of a soil texture triangle.

As expected, except for one case, all samples are formed by a high percentage of sand and silt.

FIGURE 116
The result of the soil texture test (June 2018- analyze by Mahnaz Sarlak)



[47] United States Department of Agriculture

	PH	Ec (ds/m)	caco3 %	N %	P (ppm)	K (ppm)	clay %	Silt %	Sand %	soil texture
1	7.42	2.76	17.92	0.06	8.39	535.75	27.6	3.28	69.12	sandy clay loam
2	7.98	4.29	17.50	0.03	11.72	420.95	11.6	1.28	87.12	loam sandy
3	7.44	2.71	16.25	0.04	11.30	459.22	7.6	1.28	91.12	sand
4	6.95	5.41	17.92	0.04	11.22	707.96	9.6	3.28	87.12	loam sandy
5	6.8	15.83	17.92	0.04	9.74	669.69	15.6	1.28	83.12	sandy loam
6	7.3	6.21	16.25	0.05	8.43	669.69	11.6	1.28	87.12	loam sandy
7	7.21	4.94	19.17	0.02	1.80	344.41	15.6	7.28	77.12	sandy loam
8	7.36	2.66	15.83	0.04	1.15	650.56	13.6	7.28	79.12	sandy loam
9	7.47	3.31	15.42	0.10	8.58	746.23	25.6	11.28	63.12	sandy clay loam
10	6.8	19.93	18.75	0.05	7.13	114.80	11.6	1.28	87.12	loam sandy
11	7.55	3.62	15.83	0.03	10.25	420.95	7.6	1.28	91.12	sand
12	7.29	2.15	17.08	0.06	8.84	727.09	9.6	1.28	89.12	loam sandy
13	8.85	11.8	18.75	0.04	6.46	133.94	9.6	1.28	89.12	loam sandy
14	8.04	4.18	17.08	0.04	9.98	688.82	7.6	1.28	91.12	sand
15	7.11	9.69	16.25	0.08	9.91	650.56	13.6	3.28	83.12	loam sandy
16	7.14	8.86	16.25	0.07	8.81	727.09	17.6	3.28	79.12	sandy loam
17	8.07	6.89	15.00	0.04	10.21	114.80	13.6	1.28	85.12	loam sandy
18	7.12	9.17	16.67	0.09	7.66	133.94	31.6	35.28	33.12	clay loam

FIGURE 117
Summary of water quality test (analyze by Mahnaz Sarlak)

FIGURE 118
Hydrometer method to determine Soil Texture (June 2018- analyze and photo by Mahnaz Sarlak)

DESERTIFICATION SENSITIVITY

Finally, by combining the two criteria of water and soil, a desertification map is obtained.

$$Q_D = \sqrt[2]{Q_S \times Q_W}$$

Q_D : Desertification sensitivity map

Q_S : Qualitative soil map

Q_W: Qualitative water map

The results show that a large part of the study area has a very high risk of desertification.

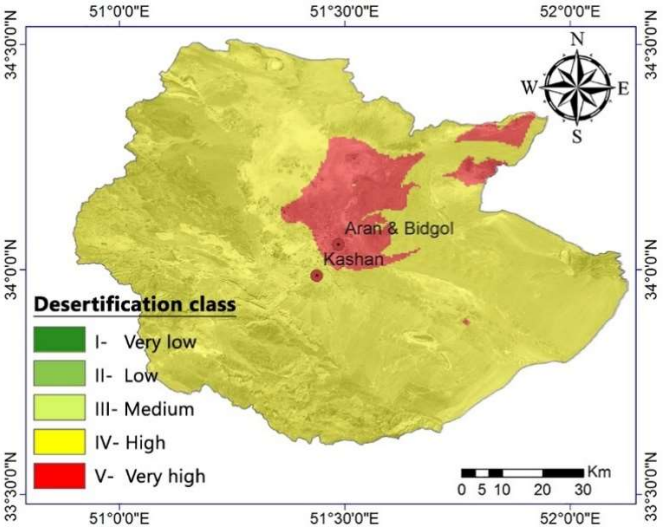


FIGURE 119
Classification of desertification sensitivity (analyze and map by Mahnaz Sarlak, using GIS, Exel, Photoshop)

BEST PRACTICES

Experiences to combat desertification in other parts of the world

Desertification is the third global challenge after water scarcity and climate change. According to the research topic, a series of important experiences of other countries to combat and control desertification in arid regions was selected, which is summarized in the following table.

Name of oasis/ project or method	*Country*	*Traditional agriculture*	*Industrial agriculture*	*regenerative agriculture*	*Green belt*	*Windbreaker*	*Water management*	*Creative methods*	*Rural land planning*
Kubuqi	China				■	■			
Great green wall (GGWSSI)	North African countries				■	■			
Zai pit	African countries	■							
Junquera	Spain			■					■
Gafsa	Tunisia						■		
GCP/RAB/ 013/ITA	Algeria, Egypt, Marocco, Tunisia						■		
Groasis waterboxx	Spain				■	■	■	■	

KUBUQI

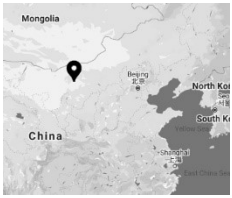


FIGURE 1
Location of Kubuqi desert in China

Kubuqi Desert is the 7th largest desert in China and is part of the Ordos Desert that has been formed because of human activities[1]. It is a good example to reverse desertification and restore the environment. The project started in 1988, today 30% of the desert has had greenery restored.

Efforts to control and manage desertification:

- Wind-shelter forests: The Three-North Shelterbelt Project was planned to be completed by 2050.[2] Vegetative cover is the key factor to reduce wind erosion, followed by soil surface hardness.[3]

- Sustainable grazing practices: "Use of appropriate grassland management practices is very important for sustainable use of grasslands. Grazing exclosure practice is to restrict both livestock numbers and grazing time, thereby reducing the negative impact of livestock's grazing and trampling on soil and helping revegetation. Further, it helps to mitigate soil erosion and enhance soil nutrient sequestration".[4]

- Artificial water-transfer: "To restore the degraded ecosystem in the *Lower Tarim River Basin*, the annual ecological water conveyance project from Bosten Lake

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[1] Y. Deren, "Culture of Kubuqi Desert and Succession of Land Desertization [J]," *Inner Mongolia Forestry Science and Technology* 2 (2004): 19–25.

[2] Z. Zhang and D. Huisingh, "Combating Desertification in China: Monitoring, Control, Management and Revegetation," *Journal of Cleaner Production* 182 (2018): 765–75.

[3] F.-R. Li et al., "Variations of Sand Transportation Rates in Sandy Grasslands along a Desertification Gradient in Northern China," *Catena* 53, no. 3 (2003): 255–72.

[4] R. T. Conant, K. Paustian, and E. T. Elliott, "Grassland Management and Conversion into Grassland: Effects on Soil Carbon," *Ecological Applications* 11, no. 2 (2001): 343–55.

began in 2000 through artificial water-transfer to the lower Tarim River".[5]

- Stabilize ecological zones between oases and deserts: "Techniques for establishing the relatively stable ecological zone between oases and deserts mainly include installing mechanical sand fences to avoid wind erosion; fixing sand with straw checkerboards; planting grass, shrubs, and trees".[6]

- Solar farm: "Kubuqi, boasts China's largest single-stage solar farm, boasting 650,000 fixed and sun-tracking panels, which together channel 1,000 megawatts of electricity into the national grid. A team of 47 households is employed to maintain the panels. Every day each household can clean more than 3,000 panels using high-pressure water jets and the run-off water feeds the crops that grow underneath."[7]

FIGURE 2
The greening of more than 6,000km^2 of Kubuqi desert (©news.cgtn.com)

[5] Zhang and Huisingh, "Combating Desertification in China: Monitoring, Control, Management and Revegetation."

[6] Zhang and Huisingh, "Combating Desertification in China: Monitoring, Control, Management and Revegetation."

[7] C. C. BAOTOU, "China's Greening of the Vast Kubuqi Desert Is a Model for Land Restoration Projects Everywhere," 2017, at https://time.com/4851013/china-greening-kubuqi-desert-land-restoration/.

FIGURE 3
The use of degradable material by sand barrier technology (©europe.chinadaily.com.cn)

FIGURE 4
Solar power station in the middle of Kubuqi Desert (©news.cgtn.com)

FIGURE 5
worker paves sand barriers between photovoltaic panels to prevent soil erosion at a photovoltaic power station of Kubuqi Desert (©xinhuanet.com)

GREAT GREEN WALL

FIGURE 6
Location of Great Green Wall project in Africa

"The Great Green Wall for the Sahara and the Sahel Initiative (GGWSSI) is a pan-African program launched in 2007 by the African Union (AU)."[8]

An 8000 kilometers wall of trees, running through 11 countries along the southern frontier of the Sahara Desert. "Slowly, the idea of a Great Green Wall has changed into a program centered around indigenous land use techniques, not planting a forest on the edge of a desert— that would be highly impractical."[9] "The Great Green Wall must not be seen as a wall of trees to hold back the desert. This idea that initially inspired the initiative has given way to the vision of a mosaic of sustainable land-use practices. At the same time, the wall is a metaphor to express the solidarity between African countries and their supporters."[10] For example, "FAO is leading initiatives in Burkina Faso, Mali, and Niger using water conservation techniques and native crops, which have delivered impressive results. Successful grassroots greening efforts in Niger have helped close the gap between the project's ambition and reality. The farmers of Niger practice natural regeneration of the land, using innovative practices such as reviving the roots of plants and trees, and digging "half-moon" pits to store water. Trees destroyed during droughts are allowed to recover over years, and then carefully maintained."[11]

[8] http://www.fao.org/3/a-az713e.pdf

[9] https://www.zmescience.com/ecology/climate/great-green-wall-04232/

[10] http://www.fao.org/in-action/action-against-desertification/overview/great-green-wall/en/

[11] https://news.globallandscapesforum.org/28687/africas-great-green-wall-a-work-in-progress/

"The first step was taken with the development of a harmonized strategy under a 1.75 million€ African Union project launched in September 2011.

The strategy has set the following main objectives:

- Improve living conditions for people in the arid zones of Africa and reduce their vulnerability to climate change, climate variability, and drought.
- Improve the state and health of ecosystems in the arid zones of Africa and their resilience to climate change, climate variability, and drought.
- Mobilize resources for the implementation of the Great Green Wall Initiative through the establishment of efficient partnerships between national and international stakeholders. Supported by the European Union (EU), Food and Agriculture Organization of the United Nations (FAO) and the Global Mechanism (GM-UNCCD), the African Union Commission works with thirteen countries and various partners to develop national action plans and project portfolios at country and trans-boundary levels, connecting multiple stakeholders."[12]

"The GGWSSI makes a vital contribution to the UN Sustainable Development Goals (known as the SDGs). In 2015, world leaders agreed to 17 goals for a better world by 2030. These goals have the power to end poverty, fight inequality, and stop climate change. Guided by these goals, it is now up to all of us, governments, businesses, civil society, and the general public to work together to build a better future for everyone. The Great Green Wall supports 15 of the 17 Sustainable Development Goals."[13]

"By 2030, the ambition of the initiative is to restore 100 million hectares of currently degraded land and create 10

[12] https://knowledge.unccd.int/publications/great-green-wall-next-world-wonder

[13] https://www.greatgreenwall.org/

million green jobs. This will support communities living along the Wall to:

- Grow fertile land, one of humanity's most precious natural assets
- Grow economic opportunities for the world's youngest population"[14]

FIGURE 7
Land in Mbar Toubab, Senegal, which was plowed in anticipation of the planting of seedlings for the Great Green Wall (©*Jane Hahn* for TIME)

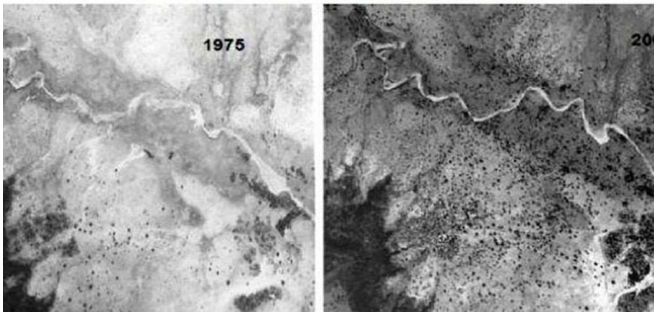

FIGURE 8
Reforestation surrounding the town of Galma in Niger is seen in this image comparing tree cover in 1975 with 2003. (©*Gray Tappan*, USGS)

FIGURE 9
Women who plant for the Great Green Wall in Senegal (© Benedicte Kurzen for FAO Knowledge)

[14] https://www.unccd.int/actions/great-green-wall-initiative

ZAI PITS

Zai pit farming technology is an African traditional method which originated from Burkina Faso. "It is a traditional land rehabilitation technology to rehabilitate degraded drylands and to restore soil fertility to the benefit of farmers living in drylands. The technique was adopted to reclaim severely degraded farmland that water could not penetrate." [15] "This technology is mainly applied in semi-arid areas on sandy/loamy plains, often covered with hardpans, and with slopes below 5%."[16]

Zai is a term used to refer to small planting pits.[17] "Zai pits, about 15 cm deep, 40 cm in diameter and spaced every 80 cm, are constructed during the dry season by digging out the soil and placing it on the downslope side."[18]

"Zai collect runoff water, improve infiltration, and can retain moisture in the soil for seven to ten days after rainfall, whereas compost manure improves soil fertility. The farms with Zai grow better crops and achieve higher yields, providing greater cereal crop security and better incomes for the farmers concerned."[19]

The new methods for increasing yields:

- "The combination of compost with water harvesting techniques, such as Zai, can substantially

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[15] F. O. Danquah, M. A. Twumasi, and I. Asare, "Factors Influencing Zai Pit Technology Adaptation: The Case of Smallholder Farmers in the Upper East Region of Ghana," *Agricultural Research and Technology* 21, no. 1 (2019).

[16] W. R. S. Critchley, C. Reij, and T. J. Willcocks, "Indigenous Soil and Water Conservation: A Review of the State of Knowledge and Prospects for Building on Traditions," *Land Degradation & Development* 5, no. 4 (1994): 293–314.

[17] M. N. Danjuma and S. Mohammed, "Zai Pits System: A Catalyst for Restoration in the Dry Lands," *Journal of Agriculture and Veterinary Science* 8, no. 2 (2015): 1–4.

[18] http://www.fao.org/3/y4690e/y4690e09.htm

[19] H. Sawadogo, "Using Soil and Water Conservation Techniques to Rehabilitate Degraded Lands in Northwestern Burkina Faso," *International Journal of Agricultural Sustainability* 9, no. 1 (2011): 120–28.

increase the effectiveness of this technique in augmenting yields. By increasing yields, this technique also contributes to farmer revenue increases."[20]

- "The combination of mulching with Zai and half-moons can increase yields of rain-fed crops (in terms of both grain and straw)."[21]

FIGURE 10
Zaï pits or Tassa, A series of pits to collect the little rainwater in arid zones.
Illela, Niger
(©C.P.Reij)

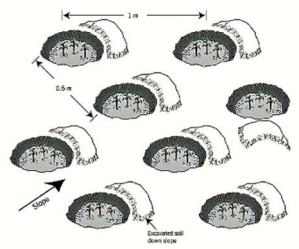

FIGURE 11
The soil extracted in the first excavation must be arranged around the pit to act as an embankment.
(©Bancy Mati)

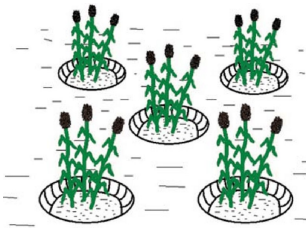

FIGURE 12
in which pit 4-8 seeds of a cereal crop, e.g., maize, are planted (©Bancy Mati)

FIGURE 13 -14
It is traditional technology at no cost, but it is a constant effort for the farmers
(©linkiesta.it)

[20] M. Salman et al., "Strengthening Agricultural Water Efficiency and Productivity on the African and Global Level," 2016., p.29

[21] Salman et al., "Strengthening Agricultural Water Efficiency and Productivity on the African and Global Level.", p.31

LA JUNQUERA

FIGURE 15
Location of La Junquera in Spain

La Junquera is a village from the Middle Ages. In the middle of the 20th century, most livelihoods were destroyed, and the village was abandoned due to agricultural mechanization and modernization.[22] Today, La Junquera is an example of a traditional farm that is fully committed to turning into a regenerative farm. The village features The Regeneration Academy, the Ecosystem Restoration camp, and new families arriving.

The Regeneration Academy: It gives students and entrepreneurs the tools to become innovators in the field of Regenerative Agriculture and Ecosystem Restoration. It is a program for:

-"Students who would like to combine their thesis/internship with an on-farm learning opportunity on regenerative agriculture.

-Educating and inspiring rural youth to get involved in climate mitigating actions in the areas of regenerative farming and sustainable agribusiness by focusing on sustainable practices related to agriculture and the rural environment

-Rural Entrepreneurship Course aims to support starting local entrepreneurs in taking the next essential steps in making their regenerative business more viable."[23]

Camp Altiplano: An experimental model for regenerative agriculture by taking a course and learn about alternative farm practices. It aims to "have a fully-functional, peaceful, abundant, biologically diverse Earth brought about through cooperative efforts for the ecological restoration of degraded lands."[24]

[22] https://lajunquera.com/

[23] https://www.regeneration-academy.org/

[24] https://ecosystemrestorationcamps.org/

FIGURE 16
The landscape consists of 1100 hectares of hilly land that is characterized by a semi-arid climate and low precipitation, mountainous terrain, and a sparse population. (©regeneration-academy.org)

FIGURE 17
A carriage ride around the farm with Spanish horses (©lajunquera.com)

FIGURE 18
Camp altiplano (©ecosystemrestorationcamps.org)

FIGURE 19
Keyline plantation (©regeneration-academy.org)

FIGURE 20
The regeneration academy (©regeneration-academy.org)

FIGURE 21
the farm facilitates land and infrastructure, while the Regeneration Academy helps the farm make better decisions on restoring landscape, biodiversity, and sustainable profit (©regeneration-academy.org)

GAFSA

FIGURE 22
Location of Gafsa in Tunisia

The oasis of Gafsa (Kasba) dates to the earliest times[25] and is known as the mastery of channeling and distribution of water, by having many natural springs from the deep aquifer waters of Gafsa. It has been chosen as a pilot for the GIAHS project[26].

The dynamic conservation activities being implemented are results of the consultation and sensitization processes strategy and methodology of the FAO/GEF[27] Project. "The following preparatory activities have been selected by the Project Monitoring and Evaluation Committee:

-Conducting a survey-inventory in the historic oasis
-Enrichment of organic waste into livestock feed
-Rationalization of water used for irrigation
-Promotion of ecotourism and agritourism
-Awareness-raising and communication"[4]

All activities are in partnership with NGOs operating in oases, research and development institutes, government agencies, and international development organizations based in Tunisia.[28]

"As there is no integrated collaborative community approach towards water management, access to the principal natural water sources and disputes between water users are beginning to pose a problem. The traditional social water management system has been largely replaced by the association of farmers for water management."[29]

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[25] P. Koohafkan and M. A. Altieri, *Forgotten Agricultural Heritage: Reconnecting Food Systems and Sustainable Development* (Taylor & Francis, 2016).

[26] http://www.fao.org/3/ap023e/ap023e.pdf

[27] Global Environment Facility

[28] http://www.fao.org/3/bp885e/bp885e.pdf

[29] http://www.fao.org/fileadmin/templates/giahs/PDF/GIAHS_FSP_Document.pdf

FIGURE 23
The historic oasis of Gafsa covers 700 hectares in an extremely harsh environment

FIGURE 24
Natural lake of Gafsa

FIGURE 25
Fair and rational management of water resources

FIGURE 26
Sustainable organic waste management Compost production

FIGURE 27
Livestock feed production

FIGURE 28
Support for poor artisans in Gafsa, Establishment of a weaving center

FIGURE 29
Launching of the national NGO network

GCP/RAB/013/ITA: USE OF TREATED WASTEWATER IN FORESTRY AND AGROFORESTRY SYSTEMS

"FAO has launched the GCP/RAB/013/ITA project, drawing on the technical expertise of Italian partner Universities and the critical financial support of the Italian Cooperation. The project intends to demonstrate the sustainability and economic viability of low-cost wastewater treatments to improve the livelihoods of the population in arid and semi-arid zones and to mitigate the effects of climate change, through the utilization of treated wastewater for irrigation in forestry and agroforestry systems."[30]

Main activities supported in the project countries:

"- In Morocco, the establishment of 10 hectares of palm grove that will be part of the green belt of the town of Marrakech. The plantation is irrigated by the innovative treatment for the reuse of wastewater for fertigation.

- In Egypt, the project provided the drafting of the first forestry management plan of the Serapium forest which is a 25 years old plantation irrigated with treated wastewater.

- In Tunisia, the project activities concern the design of a constructed wetland, planned to reduce the pollution of a water reservoir used for agricultural needs, at low cost, and in a sustainable way.

- In Algeria, the FAO project supported the completion of an already existing pilot area in the Oasis of Brézina. The reuse of the wastewater produced by the local community was tested for the irrigation of forestry and agroforestry systems, after treatment by means of the constructed wetland technology."[31]

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[30] http://www.fao.org/forestry/tww/en/

[31] M. C. Monteverdi et al., "Re-Use of Wastewater for a Sustainable Forest Production and Climate Change Mitigation under Arid Environments," *Annals of Silvicultural Research* 38, no. 1 (2014): 22–31. available in http://www.fao.org/forestry/41772-01cea356acc0425dd94bcdaeb1a65d323.pdf

FIGURE 30
Oasis of Brézina (Algeria) – waste treatment system: plan[32]

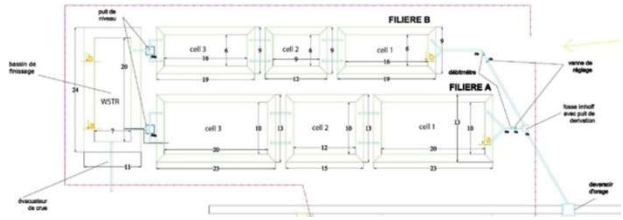


FIGURE 31
Oasis of Brézina (Algeria) – waste treatment system: section A

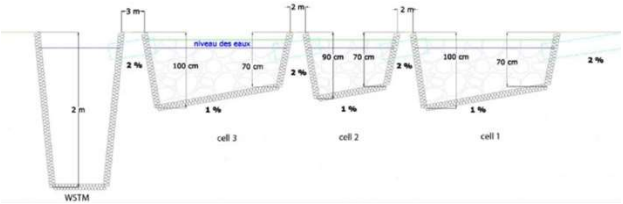


FIGURE 32
Oasis of Brézina (Algeria) – waste treatment system: section B

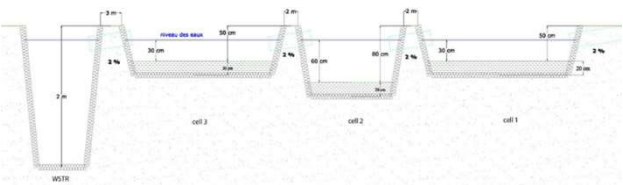
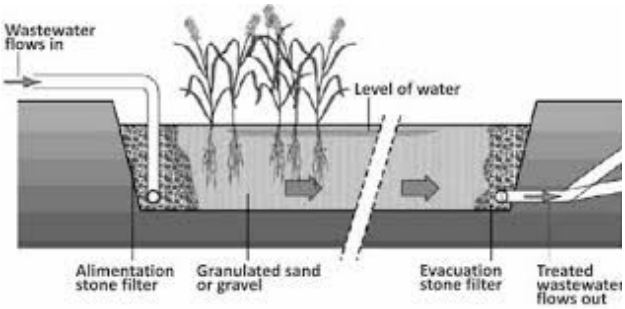


FIGURE 33
Oasis of Brezina (Algeria) - a creation of artificial marshes

FIGURE 34
Oasis of Brézina (Algeria) – view of the constructed wetlands, October 2013 (©fao.org)

FIGURE 35
Schematic diagram of a constructed wetland (©fao.org)



[32] Monteverdi et al., "Re-Use of Wastewater for a Sustainable Forest Production and Climate Change Mitigation under Arid Environments."

GROASIS WATERBOXX

The Groasis Ecological Water Saving Technology is an integrated planting technology to plant in the dry, eroded, desert, and rocky areas[33]. The intelligent buckets make it possible to tree cultivation without the use of energy, with minimal water consumption, and in a sustainable way[34]. "The Waterboxx Technology is a copy of how Mother Nature solves the problem of planting trees in deserts, eroded areas, and on rocks."[35]

The survival rate is on average over 90% no matter how difficult the circumstances are. This allows a planter to plan and industrialize the planting process for 12 months per year, independent from the season and no matter the temperature[36]. "This technology can also collect rainwater and dew. Hence it is characterized by less use of transplanting nursery stock and its effectiveness in plant cultivation and afforestation process in arid and semiarid areas."[37]

According to a study on the Effect of Waterboxx technology on Haloxylon ammodendron afforestation in arid and semiarid areas, "Waterboxx afforestation technology increased the soil moisture at the depth of 0~60 cm by 12.4% and 30.2% during the transplantation period and the growth period of Haloxylon ammodendron respectively. It reduced the ground temperature from 0~20 cm of the soil layer by 2~4 °C. The survival rate of Haloxylon ammodendron afforestation, the average crown

[33] https://www.groasis.com/

[34] https://groasis.investments/en/invest-in-reforesting-the-world/

[35] https://www.kuwait-oasis.com/technology/

[36] https://www.groasis.com/

[37] M. Liu, Z. Li, and W. Ren, "Research on the Effect of Waterboxx Technology on Haloxylon Ammodendron Afforestation in Arid and Semiarid Areas," *Advanced Science, Engineering and Medicine* 6, no. 2 (2014): 236–39.

breadth and height of the plant was increased by 30%, 30%, and 10% respectively in the same year".[38]

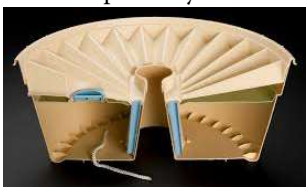


FIGURE 36
Inside of Waterboxx (All photo ©groasis)

FIGURE 37
How to assemble the Waterboxx

FIGURE 38
Cooperation with the World Food Program Innovation Accelerator and Oxfam in Algeria

FIGURE 39
Groasis cooperates with the UN World Food Program, Colombia

FIGURE 40
7months old Orange tree has grown more than 1meter, Ecuador

FIGURE 41
The first trees have been planted in Kuwait with the Waterboxx, 2012

FIGURE 42
3 years after planting the trees, Kuwait, 2015

FIGURE 43-44
planting a tree with the Waterboxx at Dhofar University Oman, 2012

[38] Liu, Li, and Ren, "Research on the Effect of Waterboxx Technology on Haloxylon Ammodendron Afforestation in Arid and Semiarid Areas."

FUTURE LANDSCAPE PERSPECTIVE AND PROPOSAL OF STUDY

Probable future of agricultural landscape in 3 scenarios

The proper effectiveness of today's decisions is fully related to future situations. "Scenario-based investigations of possible futures have been used since the middle of the 20th century to help decisionmakers cope with alternative courses of action and elements of uncertainty. Since the early 1970s, they have been increasingly used for landscape planning. Each scenario-based study is founded on assumptions of possible change."[1]

"Most conceptions of scenarios share four principles:

1) scenarios represent a process of change over some duration;

2) scenarios describe situations, actions, and consequences which are contingently related;

3) scenarios are understood to be predictive judgments which describe what could happen, not predictions which describe what will happen, or even what is likely to happen;

4) scenarios organize information within explicitly defined frameworks."[2]

---

[1] A. W. Shearer, "Approaching Scenario-Based Studies: Three Perceptions about the Future and Considerations for Landscape Planning," *Environment and Planning B: Planning and Design* 32, no. 1 (2005): 67–87., p.67

[2] Shearer, "Approaching Scenario-Based Studies: Three Perceptions about the Future and Considerations for Landscape Planning.", p.68

SCENARIO 1: Future of the present plans

The first scenario is based on the continuation of the current condition; it is based on existing plans for long-term planning in the study area, and by analyzing their strengths and weaknesses, the possible future will be evaluated. In this regard, 3 very important and effective projects have been selected:

A. Comprehensive planning-2013
B. Comprehensive tourism planning-2011
C. Afforestation; Combat to desertification projects through biological stabilization by planting Haloxylon trees implemented in Aran-Bidgol county

In the following, the main idea of each project and its effects on landscape changes are examined.

A)

In this project, secondary oases have been completely ignored, they are not in any sphere of influence of the cities. Thus, with the lack of services, the process of migration from small villages to cities is increasing. Naturally, as this urbanization phenomenon increases, economic activities are also changing; industrial activities and commercial agriculture replace traditional agriculture. In this way, a large part of the county will be abandoned, and the entire population of the county will be concentrated in a small area. Although with proper resource management, it will be possible to distribute evenly living facilities to the entire population (such as Qatar), in most cases, it is an idealistic and out-of-reach goal; and lack of proper population distribution increases the risk of land degradation and desertification.

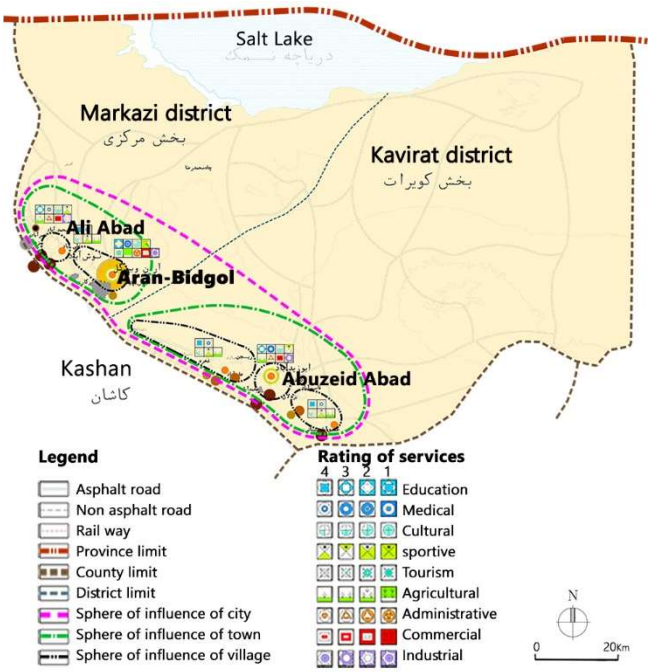


FIGURE 1
Determining the sphere of influence from comprehensive planning-2013, (Received from the general administration of urban planning of Isfahan province, original scale 1:250000)

The Impact of Landscape Changes on the transmission of the COVID-19 virus

Changes in the agricultural landscape and the reduction of employees in the agricultural sector, lead to an increase in the urban population and an increase in applicants for formal employment opportunities in administrative and industrial sectors. Due to the rapid growth of urbanization in Aran Bidgol county and the lack of job opportunities, some residents travel out of the county every day. The most important work destinations are Kashan (6km), Qom (100km) and Isfahan (200km).

On 19 February 2020, Iran reported its first confirmed COVID-19 cases in Qom.[3] Despite numerous and continuous business trips, the spread and rapid growth of the number of coronavirus patients in Aran-Bidgol county were predictable, and in less than 1 month the situation in the county became critical, and hospital facilities did not meet medical needs. According to the spokesman of Kashan Crisis Committee, on 12 April 2020, COVID-19 cases in Kashan and Aran-Bidgol increased to 1041 people.[4]

B)

The comprehensive tourism planning aims to increase revenue for the region's indigenous people through tourism. The territory of this project includes two counties, Aran-Bidgol, and Kashan. Aran-Bidgol city is considered as a center for providing services to travelers. 7 tourist routes, which often start from mountainous areas in Kashan county and end at Maranjab Caravanserai in Aran-Bidgol county, are designed. Despite its many advantages and strengths, this project also has its weaknesses. Due to the climate of the region, tourism jobs will be seasonal because, in the winter and summer, tourism will not be possible in the form of ecotourism. In a way, it can be said that in the same seasons that farmers do not have income, the employees of the ecotourism sector cannot earn any income. In order to compensate economically, a large number of tourists must enter the area in autumn and spring, which will damage the environment and vegetation of the area due to the fragility of the desert ecosystem. In addition, tourists' favorite pastimes, such as skiing on the sand, safaris, and car racing on sand

[3] New York Times, "Iran Reports Its First 2 Cases of the New Coronavirus," 2020.

[4] Rasa News Agency, "The Number of Coronavirus Patients in Kashan, Aran and Bidgol Increased to 1,041," April 12, 2020, at https://rasanews.ir/fa/news/647983.

dunes, increase soil erosion. Another criticism of the project is its disregard for other cultural potential as a tourist attraction.

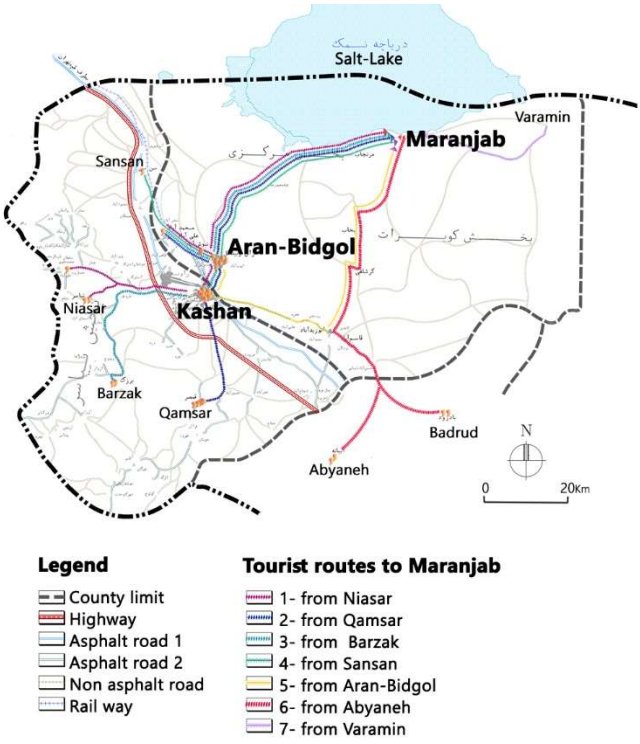


FIGURE 2
Proposed Tourist routs to Maranjab desert from Comprehensive tourism planning, 2011 (received from the municipality of Aran-Bidgol, original scale 1:600000)

The impact of the COVID-19 pandemic on farming and economy in Aran-Bidgol

agricultural value chains are vulnerable to external shocks[5] such as the COVID-19 pandemic that has strong impacts on rural producers.[6] Each spring from mid-April to mid-June, tens of thousands of tourists come to Kashan and its neighboring towns and villages to visit the festival of Rose and

[5] N. Kofi Acquah, "Mitigating the Impact of COVID-19 on Small-Scale Agriculture in The Gambia," *IFAD*, 2020, at https://www.ifad.org/en/web/latest/story/asset/41941658.
[6] http://www.fao.org/forest-farm-facility/coviden/en/

Rosewater[7]. This festival incorporates into the tourism industry, which can bring prosperity to the economy and agriculture. During the festival, there are many small markets for selling local agriculture crops and handicrafts. In 2020, according to the decision of the National Anti-Disease Headquarters of Covid-19, holding all celebrations and tourism programs in Iran, including the Rosewater festival in Kashan, was banned.

According to the interview of the president of the Union of Rosewater and traditional distillates of Kashan with Baharnews agency[8], the economic loss through travel restrictions, declining tourism in Kashan is estimated at 6000 billion rials.

C)

The afforestation project is examined in detail in chapter 3. The main points are:

-Soil stabilization

-Increase shade and increase soil moisture

-Reduction of soil erosion

-Good function as a windbreak

-Adverse changes in soil chemical quality

-An increase in the population of animals such as rats, snakes and jackals

The project, originally intended only for the establishment of sand dunes over 40 years ago, has expanded over time; and as can be seen in the map, this project is underway even near the qanats. While the deep and extensive roots of these trees cause irreparable damage to this valuable cultural heritage. In addition, according to local observations and interviews with farmers and shepherds, the project has destroyed rangelands.

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[7] Golab or Rosewater is a fragrant distillate of the roses

[8] http://www.baharnews.ir/news/214811

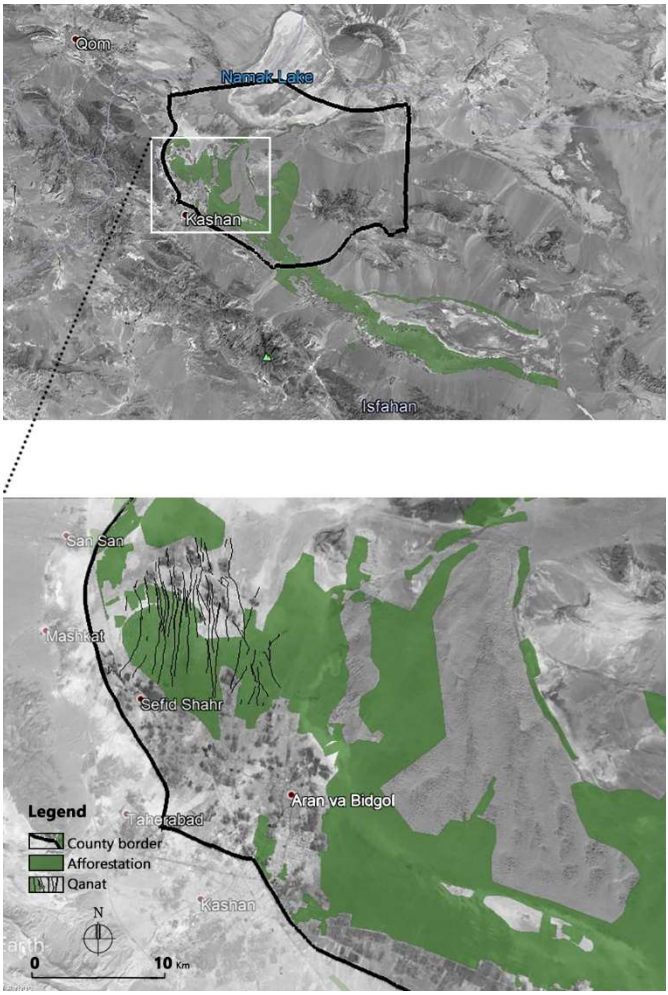


FIGURE 3
zones of biological stabilization by planting haloxylon trees (GIS information received on 2019 from the department of natural resources and watershed management of Aran-Bidgol county, map by Mahnaz Sarlak)

How the future of scenario 1 could be?

In the first Chapter (see p.100), the threats of the agricultural landscape were divided into 4 categories:

- The abandonment of agricultural lands
- The land use change
- The expansion of urbanization
- The expansion of industrial agriculture

Considering the evaluation of the aforementioned projects, it can be said with confidence that all 4 threats have been clearly seen and if the current processes continue, there will be intense landscape changes in the county. So that small villages and family farms will be destroyed, which is the beginning of the next problems such as:

- Destruction of the secondary oases of H.S.O.
- Reduction of agricultural production
- Increasing unemployment
- Increased migration
- Lack of transfer of local and indigenous cultures to future generations
- The need for more urban services
- The need for large investments in commercial agriculture to ensure food security
- The need for more job opportunities
- Increase barren lands
- Lack of recharge groundwater aquifers

As a result, soil and water erosion have increased and the phenomenon of desertification will spread more rapidly.

SCENARIO 2: Reconstruction of the past

The second scenario is based on the resettlement of rural areas by preservation and restoration of existing cultural heritages, Qanat and H.S.O. (figure 4). It will try to create a new direction of migration from upstream oases to downstream oases (reverse migration) and provide opportunities for villagers to return to their homeland by reactivating agriculture.

As discussed in Chapter 3, changes in access to water resources, from horizontal water transfer system by qanat to vertical water transfer through deep well drilling, had been started a lot of changes in the agricultural and rural landscape (see pp.142-145). Irrigation of farms with the saltwater of

deep wells has resulted in increasing soil salinity and reducing the quality and quantity of the crop (see p.150).

It is reminded that digging new wells is not allowed in this county (see p.111). Therefore, as a first step, the water required for agriculture in secondary Oases should be supplied from a source other than deep wells.

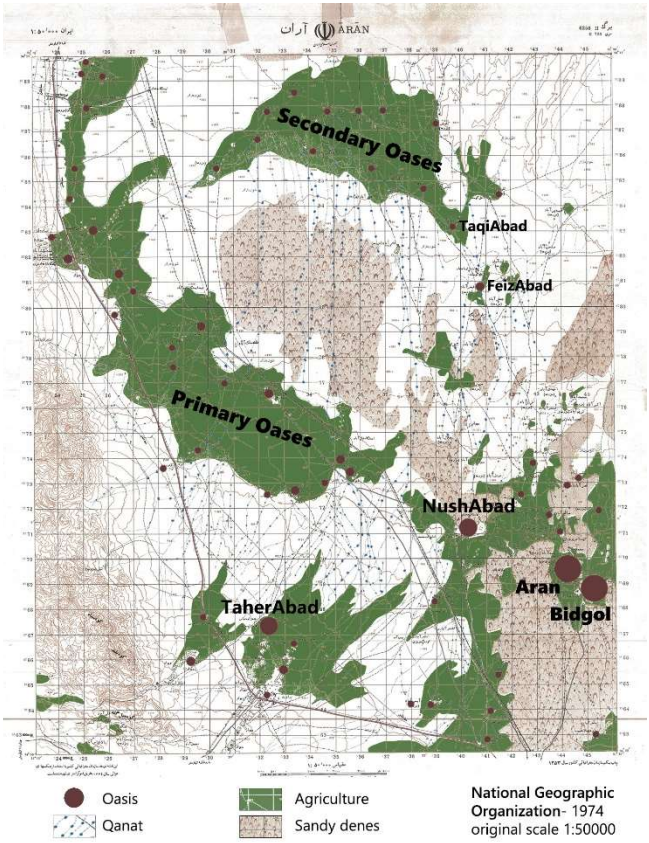


FIGURE 4
Agriculture zones in 1974 (received from Iran's National Geographic Organization, edited by Mahnaz Sarlak)

Possible alternatives to water supply:

1) Restoration of Qanats: Although technically, despite modern technology, it is possible to repair the structure of Qanats, but due to the drying of the upstream aquifer, and also due to the high cost of

annual repair and maintenance, restoration of Qanats can not be a suitable solution to supply the required water for agriculture and drinking purposes in secondary oases.

2) Water distribution system: Due to the long-distances between the low population oases and the high costs of canalization, creating the necessary infrastructure to transfer water from other areas is not economically justified and is not considered by the government and investors.
3) Aquifer recharge with wastewater: Today, one of the sources of water supply is water reuse and several studies are being done to facilitate wastewater treatment and reduce its costs. "In arid and semi-arid areas recycling of water may have a greater impact on future usable water supply than any of the other technologies aimed for increasing water supply. Treated sewage water can be used for irrigation, industry, recharge of groundwater, and in special cases, properly treated wastewater can be used for municipal supply."[9] Iran, as an arid and semi-arid country, is trying to integrate wastewater reuse in its water policy and plans.

In the topic of cultural landscapes and how to expand the HSO, the dependence of secondary oases on the upstream aquifers that were created by irrigation water of primary oases, was explained (see p. 103-105). Therefore, by injecting treated municipal and industrial wastewater into the upstream areas, it is expected that the aquifer will be recharged and the Qanat system will be reactivated.

After the water supply, the next challenge is related to the quality of agricultural soil. The results of soil analysis indicate high salinity in sandy soils (see p. 146). Today, there are many studies in the relevant specialized fields for scientific solutions

[9] A. Hamdy, "Irrigation with Treated Municipal Wastewater," *Prospettive e Proposte Mediterranee-Rivista Di Economia, Agricoltura e Ambiente*, 1992.

to improve soil quality, which is beyond the scope of this study and will not be addressed.

With proper water and soil management, and the simultaneous use of modern technology and indigenous knowledge, it would await that agricultural activity will pave the way for the return of immigrated villagers.

Another step that needs to be taken in this scenario is to rebuild the villages; because most of the villages have been destroyed and are not livable.

The positive results of this plan can be as follows:

- Stopping water extraction through deep wells
- Preventing land subsidence due to depletion of water aquifers
- Water quality control appropriate to the product
- Recharge groundwater aquifers over time can inspire a sustainable water future
- Attracting attention back on Qanat and its cultural values
- Protection of qanats against destructive factors

Weaknesses of the plan:

- Requires huge initial investments
- Long-distance from the nearest city (min 14km)
- The need for long roads construction
- Difficulty to establish securing of the remote areas
- Lack of income in winter and summer

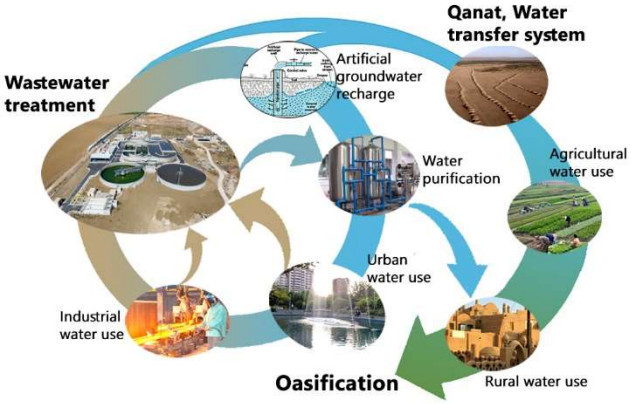


FIGURE 5
The graphic depicts the integration of the traditional water transfer system into the modern water reuse and recycling for a sustainable water future, (proposed by Mahnaz Sarlak)

SCENARIO 3: New-Traditional spatial configuration

In recent years, environmental protection schemes have ignored local communities and traditional knowledge (see scenario1). Thus, conservation and development plans are implemented without interacting with each other without a comprehensive understanding from the landscape, while the unique combination of the rural landscape is a compilation of historical, cultural, socio-economic, natural, and ecological values.

The new configuration of the rural and agricultural landscapes in scenario3 tries to take into account the different values of the landscape simultaneously and, accordingly addresses the needs of the rural community, such as health and welfare, as well as cultural and natural values of the landscape.

Scenario 3 is based on the reorganization of the rural and agricultural landscape as a barrier against desertification by oasification and creating new oases in the area with a high sensibility to desertification (see p.). The other factors influencing the location of new oases include:

- Rapid access of villagers to modern living facilities
- homogeneous distribution of population in the county
- Access to water resources
- Optimal use of seasonal floods
- An area with less soil degradation
- Existence of cultural, natural, religious attractions
- The potential for Agri-Eco-Tourism
- Ability to create a stable infrastructure

Scenario Objectives

This scenario attempts to achieve the following objectives:

- Sustainable use of available resources
- Adaptation to climatic conditions
- Optimal use of seasonal floods
- Reduce soil and water degradation

- Paying attention to environmental impact (on human, plants, animals)
- Paying attention to indigenous knowledge
- Increasing local community awareness of natural and cultural values
- Strengthen the positive points of existing and ongoing projects
- Reduce the negative effects of existing plans and modify them, if possible
- The economic benefit of local communities
- Poverty reduction by rural income-generating activities
- The economic Justification by return on the initial investment
- Food security
- Sustainability
- Increase biodiversity
- Aesthetic value
- Repeatability in other similar cases

To achieve these aims and present future patterns, landscape zones were identified based on geomorphology, vegetation, land use and traditional management. "Landscape zones are a framework for displaying the current status and they are a tool for presenting future landscape narratives."[10] This zoning forms the basis and foundation of sustainable management.

In order to consider the concept of multi-functional landscape and the multiple objectives of sustainable development, a master landscape plan is proposed that will be the framework for integrating natural values with cultural values that meet the needs of the local community and increase environmental awareness.

[10] J. Makhzoumi et al., "Landscape Approach to Bio-Cultural Diversity Conservation in Rural Lebanon," in *Perspectives on Nature Conservation-Patterns, Pressures and Prospects* (IntechOpen, 2012).

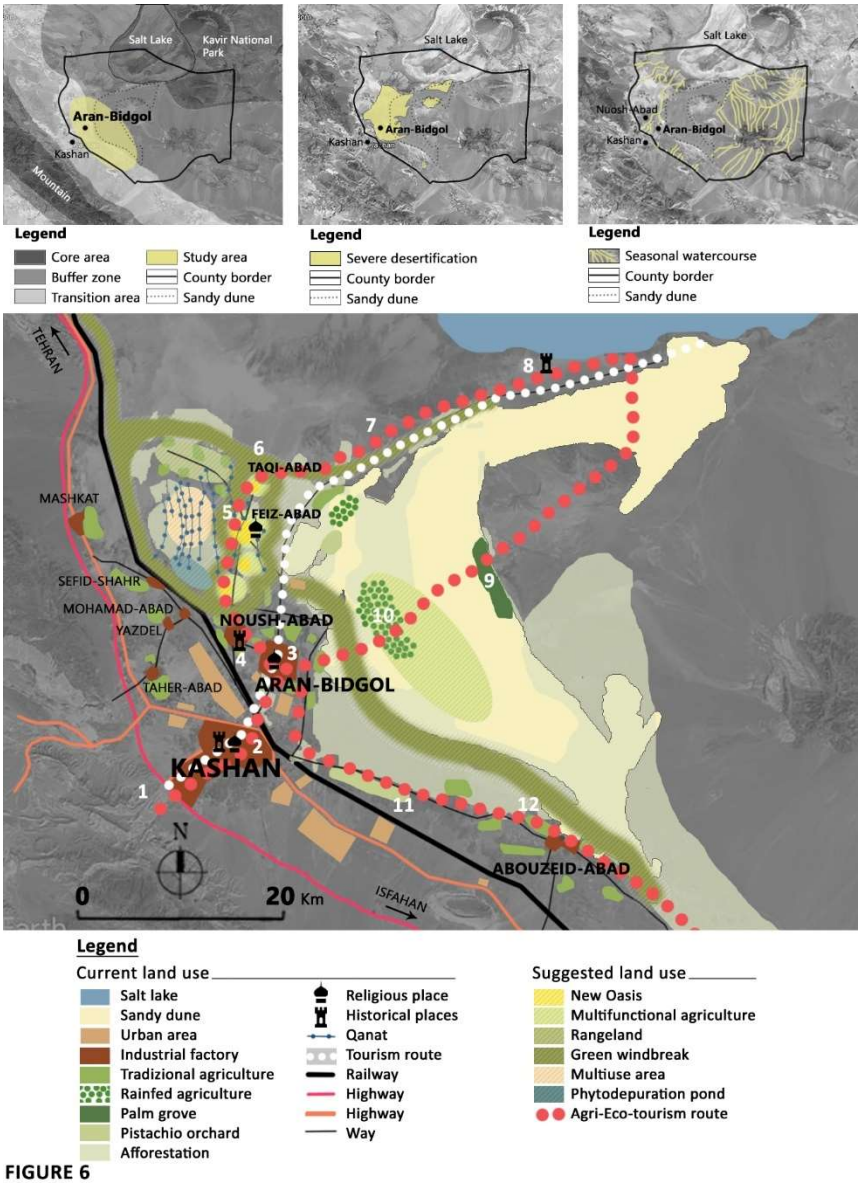


FIGURE 6

Up left: Biosphere reserve zonation, (Drawing: Mahnaz Sarlak)
Up middle: Areas with the highest risk of desertification, (Drawing: Mahnaz Sarlak)
Up right: The paths of dry rivers (GIS information: department of natural resources and watershed management of Aran-Bidgol)
Down: Scenario3, Reorganization of the agricultural landscape spatial configuration, see relevant photos on the next page (Drawing: Mahnaz Sarlak)

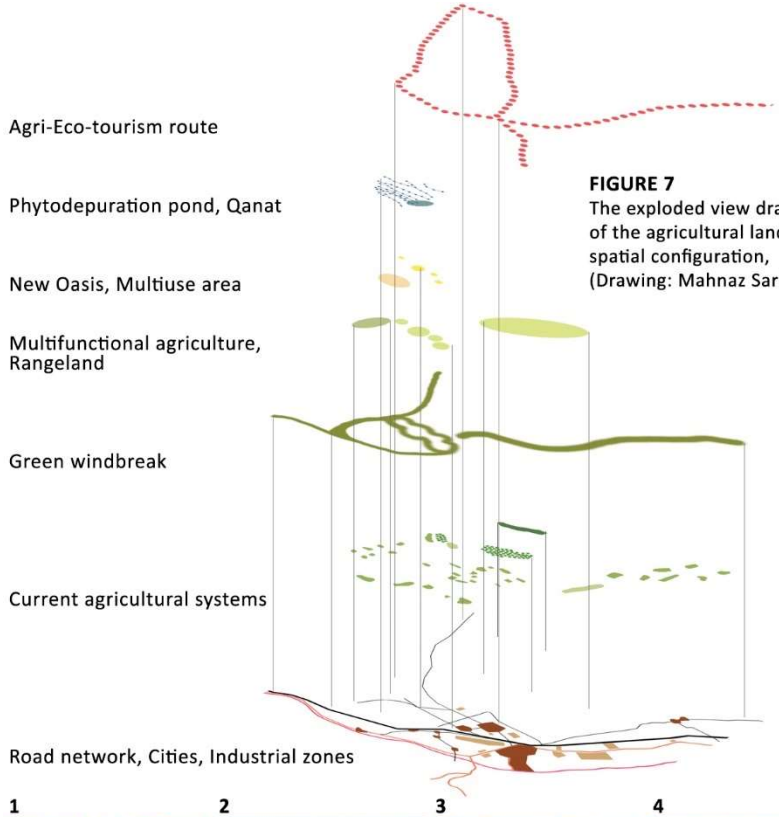
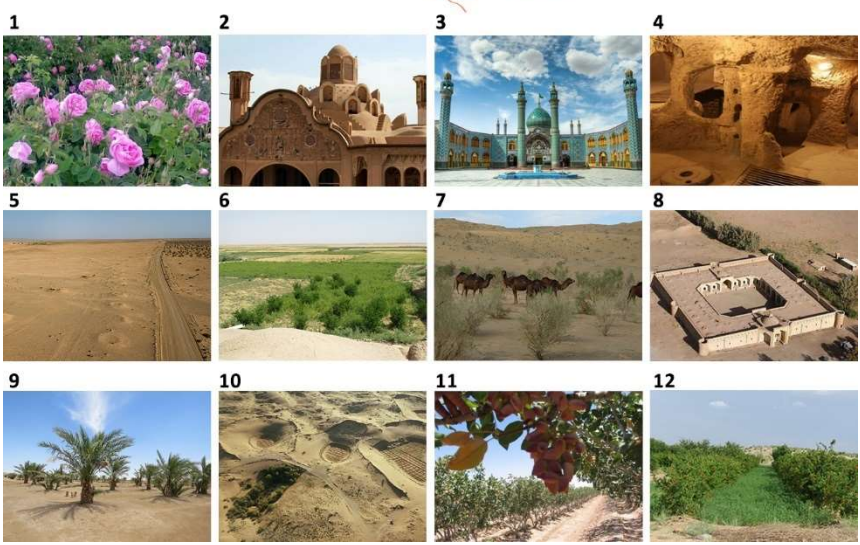


FIGURE 7
The exploded view drawing of the agricultural landscape spatial configuration, (Drawing: Mahnaz Sarlak)



"To overcome the desertification hazards, the opposite solution is considered as an effective approach by environmental scientists. Actually, this opposite approach is the so-called oasification, which is implemented by land use and environmental management and engineering measures to reach desert and oasis landscape sustainability."[11]

Three main zones were determined for oasification and spatial configuration using new-traditional methods:

1) Rainfed agriculture on sand dunes: Sandy dunes are the main natural element of the desert landscape that visually dominant but ecologically poor. In this desert ecosystem, despite the poor soil and less than 100 mm of rainfall, there is the most sustainable system of traditional organic farming (see p.124-126). It is recommended that this agricultural system be more activated and expanded with the cooperation of scientific centers. Also, based on my observations (see figures 8-9) about the growth of *Populus euphratica* trees, commonly known as the *desert poplar*, it will probably be possible to manage land use as an agroforestry system.

FIGURE 8-9
The massive growth of the *desert poplar* tree on the sand dune, (photo: Mahnaz Sarlak, using an unmanned aerial vehicle)

2) The axis connecting urban areas and secondary oases: Aran-Bidgol and Noushabad cities are connected to Taqiabad and other abandoned secondary oases by a road, as explained in the previous chapter (see p.117-118). The access to water and suitable soil for agriculture was the motivation for the formation of secondary oases; but today with severe soil degradation (see p.147) and extreme salinity of groundwater (see p.144), the traditional agriculture and rural life in these

[11] J. Xue et al., "Oasification: An Unable Evasive Process in Fighting against Desertification for the Sustainable Development of Arid and Semiarid Regions of China," *Catena* 179 (2019): 197–209.

areas face many difficulties (see p.110). So, to prevent the expansion of cities due to rural migration and for a more balanced distribution of population, for this zone, create the new oases is proposed. The traditional pattern of emplacement of oases in desert areas is often in the form of small spots along a connecting axis (see p.85 and p.102). The location of the new oases is suggested along the road from Noushabad to Taqiabad (Figure 6). The strengths of this axis are as follows:

a. Taqiabad village and its traditional agriculture (see p.120) have good potential for development.
b. Feizabad, in addition to being located at the intersection of roads, as a sacred place has a high potential to attract people and become an oasis.
c. Dry rivers are the natural paths that direct surface floods from mountainous areas to downstream areas during heavy rains and carry fertile soils with them. In the study area, the lands north of Noushabad are the site of sedimentation of floods (Figure6 up right). The existence of scattered farms confirms the feasibility of agriculture.

Since agriculture multifunctional plays an important role in protecting rural areas[12], the new oases have been considered as a complex of the villages surrounded by multifunctional agriculture and the green windbreak. Due to the importance of multifunctional agriculture in landscape and environmental sustainability, it will be discussed separately in the next topic (see p.190-193).

3) Qanats and abandoned villages: This zone includes land uses with the historical and cultural values that have lost their function in today's life. With the implementation of the afforestation project (see p.177), this area will be completely destroyed. To achieve the objectives of this scenario, this zone

[12] C. Vazzana, "Farm Management and Environmental Issues in the EU," 2002.

is divided into three separate parts that are linked together by functional relationships, to make an organic unity.

a. Phytodepuration ponds: In arid and semi-arid countries, to alleviate pressure on fresh-water resources, industrial and municipal wastewaters are often used for irrigating agricultural fields.[13] "Phytoremediation is a promising cleanup technology for contaminated soils, groundwater, and wastewater that is both low-tech and low-cost."[14] As described in Scenario 2, the aquifer can be recharged by wastewater treated.
b. Qanats: Given that the Qanat is a cultural heritage, for this zone, preservation and less access are proposed. Suggested uses may include solar energy parks and seasonal markets for the sale of agricultural products with temporary structures without damaging the aqueduct structure.
c. Abandoned villages: As previously explained, agriculture in this area will lead to environmental damage and increase the risk of desertification. Even if scenario2 be implemented and treated wastewater be used, "One challenge of promoting the use of treated wastewater on agricultural irrigation is the safety concern of produce due to contamination of various pollutants in treated wastewater."[15] For this part, land uses with less sensitivity to water quality are suggested, including: cultivation of specifically plant for fodder, rangeland and livestock.

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[13] G. Gatta et al., "Irrigation with Treated Municipal Wastewater on Artichoke Crop: Assessment of Soil and Yield Heavy Metal Content and Human Risk," *Water* 10, no. 3 (2018): 255.

[14] M. Farid et al., "Effect of Cyclic Phytoremediation with Different Wetland Plants on Municipal Wastewater," *International Journal of Phytoremediation* 16, no. 6 (2014): 572–81.

[15] X. Wu et al., "Treated Wastewater Irrigation: Uptake of Pharmaceutical and Personal Care Products by Common Vegetables under Field Conditions," *Environmental Science & Technology* 48, no. 19 (2014): 11286–93.

Agricultural landscape, beyond the food production

Today, traditional agricultural landscapes are subjected to fundamental change and transformation, and threats and pressures - on a large scale - put these landscapes on the brink of a historic rupture. In these circumstances, deliberate intervention is essential in order to protect, revitalize and strengthen these landscapes. Naveh believes that human society is currently undergoing a crucial period: the transition period from the industrial age to the post-industrial era[16]. In this period, dynamic and sustainable landscapes develop only when we deliberately take action to achieve it[17]. Nassauer considers landscape design as a deliberate act of humans, according to which the patterns provided can detect undesirable conditions and provide solutions[18]. Traditional agricultural landscapes, which have continued to survive over

[16] Z. Naveh, "From Biodiversity to Ecodiversity—Holistic Conservation of the Biological and Cultural Diversity of Mediterranean Landscapes," in *Landscape Disturbance and Biodiversity in Mediterranean-Type Ecosystems* (Springer, 1998), 23–53.

[17] A. E. Buijs, B. Pedroli, and Y. Luginbühl, "From Hiking through Farmland to Farming in a Leisure Landscape: Changing Social Perceptions of the European Landscape," *Landscape Ecology* 21, no. 3 (2006): 375–89.

[18] J. I. Nassauer and P. Opdam, "Design in Science: Extending the Landscape Ecology Paradigm," *Landscape Ecology* 23, no. 6 (2008): 633–44.

time through the perception and action of farmers, are now subjected to pressures beyond the scale of the landscape, and the preservation and restoration of such landscapes is possible only with the help of an approach that, instead of emphasizing on visual features, offers a dynamic and comprehensive conception of the landscape[19]. Such an approach is possible only with the deliberate interference of humans by utilizing the interdisciplinary knowledge that also benefits from indigenous knowledge and, by recognizing problems, threats and needs, and maintaining the temporal and spatial continuity of landscape, can respond under the conditions of time and place.

Today, agriculture in Iran's desert margin is facing unsustainability due to water crises, droughts, low efficiency, rural migration and rural population decline, environmental pressures, inefficient management, Low attention to indigenous knowledge. While for centuries, local communities have managed the landscape in an integrated way, which means a set of agricultural uses, forestry, horticulture, and pasture. These varied uses, that are environmentally sustainable and have numerous cultural values, have been considered as "multifunctional agriculture and multifunctional landscape in contemporary sciences dealing with cultural landscapes"[20]. The concept of the multifunctional character of agriculture is relevant in the UN conference on environment and development in Rio de Janeiro in 1992.[21]

In this system, agriculture in addition to its main function can provide a wide range of facilities such as landscaping,

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[19] J. M. Makhzoumi, "Landscape Ecology as a Foundation for Landscape Architecture: Application in Malta," *Landscape and Urban Planning* 50, no. 1–3 (2000): 167–77.

[20] H. Vejre et al., "Multifunctional Agriculture and Multifunctional Landscapes—Land Use as an Interface," in *Multifunctional Land Use* (Springer, 2007), 93–104.

[21] J. Lankoski, *Multifunctional Character of Agriculture* (Maatalouden taloudellinen tutkimuslaitos, 2000)., p.65

providing environmental benefits such as land conservation, sustainable management of renewable natural resources and conservation of biodiversity, and increasing the socio-economic value of rural life.[22]

So, multifunctional agricultural products can be divided into two general categories:

- Production of tangible goods or "market goods"[23]
- Production of intangible goods or "non-market goods"[24]

The main function of agriculture, food production[25], produces tangible goods.

	Tangible goods
1	Food products
2	Livestock feed
3	Textile fibers
4	Seed
5	Propagation and breeding of livestock, poultry and fish
6	Raw materials for rural handicrafts
7	Herbal Medicines
8	Raw materials for various industrial sectors
9	Biomass

[22] K. Pazek et al., "Assessment of Multifunctional Agriculture: Application of Selected Multi-Criteria Methods in Case of Slovenia.," *Bulgarian Journal of Agricultural Science* 20, no. 5 (2014): 1008–17.

[23] Z. Kallas, J. A. Gómez-Limón, and J. B. Hurlé, "Decomposing the Value of Agricultural Multifunctionality: Combining Contingent Valuation and the Analytical Hierarchy Process," *Journal of Agricultural Economics* 58, no. 2 (2007): 218–41.

[24] Kallas, Gómez-Limón, and Hurlé, "Decomposing the Value of Agricultural Multifunctionality: Combining Contingent Valuation and the Analytical Hierarchy Process."

[25] K. Knickel, H. Renting, and J. D. Van der Ploeg, "Multifunctionality in European Agriculture," *Sustaining Agriculture and the Rural Economy: Governance, Policy and Multifunctionality. Edward Elgar Publishing Inc*, 2004, 81–103., p.82

Multifunctional agriculture provides multiple benefits to society[26], such as food security, animal security, biodiversity, nutrient recycling, soil and soil protection, watershed management, flood control, cultural values, historical heritage, and the vitality of rural communities. Researchers have expressed different views on the classification of various agricultural functions and their intangible products. The various theories and researches[27] have been reviewed and the results of the study are collected in the next table.

[26] H. Akca, M. Sayili, and A. Kurunc, "Trade off between Multifunctional Agriculture, Externality and Environment," *Journal of Applied Sciences Research* 1, no. 3 (2005): 298–301.

[27] Vejre et al., "Multifunctional Agriculture and Multifunctional Landscapes—Land Use as an Interface"; Pazek et al., "Assessment of Multifunctional Agriculture: Application of Selected Multi-Criteria Methods in Case of Slovenia."; Lankoski, *Multifunctional Character of Agriculture*; Knickel, Renting, and Van der Ploeg, "Multifunctionality in European Agriculture"; S. T. Lovell, "Multifunctional Urban Agriculture for Sustainable Land Use Planning in the United States," *Sustainability* 2, no. 8 (2010): 2499–2522; D. G. Abler, "Multifunctionality, Agricultural Policy, and Environmental Policy," *Agricultural and Resource Economics Review* 33, no. 1203-2016–95091 (2004): 8–17; T. Marsden and R. Sonnino, "Rural Development and the Regional State: Denying Multifunctional Agriculture in the UK," *Journal of Rural Studies* 24, no. 4 (2008): 422–31; P. H. Vereijken, "Transition to Multifunctional Land Use and Agriculture," *NJAS Wageningen Journal of Life Sciences* 50, no. 2 (2003): 171–79; K. Anderson, "Agriculture's 'Multifunctionality'and the WTO," *Australian Journal of Agricultural and Resource Economics* 44, no. 3 (2000): 475–94.

	Functions	Intangible goods
1	Environmental and ecological	- Protection and improvement of soil and water resources - Prevention of natural hazards - Conservation of plant genetic resources - Protection of wildlife - Increasing biodiversity - Balancing the environment - Reducing greenhouse gases - Groundwater recharge
2	Social and cultural	- Reducing rural migration to cities - Integration of indigenous and modern knowledge - Forming the cooperatives and NGOs - Preserving local traditions and culture - Cultural heritage
3	Economic	- Employment and entrepreneurship - Rural economic viability - Increasing the value of agricultural land - Increasing the GDP - Agricultural tourism
4	Political	- Food security - Achieving political and economic independence (self-sufficiency)
5	Educational	- Development of biological and genetic research - Training courses and workshops - Raising public awareness of the agricultural profession

New image of the desert green belt

From 1580, that the first green belt around London ordered by Queen Elizabeth I foresaw to stop the spread of the plague[28], to today the form and function of the green belt have changed many times.

In arid and semi-arid regions, the green belt is known as the afforestation project to combat desertification and land degradation by planting trees on the edge of a desert. Many afforestation projects on the edge of the desert have failed. For example, the project of "Forestry I" in Nigeria was designed in 1979 and it was aborted in 1984. "Seedlings survivals rate was very low. only less than 5 percent of over 50 million seedlings distributed free of charge during the five years survived."[29] And Joseph Stalin launched a similar effort in the 1940s, planting more than 10,000 square miles of steppe land with trees; almost all of them were dead within 20 years.[30]

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[28] S. Halliday, *Underground to Everywhere: London's Underground Railway in the Life of the Capital* (The History Press, 2013)., p.118

[29] N. I. Medugu et al., "The Role of Afforestation Programme in Combating Desertification in Nigeria," *International Journal of Climate Change Strategies and Management*, 2010.

[30] https://www.scmp.com/magazines/post-magazine/long-reads/article/2177586/chinas-green-great-wall-front-line-its-fight

Considerable work has been done in sandy deserts, especially in North Africa, on the stabilization of sand dunes or at least the arresting of their movement by plant growth. "Insufficient protection of saplings from grazing livestock, inappropriate choice of trees species, conflicting scheduling times, poor transportation and insufficient distribution methods, etc. were some of the limiting factors that constrained this precursory tree – planting initiative."[31] From the unsuccessful experiences of these projects, useful lessons have been learned for future projects. So that in 2007, has been changed the definition of the African Great Green Wall from a wall of trees to a great mosaic of green and productive landscapes[32]; Based on this new concept, various methods for creating a sustainable green landscape in desert areas have been considered and researched. Including agroforestry, wastewater treatment, traditional agriculture, water management.

In the study area, scenario 3 was proposed by modeling the results of this research and experiments. This scenario tries to regulate relations in the sphere of development and protection of cultural and natural landscape by a composite green belt consisting of:

- Multifunctional agriculture in farmland landscapes
- Eco-friendly village in new oases
- Green windbreak instead of Haloxylon afforestation
- Watershed management projects and Wastewater treatment
- Rangeland instead of degraded farmlands
- Research farms
- Eco-Camping
- Solar farm
- Industries related to agriculture and animal husbandry

[31] Medugu et al., "The Role of Afforestation Programme in Combating Desertification in Nigeria."

[32] http://www.fao.org/in-action/action-against-desertification/overview/great-green-wall/en/

- Industries related to indigenous knowledge (For example, in the study area, handmade carpets have a long history, so, the relevant industries such as dyeing and spinning are justified)

Therefore, in this idea, the green belt will be a set of land uses that interact with each other, and the functioning of each component depends on the activity of the other member or even on the whole of the system. In other words, the Green Belt is a unified system of small-scale projects, most of which are funded and implemented with the participation of local society.

Mention should be made here of the Sustainable Development Goals (SDGs)[33] that are the blueprint to achieve a better and more sustainable future for all. The 17 Goals are all interconnected, they address the global challenges we face, including those related to poverty, inequality, climate change, environmental degradation, peace and justice. The ability to achieve 16 goals of SDGs, can justify the idea of this green compound of various land uses.

FIGURE 10
Schematic of all SDGs and 16 achievable goals

Moreover, this sustainable green complex will be able to activate the oasification process, "the oasification process

[33] https://www.un.org/sustainabledevelopment/

improves the condition of soil and water, increases the vegetation cover, and provides the habitats for wildlife and human beings" [34]. By expanding the oases, the desertification process will be limited.

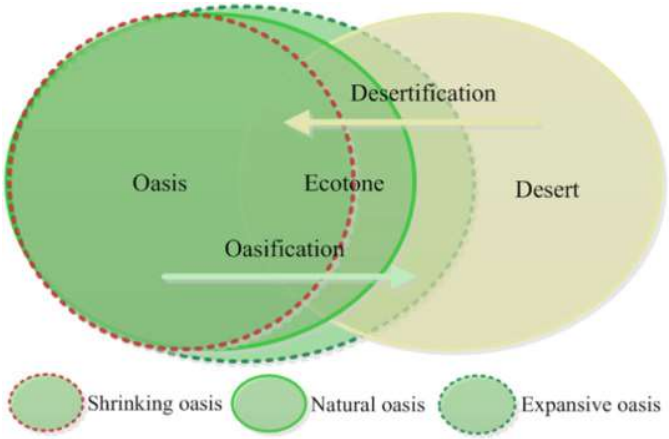

FIGURE 11
Schematic diagram of desertification and oasification processes[35]

Repeatability: In addition to the mentioned aims, since there are similar problems in Iran's desert margin and the HSO has been repeated in most of these zones, the pattern of green belt in the form of a mosaic of various landscapes is repeatable too.

[34] Xue et al., "Oasification: An Unable Evasive Process in Fighting against Desertification for the Sustainable Development of Arid and Semiarid Regions of China."

[35] Xue et al., "Oasification: An Unable Evasive Process in Fighting against Desertification for the Sustainable Development of Arid and Semiarid Regions of China."

Research Limitations and the way forward

The research deals with an original theme, on which yet little has been written systematically. The scarcity of scientific references available, and sometimes the difficulty of access, limited access to data, poses the problems of verifiability and slowed down the research. The breadth of the subject also took a lot of time to collect the necessary information.

Lack of statistical information and update maps, due to the remoteness of the study area, affects the accuracy of the research. In some cases, the information is available on a scale that is disproportionate to this research; For example, Iran's Atlas of Desertification has been prepared at a scale of 1: 2500000, which isn't applicable for small study areas. In this research, as much as possible, the required basic information has been prepared by scientific visits, local information collection, sampling and analysis.

The high cost of intercontinental travel, renting, or purchasing equipment necessary to travel to the desert such as off-road vehicles, handheld GPS, cameras and drones, as well as soil and water laboratories and the purchase of software, is another limiting factor of the research. Part of these costs was

covered by the grant of mobility projects for Ph.D. students. Limited financial resources limit the number of research trips and the number of samples, so the results of the study might be affected by it.

Due to the time constraints for traveling to the desert, the observations made in the field could not benefit from a cross-comparison of the visit made in the different periods of the year.

But despite the physiological limitations of a doctoral thesis, the research opens the way to a field of future investigation. Providing a comprehensive model for achieving sustainable development requires extensive and in-depth studies and is not possible with studies limited to one field or limited to a small area.

In this research, it has been tried to study different components as much as possible, but due to the limitations of the research, it is necessary to conduct additional studies.

GLOSSARY

Ab	Water
Abadi	Oasis
Ab-anbar	Cistern of water
Badgir	Wind catcher
Biaban	It means a land without water. A place with less than 250 mm of rainfall per year and a low groundwater level. It has very poor vegetation. If there is water, farming in the desert is possible. The equivalent word in English: Desert
Chal	Pit; farm pit
Jaliz	Kitchen garden to planting juicy summer fruit bushes such as watermelon, persian melon, cantaloupe, honeydew melon, cucumber and et.
Kariz	An underground water transport system used to provide water supply for human settlements and for irrigation in hot, and arid environments
Kart	Internal divisions of the farm in the form of rectangles for basin irrigation
Kawir	The land with swollen clay soils, with very high salinity in which plants can not grow, and in some of which less salinity may grow halophyte plants that are resistant to salts. Agriculture is not possible in it.
Qanat	The Arabic equivalent of the *Kariz*

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