Agricultural transition and regional development in Rafsanjan. A technology-driven approach in a drought affected county

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Agricultural transition and regional development in Rafsanjan. A technology-driven approach in a drought affected county

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I would like to dedicate this dissertation to my dauther, Aysan.

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Preface

This dissertation is the final work of a three-year research project based in University IUAV of Venice. A one-year visiting research period at Wageningen University and Research, Rural Sociology group was part of the research activities that were done for conducting this research project.

This project couldn't be done without the patient encouragement, guidance and advices my supervisor, Viviana Ferrario for her support and guidance. I also would like to thank Domenico Patassini, advisor of my PhD thesis, and Stefano Tornieri my tutor for their continuous assistance. Special thanks go to Benno Albrecht for his support from the beginning.

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Abstract

The agricultural sector in developing countries is one of the most vulnerable sectors in terms of climate change and water scarcity. Iran is one of the Middle Eastern countries facing a growing water crisis. For instance, Rafsanjan County, located in the Province of Kerman, is losing its pistachio orchards to water shortage, climate change and high temperatures. Additionally, the environment is negatively affected by unsustainable agricultural practices, which aggravate the water crisis in the region. In the past years, these practices not only led to a water crisis but also caused a number of problems for the city and residents of Rafsanjan. In order to overcome the challenges of the agricultural sector in Rafsanjan, several approaches have been taken by the national government, local authorities, private sectors and social organisations. Modernisation of agricultural sector in Rafsanjan and transition to high-tech polyculture are the main strategies which have been followed by the authorities. This study analyses the actor-network of the transformation in the agricultural sector as well as tends to understand the impact of development policies and plans in this transition trajectories. Additionally, the thesis attempts to identify both the barriers and driving forces of each strategy. This research draws on the concept of Translation of Transition to analyse the technology-driven transition. Therefore, the interactions among social and materials entities and configuration of their relationships during the transition trajectories have been studied. Using the conceptual framework of translation of transition, the transition process has been divided into three stages a) ''disentanglement of the incumbent sociotechnical regime under pressure from the landscape''; b) ''punctualisation process of novelties''; and c) ''re-entanglement of punctualised actor-networks and the creation of a new sociotechnical regime''. This research project is exploratory case study research and uses a mixed quantitative and qualitative data collection method. The data in this research has been gathered through field research, literature reviews survey and in-depth interviews with farmers, planners, researchers and policy makers in Rafsanjan. The principles of the Actor-Network Theory have been used in the methodological framework. Therefore, the roles of both human and non-human actors have been investigated, and the relationship between actors and their integration has been studied. The results of the study show that the actors with higher power (the actant related to government) are more successful than niche developers and knowledge institutes (e.g. universities) due to the top-down policy of Iran. Based on the analysis "Jihad agriculture organization", "10-year plan for the development of greenhouses", the public relation office of Jihad agriculture organization was defined as the focal actor, the obligatory passage point of other actors involved in transition processes. The actor network of transition in the agricultural sector of Rafsanjan tends to shift to a polyculture agriculture due to the minimisation of the social, environmental and economic issues of agricultural practices. The findings of this research suggest that the elimination of pistachio fields within the city created social and environmental problems and limited the cultivation of the pistachio to peri-urban areas with fertilised soil and appropriate conditions for producing the high-quality pistachio. The pistachio farms inside cities can be replaced with high-tech polyculture agricultural practices. Hydroponics cultivation methods are among the most appropriate high-tech systems used by experts and authorities. These new technologies can also be considered as a job creation opportunity for local people.

Abbreviations

AB: Road and urbanization Administration

AC: Agricultural Clinics

AE: Agriculture equipment

AIF: Agricultural Insurance Fund

AL: Agricultural Laboratory

ANREO: Greenhouses

ANT: Actor-Network Theory

AO: Governorate

APG: Agricultural products of greenhouses

C: Weather

CAH: Companies active in hydroponic agriculture

CDP: Foreign Relations Policies and Programs)

CPP: Experts who are Farmers Consultant

CVC: The village office (Dehdari)

DIC: Companies active in irrigation with a new method

DPG: Dried pistachio gardens

E: Electricity

EIP: Poison

EO: Power Department

F: Fertilizer

FA: People

FAR: Farmers, minor owner of agricultural land

FEA: University professors

FKG: Advanced technologies incubator

FPC: Fertilizers and poisons Companies

FRPP: 10-years development high tech agriculture plan

G: Laboratory materials

GA: Graduates in Agriculture

GE: Greenhouse equipment

GO: Gas office

GR: Agricultural and Natural Resources Engineering Organization

HT: Hydroponic Technologies of the Interior Industry

IHT: Imported hydroponic technologies

IM: Representative of the supreme leader

IPRI: Iran Pistachio Research Institute

LM: Gas

LN: Local newspapers

LRT: Local radio

MAB: Agricultural bank

MF: Agricultural-Jihad Organization

MLP: Multi-Level Perspective

Mu: Country Development Program

MV: City Council

NRO: Department of Environment

OCWS: Co-operative, Labor and Social Welfare Office

P: Pistachio

PG: Pistachio agricultural land

PO: Municipality

PPH: Pistachio Process Houses

PWW: Pumps and water wells

RUO: Major Owners of agricultural lands

R&D: Research and Development

S: Seed

SC: Cooperative Pistachio Company

TPO: Technical and professional organizations

U: Natural Resources Organization

UDP: Detailed design and land use plan

UP: Member of Parliament

UVA: Rafsanjan Universities

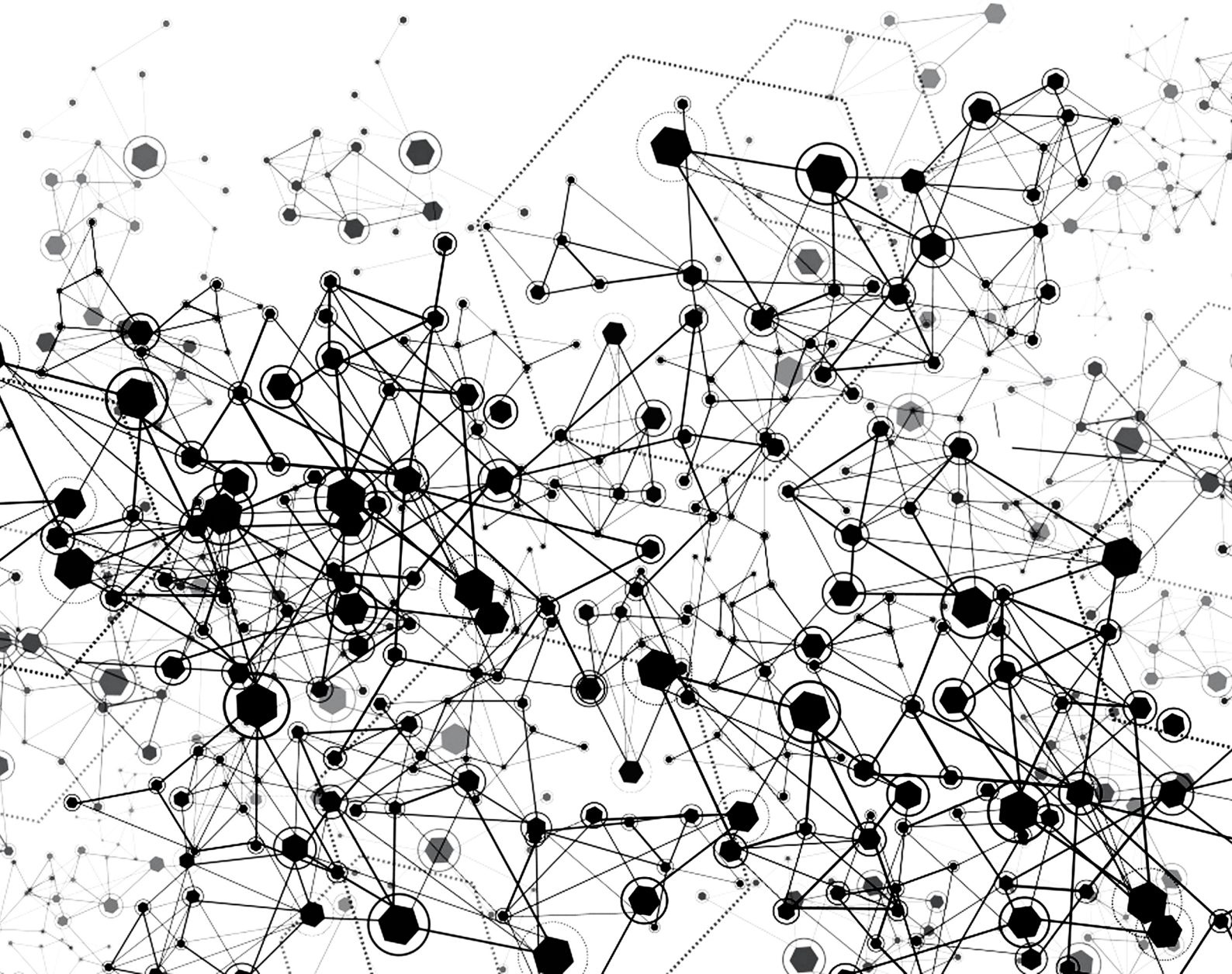
W: Farmer advisors

WR: water resources

WSO: Water Organization

Chapter 1

Introduction



1.1 Water, agriculture and food: challenges and issues

The current world population, which is approximately 6,500 million people, is estimated to increase to over 9,100 million by 2050. To keep up with global population in future and feed people, food resources should be increased by at least 70% (Martinez-Mate et al. 2018; Ritzema and Schultz, 2011). Thus, in order to provide enough food supply as well as secure food resources, the development of sustainable agricultural systems is necessary (Rockström et al. 2017). Sustainable agriculture should lead to stable economic conditions and foster social values. Applying particular policies and actions, sustainable agriculture aims to produce food without harming the environment or natural resources (Hosseini and Shariati, 2004; Motiei and Shamsaee, 2010). Water resources can be considered as one of most important natural resources that have been decreased globally not only due to global warming and drought (Dhanarajan, 2017; Khanian et al. 2018) but also because of unsustainable agricultural systems. In fact, water shortage "would be a major challenge to achieving global food security" (Ramachandran et al. 2017).

Drought, which is defined as an extended period with below-average rainfall in a given geographical region, can result in acute water deficit. However, water shortage is a significant concern for agricultural researchers and plant breeders, as it is estimated that by the year 2025, around 1.8 billion people will be facing absolute water shortage, and 65% of the world population will live under water stress environment (Ramachandran et al. 2017; Ingram and Bartels, 1996).

According to a FAO report (2017), developing countries, especially those located in the Middle East, are facing water shortage issues in a serious manner. Agriculture plays a highly important role in the countries located in the Middle East region. Research studies (Bhatasara, and Nyamwanza, 2018; Morris, 1997, Barron et al. 2002) indicated that 75–90 percent of water resources of the Middle Eastern countries have been consumed in agricultural sections. The percentage of water used in agriculture, compared to the domestic and industry sectors in the Middle East versus other parts of the world, is illustrated in Figure 1. As shown in the graph, the consumption of water in the agriculture sector in the Middle East and North Africa exceeds that of other geographical regions.

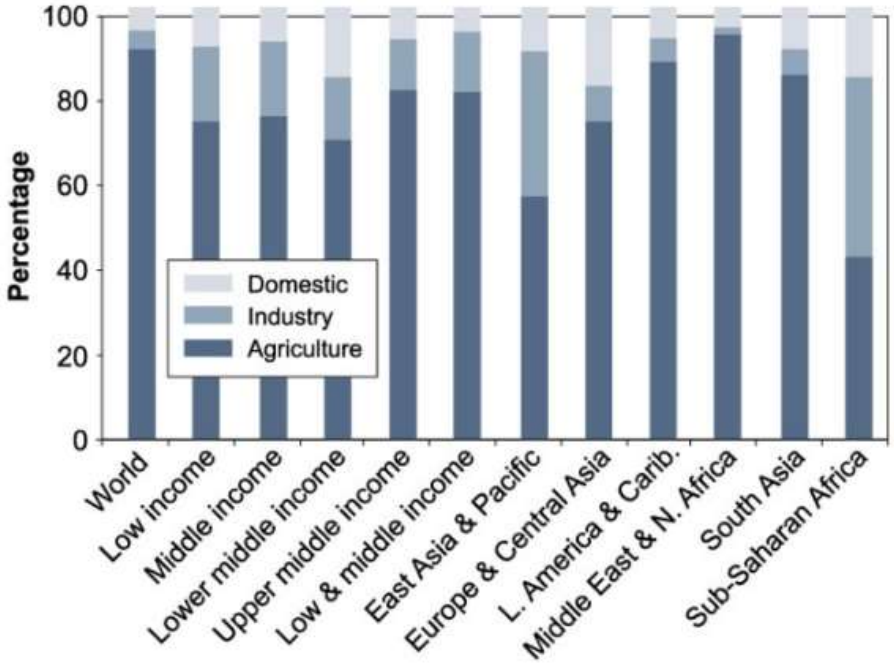


Figure 1. The percentage of water used in agriculture compared to domestic and industry sector in different regions (Barron et al. 2007)

The main cause of water shortage in the Middle East can be associated with climate change as well as applying unsustainable conventional agricultural systems. The Middle East contains semi-arid areas including huge deserts. The majority of the Middle Eastern countries experiences two seasons: mild winters and summers with high temperature (sometimes exceeding 50 degrees), apart from some countries in the northern section of the region, such as Iran and Iraq, where winter is rather colder. According to FAO reports, it is predicted that the Middle East will be affected by climate change and due to current policies, in future, climate is expected to be hotter and drier (FAO, 2018). Hoerling et al. (2012) conducted a research study on "increased frequency of Mediterranean drought" during the past 20 years, which is granted by NOAA office of global programs climate variability program. Their results revealed that 10 of the driest 12 winters occurred in this area due to greenhouse gases which are triggered by human activity as well as the extraction of the fossil fuel in the region. The pattern, created in Hoerling et al. (2012), of dry winter during the period between 1902 and 2010 in the Middle East, caused by greenhouses gases is shown in

.

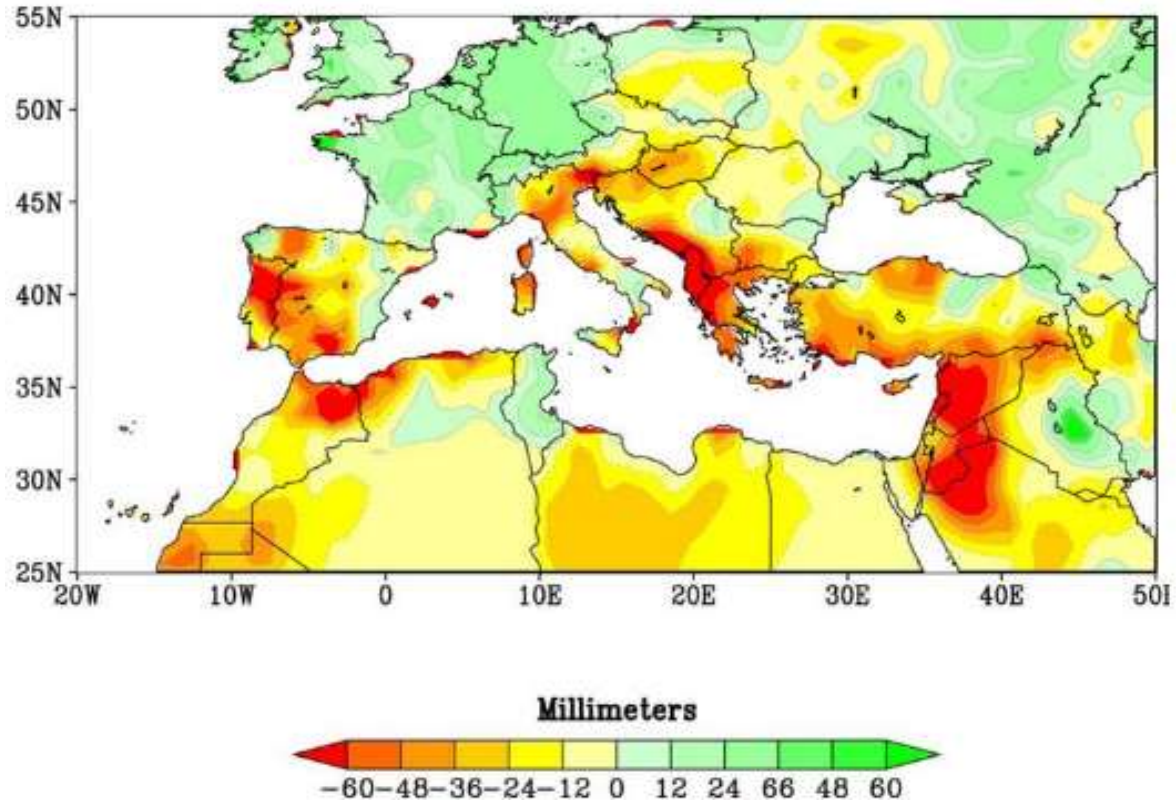


Figure 2. The areas in red and orange had drier winters between 1902 and 2010 (Hoerling et al. 2012)

As a consequence, based on the above, the Middle East is rapidly becoming one of the least agriculturally self-sufficient regions across the world. Thus, governments are concerned about the financial problems that they will be facing due to importing agricultural crops from other countries. Additionally, dependency on other countries in terms of providing food has an important effect on national dependency and security. Therefore, the governments of the countries in the Middle East are exerting great effort to become agriculturally independent. In order to increase the availability of water resources, it is evident that agriculture cannot continue the way it was in the past two or three decades and, thus, major investment in improving current conventional agriculture irrigation systems is required (Morris, 1997; Camargo et al. 2017).

1.2 Technology driven transition in agricultural practices

As mentioned in the previous section, due to water shortage and the agriculturally-related problems of the countries in the Middle East, during the past decades, the governments emphasized on changing the conventional agricultural systems to avoid their dependency to other countries in terms of providing foods. Technological changes have considerably affected agriculture for over a hundred years, during which there was a dramatic rise in innovations to increase yield, reduce costs and enhance product quality (Jayashankar et al. 2018). Over the past 30 years, impressive innovative solutions and strategies were applied in food production processes, especially for cultivation phases,

such as producing new varieties and introducing efficient irrigation approaches and systems—pressure irrigation systems including sub-surface drip irrigation and bubbler irrigation—(Vatanperast, 2017; Abdolahi et al., 2005), as opposed to outdated systems such as open canals and surface irrigation (Pereira, 2017).

Moreover, another technology which had an important impact on the agriculture of the region was indoor cultivation and building modern greenhouses. Conventional soil cultivation, which is outdoor agriculture (Farran and Mingo-Castel, 2006), creates many problems, such as soil degradation. Furthermore, in such cultivation systems, environmental conditions is an important limitation factor only allows to cultivate limited types of crops. Non-precise control of nutrients, difficulty in eliminating grass weeds, and the lack of control of other factors such as light and temperature, can all be considered as disadvantages of outdoor conventional agriculture (Nistor et al. 2009; Farran and Mingo-Castel, 2006).

However, new agricultural technologies in lighting, ventilation, robotics, creating greenhouses and irrigation are merely a few examples of the innovations that will lead to an increase in the crops per unit area, producing more than one product per year, increasing the quality of the product, saving water consumption, using uncultivated lands, producing products independent on environmental conditions, cultivating according to market requirements, controlling the environmental factors and creating job opportunities (Folta, 2019; Beaver, 2002).

In spite of the many advantages of using new technology, since people are not completely aware of its importance and the effect on the water shortage issue and generally on their future life, the implementation of these technologies is progressing slowly. Furthermore, other factors such as uncertainties about technologies during the initial stages of diffusion (Kumar et al. 2018), economic factors such as availability of investment, expected profits and availability of high-skilled labour (Croft et al. 2017; Kumar et al. 2018) all have an undeniable effect on technology-driven transition in the agricultural sector.

Although the adoption of new technologies, developed through research and surveys, is indeed complicated, technology plays a key role in the evolution of agriculture (Kumar et al. 2018). However, the governments of developing countries have become conscious of the importance of improving the preservation and protection of natural resources. Thus, they attempted to import new technologies in their countries (de Anda and Shear, 2017), and the support of the development and diffusion of sustainable innovations has become a dominant theme in the political agenda of many countries (Hillman et al, 2008). These, rapid technological developments and their adoption in cities and villages are having profound impact on urban/regional systems.

1.3 Research problems

The City of Rafsanjan, with an area of 12,421 square kilometres and a height of 1,400 to 3,443 meters above sea level, is located in the northwest of Kerman Province in Iran (Iranian Statistics Centre, 2017). Similar to most Middle Eastern cities, agriculture is the most important economic activity in Rafsanjan (Abdollahi et al. 2011). Rafsanjan is one of the biggest pistachio production centres in the world. The lifestyle of the residents and the economy of the rural and urban areas in the region are dependent on pistachio production. Pistachio fields, agricultural centres and pistachio markets shape the most landscape and built-up spaces in urban, peri-urban and rural areas (Abdollahi et al. 2011; Iranian Statistics Centre, 2017).

Similar to other cities economically dependent on agriculture, the majority of Rafsanjan population are working in the agricultural sector as farmers, farm workers or farm owners. Nowadays, agriculture in Rafsanjan is threatened by several aspects, most important of which is water shortage. In the recent years, Rafsanjan has been affected by extreme draught and water shortage. Additionally, unsustainable agriculture practices such as inefficient and conventional irrigation systems are aggravating the problem of water scarcity in the region (Abtahi and Karimian, 1995; Abdollahi et al. 2011). Unsustainable agriculture not only has an effect on water resources, but is also considered as the main source of pollution in the region. In such systems, farmers use an excessive amount of pesticides and agrochemical products to increase their yields without considering the effect of them on environment (Abdollahi and Javanshah, 2006; Sedaghati and Mohammadi, 2009).

Therefore, due to negative impacts of the conventional agricultural practices on both the residents and environment, local authorities, planners and national policy makers were forced to find a solution to promote the agricultural sector. The main focus in the recent years has been on the application of new technologies and more sustainable agricultural practices in Rafsanjan. However, the complexity, lack of trust and high costs of new technologies and irrigation systems for small-scale pistachio farmers have been an obstacle for this agricultural development plans. The creation of larger scale farms by combining small-scale lands is encouraged. The shift from monoculture, small-scale conventional pistachio production to high-tech agriculture practices for production of vegetables and fruits is also supported by the government. As a result, many hydroponic greenhouses and indoor farming practices are emerging in the region. These practices are replacing small-scale pistachio farms especially in urban and peri-urban areas. The success of these initiatives and education activities that have been done for promoting high-tech agriculture, is making these practices more popular and attracts more social capitals for development of high-tech agriculture in Rafsanjan. Transition to high-tech agriculture simultaneously with the development of new infrastructures such as roads, building new greenhouses, and farmer's markets, encouraged new businesses in the city to support high-tech agriculture practices through educational programs, producing the accessories and products required for high-tech agriculture and providing related services (Khattabar et al., 2007; Delshad, 2006).

In the past decades, many studies were conducted on high-tech agriculture, the possibility of using this technology and its economic profitability aspects in Rafsanjan, but what has not been addressed yet is how to create this transition in the region and how national and local policies and programs and the organisations and individuals that implement it affect this transition. Apart from the ethnography research studies that have been conducted to understand the transition pattern in the County of Rafsanjan and its impact on urban developments, this study analyses the effectiveness of policies and approaches and the role of local authorities to policy implementation on transition processes.

Additinally, we try to determine the social and political variables which have effect the reansition process from current agriculture to high technology and are detected using the collected data through qualitative and quantitative methods. Therefore, we explain the relationships of the variable using a framework designed by Hosseini Farhangi et al. (2019). The selected framework is named "Translation of Transition" or TT framework and is a combination of two theoretical frameworks; Actor Network Theory (ANT) and Multiple-Level Perspective (MLP).

1.4 Research objectives

Firstly, this research aims to gain a better understating of conventional and high-tech agricultural practices in Rafsanjan. Secondly, the actor-network of the development of high technology agriculture practices to study the role of development policies and planning approaches and organisations and individuals involved in transition of current agriculture to high-tech agriculture is analysed. Finally, the recommendations for policymakers, industry and other actors interested in bringing about change are identified.

1.5 Research questions

This research attempts to analyse the impact of interactions among policies, development plans, institutions, decision makers and technologies on transition of agriculture sector in Rafsanjan. In order to gain a better understanding of these interactions and their impacts on the agricultural sector, the research question and sub-questions of this research are formulated as follows:

1.5.1 Main research question

The main research question in this study is: How do regional development polices, and development plans affect configuration and reconfiguration of social and material entities and what are the possibilities and constraints to transfer conventional agriculture in Rafsanjan into high-tech agriculture?

1.5.2 Sub-questions

In order to answer the main research questions, the following sub-questions should be addressed:

- What regional development plans and policies affect the transition process?
- What is the role of human and non-human actants in the transition process?

1.6 Thesis outline

This thesis consists of seven chapters. First, it begins with a general introduction and ends with a general conclusion and, therefore, there are not separated introductions and conclusions for each chapter. The seven chapters of the dissertation are briefly introduced in this section:

Chapter One is the introduction of the research project. The chapter starts with a summary of the research project and personal objectives for conducting this research. It then continues with a general overview of global challenges of food and agriculture, technology-driven transition in agricultural practices and the effect of policies and plans on this transition. This is followed by a description of the current situation of the agricultural sector in Rafsanjan.

Chapter Two explains the theoretical approach which turned from empirical research into a theoretical analysis and conclusions through applying the concept of Translation of Transition which is a combination of a multi-level perspective in sustainability transitions and the actor-network theory.

In **Chapter Three** the methods that were used in this study to gather data are outlined. This study combines a variety of data collection methods such as survey, in-depth interviews with agricultural experts, policy makers and technology developers, observational research (site visits and discussion with planners and developers) and document analysis (development policy documents, planning policy documents, etc.).

Chapter Four describes the agricultural practices performed in Rafsanjan and their impact on the quality of life in the region as well as the decline of the agricultural sector in Rafsanjan due to extreme drought and climate change.

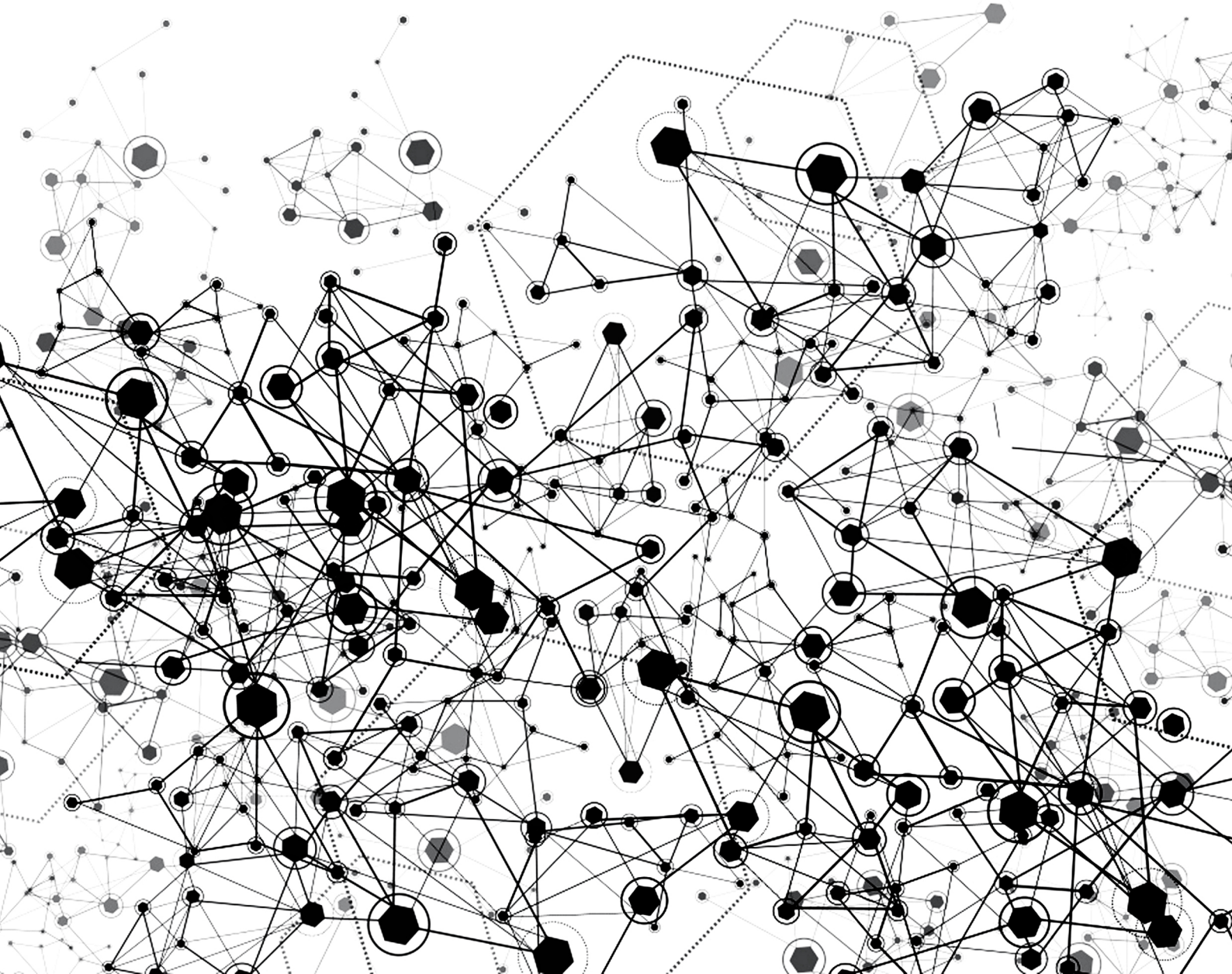
In **Chapter Five** the effect of region spatial development plans, development policies, planners and decision makers on transition of agriculture is analysed.

In **Chapter Six**, the development and adoption process of horticultural technologies in Rafsanjan are analysed. This section focuses on both the human and non-human influential actors in the development of horticultural technologies.

Chapter Seven discusses the findings of this project and provides a general conclusion for this study. The chapter explains the destabilisation of incumbent regimes and the development of new urban practices for the re-stabilisation of the socio-technical regime. The final part of thesis engages with the findings from the preceding chapters to draw out methodological, theoretical and policy lessons. The driving forces and limiting factors in transition towards high-tech agriculture are elaborated. Based on conclusions, some mentioned considerations and recommendations on how one can adopt and move towards technology-driven sustainability transitions in the agriculture practices in Rafsanjan.

Chapter 2

Theoretical framework



2.1 Theoretical framework

In this study, agricultural practices are seen as a sociotechnical system that are shaped by routine practices, and its transition is considered as a transformation in the practices that shape them. In order to study technology-driven transition, technology developments, their adoption and incorporation into sustainable agricultural practices in drought-affected areas are analysed.

This study aims to analyse the transition trajectories in the agricultural practices in drought-affected areas of Iran, Rafsanjan. In order to understand how institutional organisations, public policies and planning approaches can affect these transition trajectories, this research draws on a recently developed theoretical framework, i.e. Translation of Transition (TT) (Hosseinifarhangi, 2019).

Based on the literature (Geels 2002; Geels & Schot 2007), the transition process can be considered as the generation of a new networks resulted from involved human and non-human actors which can be explained using the theoretical framework presented in this study.

Applying the TT framework, the study analyses the role and agency of various social and material entities in the transformation of the agricultural sector of Rafsanjan. Furthermore, the application of the TT framework allows to understand the role of governmental organisations, private sectors and technologies in transition processes. However, as mentioned by Hosseinifarhani (2019), the TT framework is facing several limitations. The main obstacle in the framework is related to the way it can be applied in empirical studies. This study attempts to find solutions to both improve and enhance the TT framework.

2.2 Technology-driven transitions

Technology-driven transitions include the transformation of technology, infrastructure, industries and user practices. It can also be considered as "major changes in the sociotechnical configuration" (Geels 2002). According to Geeld (2002)'s definition, technology-driven transitions as a "reconfiguration process" involve the separation of old linkage which can result in building new ones (Geels 2002). In sociotechnical systems, TT can explain the process of transferring towards high-tech agriculture using high innovative technologies (Ulli-Beer, 2013; Geels 2004). A **"sociotechnical system"** can be defined as a political structure which operates by distributing authority and exercising power (Callon 1981). Sustainability of transition processes occurs by parallel coevolution of different aspects of developments (Kemp et al., 1998).

In the present study, a framework named "Translation of Transition" or TT, which was developed by Hosseinifarhani (2019), has been used, to understand the process of technology-driven transitions. Hosseinifarhagi (2019) developed the concept of TT to analyse the transition trajectories in the development of high-tech urban agriculture practices.

In the TT framework, the relationships among the various actors are quantified and by using the collected data through qualitative and quantitative research methods (see Chapter 3), the relationships and interaction among actors are studied. The TT framework is a combination of two theoretical frameworks; Actor Network Theory (ANT) and Multiple-Level Perspective (MLP). The ANT and MLP theories are further explained later in this chapter.

2.3 Actor–Network Theory

The Actor-Network Theory or ANT, which is an explicit approach to understand the transformation and creation process, was developed by French sociologists Michel Callon, Bruno Latour and John Law in 1980s (Cressman, 2009; Latour, 1987). ANT, which is based on science and technology (STS), defines how the ideas, values and intentions of social elements interact with one another (Melian and Mähring, 2008). Latourian ANT is based on flat ontology of human and non-human actors. The flat ontology of ANT stresses on equality and the importance of both human and non-human actors. The agency of actors is, therefore, dependent on their capacity to influence the relationships among other actors. The flat ontology of ANT is applied in this research and the TT framework.

There are several key concepts in the Actor-Network Theory that are used for the development of the TT framework. These concepts are 'immutable mobiles', 'generalised symmetry', and 'translation'.

"Immutable mobile" can be interpreted as fixed and time-defying **"black boxes"** used for research purposes. The term **"black box"** refers to a piece or part, which does not change over time, of a certain object such as machines, commands or even a community. The only difference between the general meaning of the two terms is related to the independency of context of immutable mobile (Latour, 2005). In other words, immutable mobiles are technologies that allow the standardisation and reproduction of actions in different places.

However, all entities in ANT studies which are either human or non-human materials (such as documents, technologies, money, and buildings), are equal terms based on the ''**generalised symmetry**'' concept of ANT theory. Although, based on Latour's definition (2005), the term "**actors**" can be used for social elements as they "modify state of affairs by making a difference"; it is not an appropriate term for non-human elements which are neither subjects nor objects of any activities (Latour, 1996; Cvetinovic, Nedovic-Budic, & Bolay, 2017). As a result, in order to have symmetrical treatment for human and non-human actors, which is the main characteristics of ANT, all social elements are referred to as **"actants"** (Bank 2011; Latour, 2005). The concept of generalised symmetry emphasises the role and agency of both human and non-human actants in transition processes.

Thus, because of the heterogeneity of social elements, the social world can be considered as "patterned networks of a heterogeneous material" (Law 1992). ANT attempts to find how social products such as power, knowledge and structure, created by interaction of human as the key elements and non-human elements and their relationship (Pohle, 2013). Since ANT does not have any priority between humans and non-human actants, it merely ignores the fact that humans have intentions and interests, so the terms 'interests' and 'intentions' are used for all social actants either human or non-human (Müller, 2015).

Recently, urban researchers have been using ANT to explain the process and events which happened during the time in urban areas. In urban research, ANT creates new insights, especially for explaining technology-driven changes in cities (Hosseinifarhangi 2019; Banks 2011). Cities, an example for social world, are considered dynamic entities and embody social interactions and spatial developments. This social network is a complex of economic, social and environmental contexts (Friedmann, 1987; Cvetinovic, 2017). In such systems, ANT can explain how innovative and advanced technologies change the system. The reason why some technologies fail can be explained using ANT as well. In the present study, the purpose is to use ANT to understand the process of transition from current agriculture to high-tech agriculture (Evans & Karvonen, 2011; Bulkeley, 2012). As mentioned

earlier, ANT studies a heterogenic social world including both human and non-human actants and their interests. It is the reason why, initially, ANT was named "sociology of translation" to emphasise such heterogeneity (Shiga, 2007).

Translation is the process of establishing a network where actants are aligned and enable the enrolment of other actants to align their interests. **"Power"** is a common social product to form a common interest in ANT research through translation of actants. It results in a stable actor-network (Müller, 2015). In conclusion, translation is the strategy of "power to overcome resistance and shape new assemblages" (Callon 1981). It allows to study the agency of various actors in technology adoption and adaptation processes. The concept of translation explains how a group of influential actors reconfigures the interactions between interested actors in transition and mobilises forces inside an actor-network.

Translation processes contain four phases, including '**Problematisation'**, '**Interessement'**, '**Enrolment'**, and '**Mobilisation'**, which are displayed in

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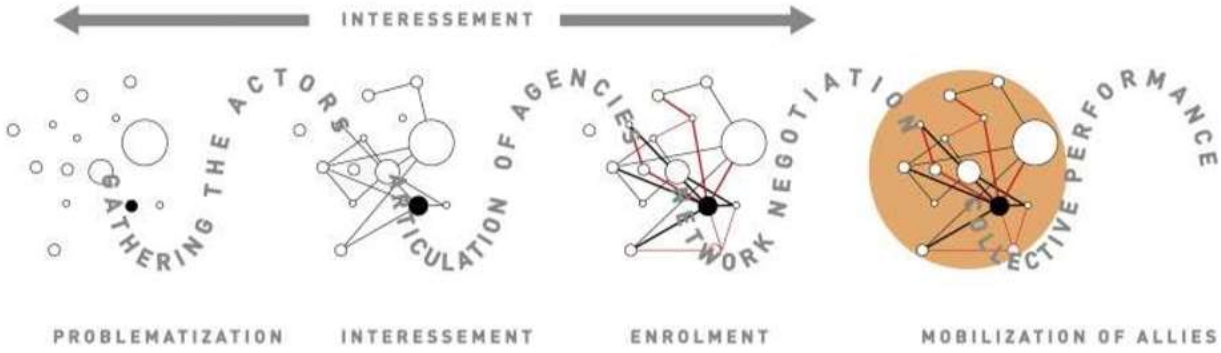

Figure 3. The phases of ANT (Anne Tietjen, 2016, p. 32)

2.3.1 Problematisation

As indicated in

, "problematisation" is the first moment of the translation process. During this step, all involved actants and their associated goals are identified and then the main actor which is named the **'translator'** or **"focal actant"** is defined. The focal actant is determined as an actant with the highest centrality in the relationships among other actants. Hence, as the main actants, focal actants have a very important role in controlling the relationships of technologies, technology developers and users, regulations, the state, and the public (Melian & Mähring).

Focal actants determine the **"obligatory passage points (OPPs)"** including any social elements either human or non-human actants, such as a project or technology, to make itself indispensable and

align interest of all actants. Each actant attempts to overcome existing obstacles so as to achieve its final goal (Melian & Mähring, 2008; Callon, 1986) (

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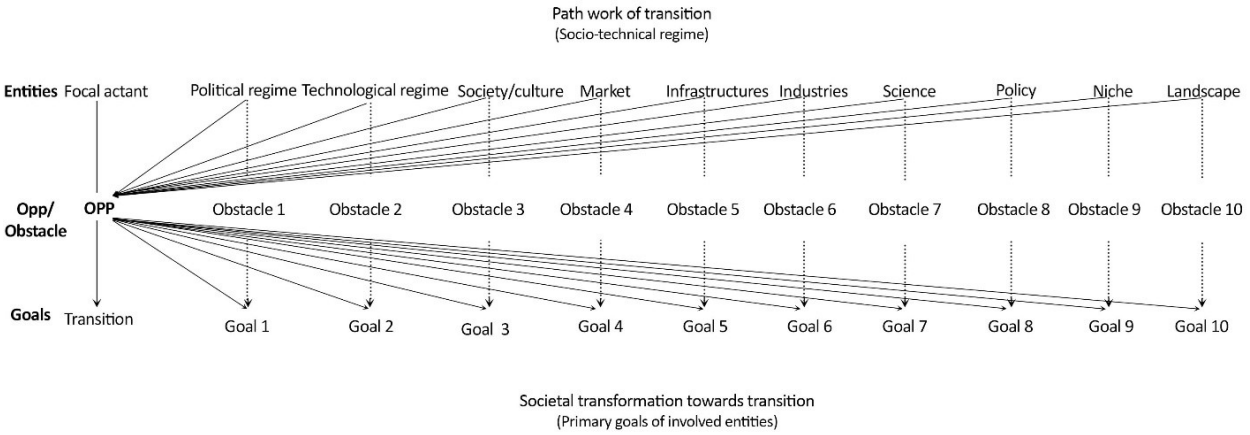


Figure 4. Obligatory passage point in ANT (Hosseinifarhangi, 2019)

In the urban studies on technology-driven transition of urban sociotechnical systems, in order to develop new practices, OPPs need to create an appropriate connection between developers of key technologies as inventions and niche as innovations. However, the power and the strength of OPPs can be considered as a very important factor to create such connection; if not found, there is no guarantee to overcome the resistance of the sociotechnical regime and develop a potential niche (Callon, 1986).

2.3.2 Interessement

"Interessement" is the second step of translation. In this phase, focal actants attempt to build a connection among all involved actants, make them interested in the main aim of the process and then create a stronger actor-network to overcome existing problems. To achieve this purpose, focal actors convince other actants which are defined in the previous step (the problematisation step, see Section 2.3.2) to accept and stabilise their identities, by bringing different strategies and technologies of interessement such as policies, technologies, physical device, plans, or any other actants with agency which are referred to as **"intermediaries"**. Thus, intermediaries regulate the relationship among involved actants in the translation process (Callon, 1986). The term **"agency"** in the translation process refers to the ability to find allies to generate the actor-network or configure the interactions among other actants involved (Latour, 2005).

2.3.3 Enrolment

"Enrolment" is the third phase of the translation process (see

) which occurs after a successful interessement. After accepting stable identities by actants during the 'interessement' phase, all actants are enrolled. In case there weren't enough actants, new actants would be added. Hence, as a result, an actor-network would be generated.

Several strategies have been selected by focal actants in the enrolment step for managing the roles of other actants (Singleton & Michael, 1993; Callon, 1984). The most important part of this step is the negotiations between highest resistant actants. According to Callon (1986), translation without discussion can be considered as an alternative for the enrolling process.

2.3.4 Mobilisation

The last step of the translation process is **"Mobilisation"**, during which some actants represent others to create a stable actor-network and to keep actors behaving in their interest and identity. Thus, all actants are organised and controversial issues among actants are removed (Melian and Mähring, 2008).

In the mobilisation step, interests, aims and identities are mobilised by representative actants (Shiga, 2007). Representative actatnts, which are used by focal actants, should represent the whole network and be a proper agent for all actants (Callon 1986). Furthermore, the representative is a stockperson(s) or even an organisation that attempt to speak in the name of other actants to solve their problems and also try to keep all actants in the network (Callon 1984). Since according to Shigna (2007), the translation process attempts to combine, associate and simplify the actants, the representative should be limited to a few actants.

2.4 The multi-level perspective (MLP) on sociotechnical transitions

Although the concept of multi-level perspective or MLP was developed by Rip and Kemp (1998) for the first time, it was defined theoretically by Geels (2002), Smith et al. (2005), and Grin et al. (2010). The MLP has been used in a variety of research such as food and agriculture (Spaargaren, Oosterveer, & Loeber, 2013; Huang & Glass, 2008; Marsden, 2013; Shove, 2003) and is useful in understanding the transitions of incremental and radical innovation (Whitmarsh, 2012).

The MLP, which is composed of three levels, is used as a framework to analyse the sociotechnical transition process from current to high-tech agriculture in the present study. The three levels of MLP including landscape (macro level), socio-technical regime (meso level) and niche (micro level) are described in the following sections (

). Each level of MLP is composed of several entities and elements, and, generally, higher levels are more stable than lower levels in terms of number and compatibility of actors (Geels, 2011).

The multi-level perspective conceptualises the transition patterns. The MLP analyses transition processes in three analytical levels of ''**niche''** level, where the novelties emerge, ''**sociotechnical regime''** a stable complex shaped by routines, laws, policies, technologies and others, and ''**sociotechnical landscape''** level which is shaped by factors beyond direct influence of niche and regime actors such as climate change and cultural patterns. In transition pattern of Multi-level perspective, technological novelties are developed at niche level, changes at landscape level put pressure on the regime, and finally destabilisation of regime opens window of opportunities for niche innovations which will result in the transformation of incumbent sociotechnical regime and its

replacement with a new regime. Each analytical level of MLP is further explained in the following sections.

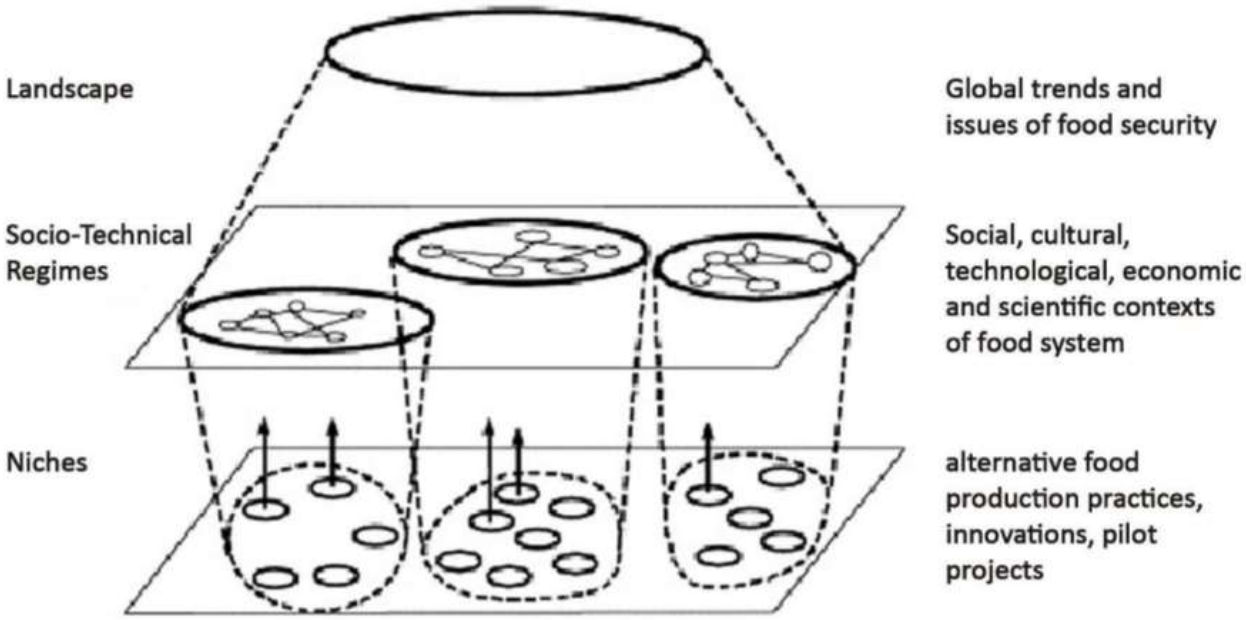


Figure 5. The levels of MLP (Geels, 2002, p. 1261)

2.4.1 Landscape

The **landscape** include macro-level phenomena such as environment (e.g. climate), policy (e.g. political ideologies) and society (e.g. social values), which form the external context and it is a wider context of changes. This level is not influenced by the next levels or transformed rather slowly, compared to the dynamics of the other levels (Geels, 2011; Smith et al., 2005).

2.4.2 Socio-technical regime

The term **socio-technical** in MLP refers to the dependencies and coevolution of infrastructure, institution and society. MLP can be applied to understand the interaction among involved factors to generate stability and changes in the system, which is also known as structural transformation in a sociotechnical system (Whitmarsh, 2012).

Transition is the process of shifting from current regime to a new regime, so the transition focuses on the regime level. The other two levels have been defined in association with regime level. The landscape level effects regime conditions by creating some pressure using its actor and the changes occur due to interaction between this level and the next level (niche, see Section 2.3.3) of the MLP framework (Geels & Schot, 2007; Geels, 2011,). Because of some factors such as sunk investments,

vested interests, habits and bureaucracy, changes in the regime level are incremental and create stability as well as flexibility against radical changes. According to Geels (2011), 'existing regimes are characterised by lock-in, innovation occurs incrementally, with small adjustments accumulating into stable trajectories' and can result in stable directions in different aspects such as technology, policy, culture and industry.

2.4.3 Niche

The last level of MLP is known as the **niche** level, which is also referred to as the **micro** level. The novelties outside of contexts and high-tech technologies are part of the niche level which can lead to innovation. The successful and efficient technologies can be part of the regime as well (Avelino, 2009). The actors of the micro level, which are called niches, such as entrepreneurs, start-ups, and spinoffs, are less limited by dominant institutions and attempt to solve existing problems in the **meso** level created by pressures of the **macro** level (Whitmarsh, 2012). The final aim of niche actors is to find efficient and appropriate innovation to use in the meso level as an alternative. Since normally the meso level is stabilised with existence mechanisms and technologies, the process of adding and matching the innovations of micro level such as new technology to meso level is a rather complicated process (Geels, 2011).

2.5 Translation of transition framework (TT framework)

As mentioned earlier in Section 2.2, a framework named TT (translation of transition framework) has been used to analyse technology-driven transition in this study. This framework, designed by Hosseini (2019), is the result of incorporating ANT into MLP frameworks which are described in Sections 2.3 and 2.4, respectively.

As explained in Section 2.4, MLP is a framework that encompasses three steps (landscape, sociotechnical regime and niche) to analyse the directions of transition in sociotechnical regimes. It attempts to find the role of niche actors and their effect on the development and stabilisation of regimes. According to previous research, MLP is very descriptive and cannot efficiently analyse technology-driven transition processes (Smith et al. 2005).

The most significant problems of MLP are:

- In the MLP framework, the niche concept does not consider the technology origin which has been adopted by niche actors. Also, MLP ignores the interaction between current actors in regime and niche levels. However, this problem can be solved by the application of the ANT framework which can determine the interaction among all actants in current and new regimes and generate a stable network including aligned interest throughout (Geels, 2011, Hosseini 2019).

- The role and importance of agency in the translation process are ignored by the MLP framework. Incorporating the ANT into MLP cab be considered as an efficient solution to solve this problem (Genus and Coles 2008).

- Since MLP cannot focus on analysing the dynamics of sociotechnical systems, ANT is an efficient tool in this regard. As mentioned in Section 2.2, ANT can examine the interaction between both human and non-human actants to understand the dynamics of the network and can also detect

the effect of different policies and strategies on the stabilisation of network (Farías & Bender, 2012).

Hence, as mentioned considering the problems related to MLP, in the TT framework, one can take advantage of ANT by incorporating it into MLP to discover the direction of technology-driven transitions using the general symmetry and translation concepts of ANT (see Section2.3). As a result, the TT framework attempts to explain the relationships of actants at three levels of MLP and establishes a way to enter the successful and appropriate niche actors including innovations and new technologies into sociotechnical regimes. In general, the transition process which can be influenced by the agency of landscapes, regimes, niche actants, existing institutions, and decision-making systems will be explained and analysed using the TT framework. As indicated in Figure 6, the TT framework encompasses three steps including "**disentanglement**", "**punctualisation process**" and " **re-entanglement**" which are explained in the next sections.

2.5.1 Disentanglement

Disentanglement is the first step of the TT network, which destabilises the current sociotechnical regime due to pressure of landscape and niche pressure. Thus, this destabilisation in sociotechnical regime causes increasing of interest for change of actors and can result in generating new niche developers as well as new technologies.

Landscape pressure is the result of political reforms, long-term plans and social and environmental dynamics, whereas niche pressure occurred due to the emergence of new technologies in niche level and applying them in the sociotechnical regime.

2.5.2 Punctualisation process

The punctualisation process, as the second phase of the TT framework, is developed by niche actors and will result in the transformation of sociotechnical regimes. Resistance of current sociotechnical system systems against any changes is the most serious obstacle facing the transformation process. In order to reach the goal of the system, focal actants and core technologies play an important role in removing the resistance of sociotechnical regimes. Focal actant as the main actants and the absolute power in the decision-making process, define an OPP which can be a plan, project, policy or any actants (see Section2.3.1) (Geels, 2011).

The punctualisation process starts with the first moment of ANT which is "**problematisation**" and then continues with the next three moments which are "**interessement, enrolment, and mobilisation**". As the four moments of the ANT network are explained in Section2.2, the focal actants and OPP are defined in the "**problematisation**" moment, and in "**interessement**", the focal actant identifies the roles and negotiates the identities of involved actants, then the " **enrolment**" moment focuses on applying new tools to identify the roles of actants and, finally, in " **mobilisation**", all actants are represented by selecting the right spokespersons.

2.5.3 Re-entanglement

Re-entanglement is the last phase of the TT framework. In this step, the actors of different levels of MLP (landscape, regime, and niche), (see Section 2.4), generate a new network including aligned interest by re-creating their interactions in sociotechnical regime which is made of heterogeneous actants. The role of actors in the new actor-network will be negotiated and defined in the creation phase. Thus, the new reconstructed actor-network and their actors re-stabilise the regime level by reducing the pressure of landscape level.

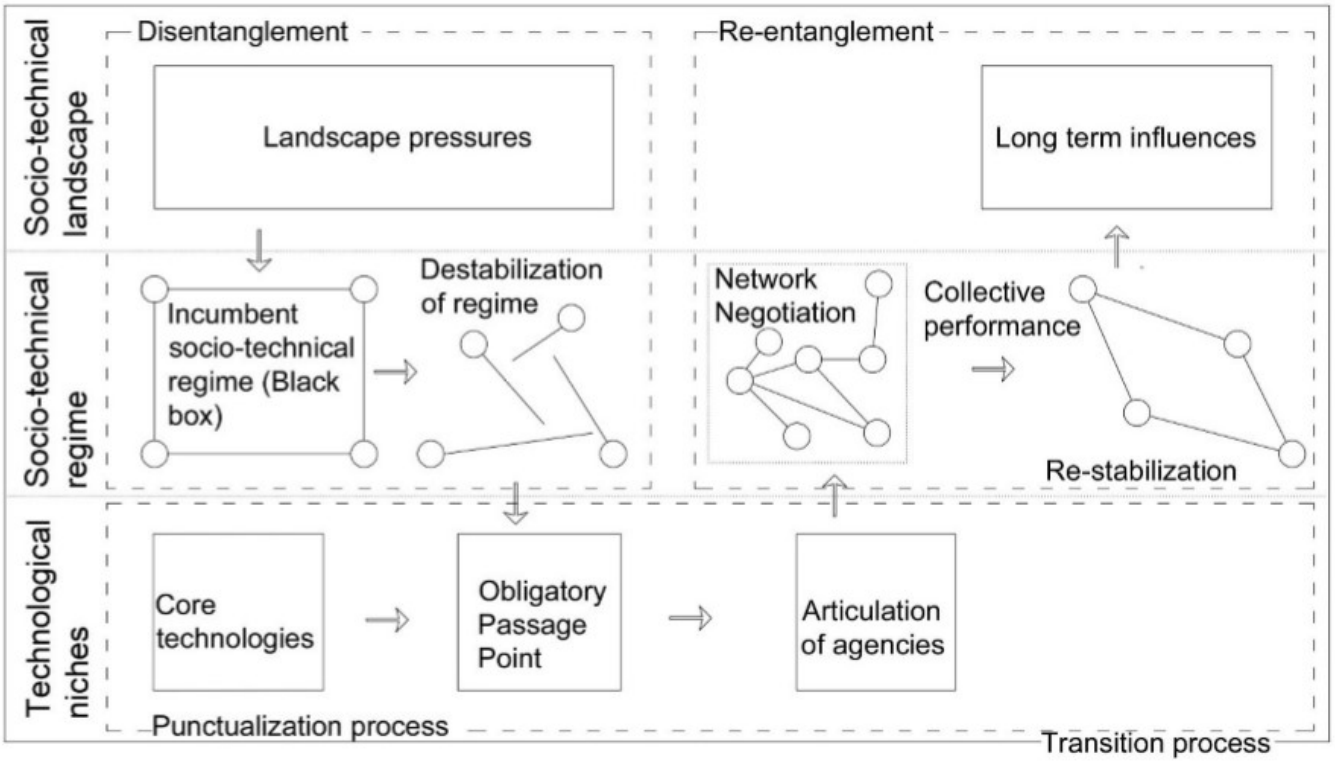


Figure 6. Translation of transition steps (Hosseinifarhangi, 2019, p. 31)

2.6 Applying the Translation of Transition

In translation of transition, the technology-driven transition is analysed in three stages: First, the disentanglement of incumbent sociotechnical systems under pressures from landscape and niche levels, then the punctualisation process of novelties through the creation of actor-network of transition, and, finally, the last stage, re-entanglement where technological novelties are created and diffused in the socio-technical regime. This study will improve and adopt the TT framework. In the following sections, the limitation of the TT framework and solutions that are used in this study for the improvement of the theoretical framework are explained.

2.6.1 Limitations of Translation of Transition

The concept of 'Translation of Transition' conceptualises the transition patterns. It describes trajectories in which a socio-technical regime will transform. The TT framework analyses the role of

social and material entities and the impact of their interactions on these transformations. However, the TT framework, which has been developed by Hosseinifarhangi (2019), has several limitations. These limitations are related to, firstly, the complexity and ambiguity in the definitions of the three stages of transition. The three stages of transition that are defined in TT framework are not limited to time and space. Additionally, they are not linked to innovation processes, which makes it complicated to connect the events and progresses in case studies to the three studies of transition. Secondly, the framework that is used by Hosseinifarhangi (2019) for the application of the concept of TT in empirical studies has several limitations. Hosseinifarhangi (2019) suggests that ''the conceptualisation of translation trajectories through TT, the relationships of involved actants must be quantified. A further challenge was encountered in the attempt to achieve an accurate quantification of the relationships between actors in the complex stakeholder fields. In order to increase the reliability of the methodology for quantifying relationships, this study uses ethnographic research by participating in technology development projects through collaboration with public or private companies in the case study. The ethnography research methods have been used to trace actors involved in technology-driven transitions. These methods helped to gain a deep understanding of the identity and relationships among human and non-humans actors through interviews and site visits. The data that were gathered through these research methods helped to quantify the relationship among all actors. However, in more complex fields, the involvement of researchers in technological developments can be difficult; therefore, the application of this methodology is not possible''. Hosseinifarhangi suggests that a mix quantitative and qualitative approach can remove these limitations and ''to achieve greater accuracy and reliability in the quantification of relationships and calculation of betweenness centrality between involved actants. Quantitative research methods, such as surveys, can be helpful for analysing the DR and rating the relationships between involved actants from different perspectives'' (Hosseinifarhangi, 2019, p. 205).

2.6.2 Enriching the conceptualization of three stages

The transition processes in Translation of Transition are divided in three stages of disentanglement, punctualisation and re- entanglement. The events and processes within each of these stages are explained in sections 2.5.1, 2.5.2 and 2.5.3(Hosseinifarhangi, 2019). In order to avoid ambiguity in the definition of each stage, this study tends to enrich the conceptualisation of the stages.

2.6.2.1 Enriching the conceptualisation of disentanglement

Disentanglement in this study is defined as the destabilisation of the incumbent socio-technical regime. It refers to the malfunctions in existing systems such as agriculture and food production systems. Food system in a specific context is at disentanglement when interactions among the social entities (farmers, residents, decision makers, planning organizations, local government, etc.) and material entities (agricultural technologies, agricultural infrastructures, farms, urban and rural infrastructures) are no longer able to satisfy the needs of the consumers. The malfunction is caused by the dynamics in the socio-technical regime (such as increasing population, new policies, etc.) and pressures from socio-technical landscape (climate change, long term cultural changes etc.).

2.6.2.2 Enriching the conceptualisation of punctualisation process

The punctualisation process in this study is defined as the adoption and adaptation of technological novelties in the socio-technical regime. The technological novelties are divided into three categories:

1- Newly developed technologies by niche actors and are developed through bottom-up approaches.
2- Cutting-edge technologies that are the result of R&D project by governmental organisations and private sector through top-down approaches.
3- The novel technologies that are transferred from other places to the context. In the punctualisation process, technological novelties are standardised and made ready to be adopted by social entities involved in actor-network of transition.

2.6.2.3 Enriching the conceptualisation of re- entanglement

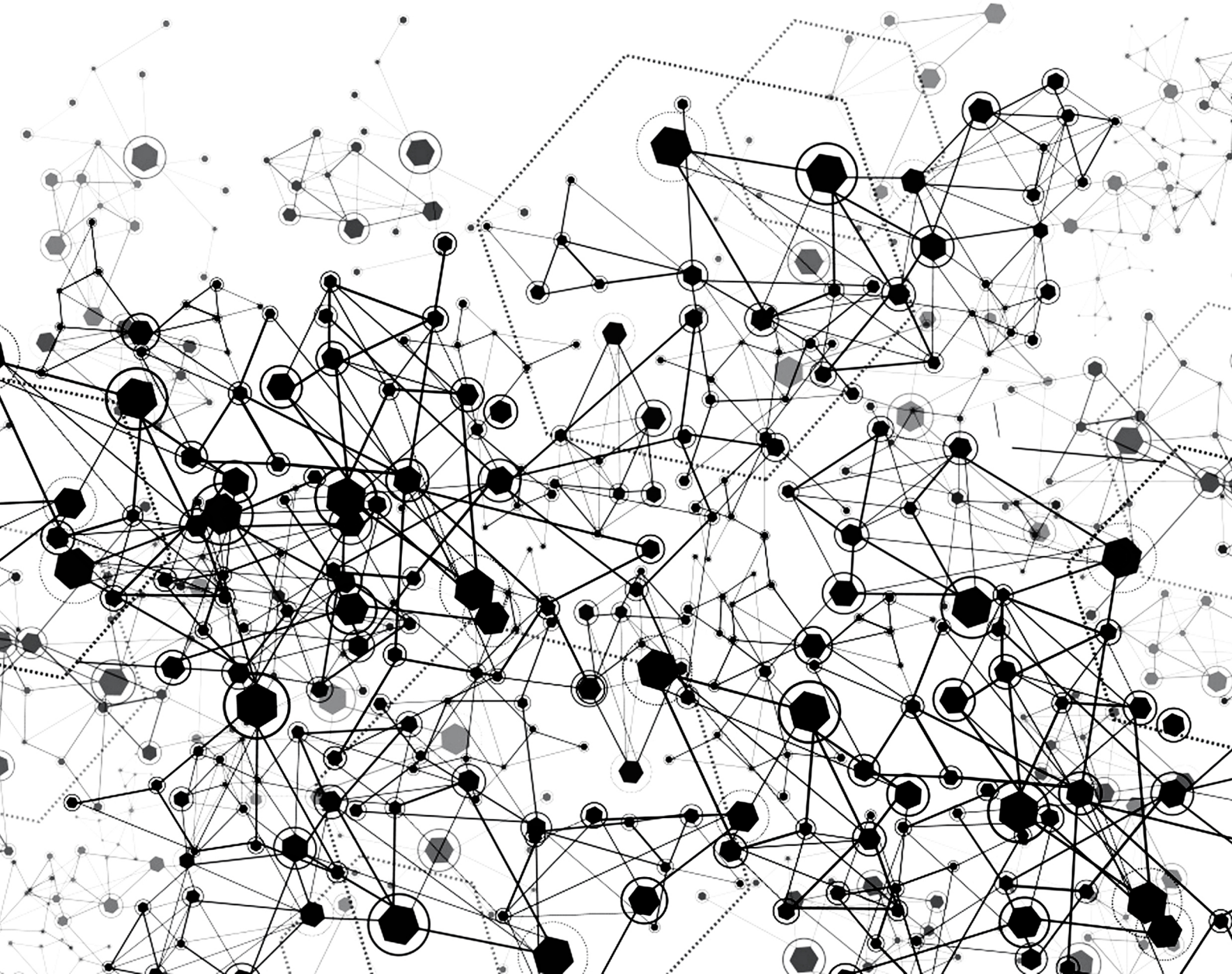
The re-entanglement of the sociotechnical regime is the diffusion of new technologies and the creation of new sociotechnical systems. These new systems have adopted new technologies and the relationships and interactions between actors in that system are configured based on the characteristics of new technologies.

2.6.2.4 Application in the empirical study

For the application of the concept of TT in the empirical study, this research uses combined quantitative and qualitative research. The methodological framework is explained in the next chapter. However, in order to surpass the limitation of the TT framework in the quantification of the relationships between the actors involved, this study designed a framework that allows to analyse the interactions and agency of both human and non-human actors. The interviews and surveys that are conducted in this study are planned in a way that all actors are represented by at least three interviewees. In addition, the surveys allow to gain a better understating of the lager group of social actors.

Chapter 3

Methodology



3.1 Research methodology

3.2 Research methodology

This research examines current agricultural issues and the impact of policies and plans on the transfer of current agriculture to high-tech agriculture in the Rafsanjan region which needs to be descriptive and exploratory study about a specific case. Thus, it means that the present study is case study research.

The primary aim of the case study research was to gain a better understanding of complex social phenomena that have an exploratory and descriptive attribute (Yin, 2011). Additionally, the case studies are thematic studies by focusing on one or more items in a bounded system. To this aim, either several programs (multidisciplinary studies) or only one program (in-situ study) can be selected for the research (Zuker, 2001; Tellis, 1997; Denscombe, 2014) which are performed using detailed and in-depth data collection processes including multiple sources of information (e.g. observation, interviews, audio-visual materials, documents and reports).

In this study, to answer the research questions, a framework which is designed by Hosseini et al. (2019) has been used, including three steps and is named TT framework (see Chapter 2).

In the first step of the used TT framework, the problems and barriers of current agriculture in the socio-technical regime, the pressure on existing socio-technical regimes, social and technological implications of the transition to high tech agriculture, as well as the policies and plans in this field are identified after collecting data using interviews and secondary documents.

In the second step, the punctualisation process of novelties, the influential human and non-human actants are detected using interviews and questionnaires.

In the third step, the dissemination and acceptance of high-tech agricultural technologies in social regimes and the development of social practices have been examined using the data collected in interviews.

As mentioned earlier in Chapter 2, the TT framework itself is composed of two other frameworks known as Actor-Network Theory (ANT) and multi-level perspective (MLP). ANT can be translated in associated with the transition pattern and studied actants in three levels of MLP. Moreover, ANT is also a methodological approach that can be used to both organise and order the structure of the research (Latour 1996, Müller 2015). Thus, in the next parts of this chapter, the methods, case study and data collection tools used in the present survey are explained.

3.3 Case study

The case study in this research is the process of transferring current agriculture to high technology agriculture in Rafsanjan which is an important agricultural centre in the south-western part of Iran. Rafsanjan has recently been facing several challenges, such as water shortage, air pollution and land subsidence, created by current agricultural systems. In this study, which is qualitative research, more attention is paid to the deep recognition and exploration of phenomena. Therefore, selecting individuals and locations can be done via either purposeful sampling or intentionally (Creswell et al, 2003; Creswell, 2011).

3.4 Data Collection

In this study, a mixed approach including both quantitative and qualitative data approaches has been used to collect data. A mixed approach is a type of research in which the researcher or group of researchers have elements and features in quantitative and qualitative approaches in order to further deepen and broader understanding. This method has been known as blended research, integrative research, multi-method research, multiple methods, triangulated studies, ethnographic residual analysis and mixed research (Johnson et al, 2007).

In this study, a mixed approach for collecting data has been used so as to earn more credibility by communicating quantitative and quantitative data; perform more researching; have more comprehensive pictures of the studied phenomena; remove the limitations of each of the quantitative and qualitative approaches and strengthening their positive aspects and, consequently, make more precise conclusions; provide a wide range of tools to achieve research goals; use a qualitative approach to describe and explain quantitative data, or vice versa, which can provide a better picture of the studied phenomenon (Creswell et al, 2003; Creswell, 2011).

Quantitative data, which is typically collected by questionnaires or interviews (Singleton, 1988), have been used to investigate the status of the survey. The current survey used a structured questionnaire (Hanson et al, 2005) to provide a quantitative description about the tendencies, attitudes, or ideas of a group of people through sampling, so the results of the sampling can be generalised to the population. The high number of population in this survey is the reason why we opted for a questionnaire to collect data.

Apart from quantitative data, we also collected qualitative data to perform the current survey by interviewing the selected people. Qualitative researchers usually analyse their data statistically as well as logically which mostly results in making research questions, guesses and assumptions but neither can they predict the outcomes nor proof or reject a hypothesis (Gorman et al, 2005).

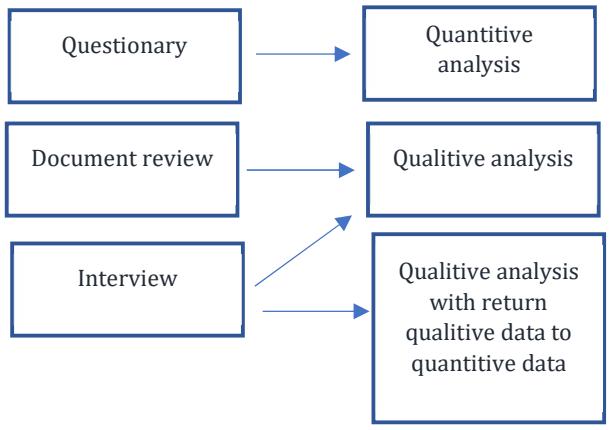


Figure 7. Data collection methods

3.5 Data Collection tools

The data collection tools are any tool that can be used to measure a variable or a feature, or to collect the information needed to answer the research questions. In this research, questionnaires interviews and a review of the documents and resources are the selected tools which have been used to collect the data.

The most common and perhaps the most important tool for data collection is a questionnaire. A questionnaire consists of a set of items or questions that seek to investigate research questions and ultimately achieve research goals. In this research, we used a questionnaire to navigate attitudes, beliefs, and views of authorities, experts and local people about different aspects of the transition process from current agriculture to high-tech agriculture. The questions/items of this study are divided into two general categories: closed-ended and open-ended questions. In open-ended questions, the respondents including authority and experts could answer questions and express their feeling and attitude, without any limitations. Although the information obtained from open-ended questions are more accurate, complete and valuable than close-ended questions, the classification and conclusion based on open-ended questions are difficult. In the questionnaire with close-ended questions, the respondents including local people were forced to answer the questions only by selecting the predefined responses of the questionnaire. Thus, the respondents did not have freedom to fill in the questionnaire with their own responses but the predefined options. However, the data collected through close-ended questions are known as quantitative data.

Interviews are some of the most important tools to collect data in research conducted using a qualitative approach. Interviews are more flexible than other data collection tools such as questionnaires which are more commonly used in the quantitative approach. Being completely based on the power of the researcher to manage the process of interviews, interviews can be considered as structured, semi-structured or deep. In this study, we did not use structured interviews because this type of interviews is similar to questionnaires. In a structured interview, the questions that are to be discussed are pre-prepared and, therefore, the researcher cannot invent or design new and unpredictable questions. However, in this survey, we used semi-structure and deep interviews to collect data from authorities, experts and project developers. In contrast to a structured interview, the questions of semi-structured interviews do not have any particular structure, so we prepared a considerable number of questions and during each interview we were allowed to change the structure and shape the interview process by bringing up new questions. Additionally, we used deep interviews which are individual and unstructured interviews to identify the opinions and feelings of the interviewee about our research topic. Using deep interview, we were able to examine complex, sensitive, contradictory, controversial, and challenging issues.

The last research tools which have been used in this study are known as secondary data. Secondary data is based on previously compiled information and the existing information, such as personal documents (e.g. letters, memories), official documents (e.g. newspapers, magazines and journals, annual reports) and archival data (e.g. document of historical agreements).

3.6 Actor-Network Theory as a methodological approach

ANT is a theoretical framework (see Chapter 2) of this study which can be used as a methodological approach as well (Latour, 1996). The detail of ANT concepts and its definition in association with

MLP and as part of the TT framework have been explained in Chapter 2. The principals of the actor-network theory have been used to collect data through tracing actors and their relationships.

The ANT principles for following actants and tracing their relationship are:

1- The context is boundaryless and a holistic approach is used for tracing the relationships of various actors involved.
2- Only actants that leave traces exist. Actors that leave no traces based on ANT principles are not part of the study. This helps to focus on actors with the highest degree of relevance.
3- Actors are differentiated into four different categories: Humans, associations and institutions (individuals, organisations, cultural features); representatives of nature (land, environment, water, ecosystems, natural phenomena); technologies (infrastructure, regulatory, and accounting); and buildings and structures.

Surveys and interviews are conducted to trace actors and to study their interactions (Hosseinifarhangi, 2019). In-depth exploratory interviews in this research are conducted to identify influential human and non-human actors. After the identifications of influential actors, each actor was given a number. For tracing actors and understanding the role and agency of both social and material entities, for each actor at least three interviewees were selected for in-depth interviews (second column and Table 1). For non-human actants (material entities), their spokespersons or experts familiar with all features of them were interviewed. This approach allowed to understand the agency of both social entities and material entities such as technologies and to gain a better understanding of the relationship between social and material entities.

In this study, interviews have been used as a data collection tool to gather information about current agriculture and transfer of current to high-tech agriculture by interviewing with experts, authorities and project developer. To this aim, we used mostly semi- and deep-structured interviews and, in a few cases, structured interviews which are explained in the previous section. A list of interviewees who participated in the present thesis has been shown in Table 1. For a confidentiality reasons, we excluded the names of the interviewees, but they were saved in case of necessity. Each interviewee is identified as expert on several actants (Second column of Table 1). Interviewing people with an in-depth knowledge about actants involved and their connection is used to trace all the actors and their connections.

Table 1. The list of interviewees in the ANT survey for tracing actors involved

No.	Experties on the actants	Affiliation	Date	Location
1	15/27/29/32/40/41/42/49/55/57/58/59	Agricultural expert	14/10/2017	Vali/Asr University
2	7/8/9/10/15/17/26/27/29/32/40/41/42/44/46/48/49/52/55/58/59	Project developer and agricultural expert	28/10/2017/12/11/2017	Vali/Asr University and Greenhouse
3	5/10/11/16/18/19/21/23	Agricultural expert	21/9/2017	Pistachio Research Institute

	/44/47/48/50/58/			
4	3/4/10/11/12/23/30/34/38/39/44/48	Project developer	28/11/2017	Uban Water and Soil Laboratory
5	5/7/10/11/15/16/17/18/23/24/25/26/27/28/30/33/34/35/37/38/39/40/41/44/45/47/48/49/50/53/54/55/57/58/61	Projects developer and agricultural experts	3/10/2017	Pistachio Research Institute
6	7/8/9/10/21/27/28/29/35/40/41/42/43/44/46/47/50/56/58/61	Project developer and major agricultural landowner and agricultural expert	9/11/2017	Greenhouse
7	19/26/28/30/31/33/34/35/38/39/43/44/45/47/48/50/52/53/55/56/58/61	Researcher in agricultural history and agricultural expert and project developer	2/9/2017	Abtahi pistachio company
8	1/7/10/22/26/29/40/41/42/43/55/58/59/60	Project developer and agricultural expert	22/11/2017	Technical and professional organizations
9	15/17/24/27/32/41/50/57/59/61	Project developer and agricultural expert	4/9/2017	Uban company
10	5/10/15/17/18/19/24/26/27/29/30/34/35/38/40/41/44/45/47/48/49/50/52/55/57/61	Project developer and agricultural expert	24/8/2017	Uban Water and Soil Laboratory
11	10/11/18/23/30/44/47/48/49/50/53	Agricultural expert	30/8/2017	Pistachio Research Institute
12	1/4/15/32/47/50/59	Agricultural expert	7/8/2017	Vali/Asr University
13	2/6/8/9/22/43/50/51/56/60/61	Urban planner	21/12/2017	Municipality
14	26/27/38/47/57/61	Agricultural expert	5/8/2017	Barafraz Keshavarz Pars company
15	10/25/34/35/49/50/55/58/61	Agricultural expert	21/8/2017	Agricultural Organization

16	2/6/8/9/15/21/31/32/35/36/43/45/47/50/51/54/61	Construction expert	7/8/2017	Vali/Asr University
17	3/5/10/16/18/19/24/25/26/28/29/30/34/35/38/39/42/43/47/50/52/55/57/58/59/61	Project developer and agricultural expert	14/11/2017	Kiyan Mehr company
18	5/15/17/26/30/32/35/38/47/50/52/58	Project developer and agricultural expert	15/11/2017	Vali/Asr University
19	2/6/8/9/22/43/45/50/51/56/60/61	Urban planner	1/12/2017	Municipality
20	1/10/16/39/43	Agricultural expert	11/11/2017	Agriculture Organization
21	2/5/6/7/8/9/10/11/12/13/14/15/16/17/19/20/21/22/28/29/30/31/33/35/36/37/44/45/46/47/48/50/51/52/53/54/60/61	Politician	6/1/2018	Vali/Asr University
22	1/38/39/53	Urban politician	2/12/2017	
23	1/7/12/17/20/45/46/52/53/54	Agricultural expert	15/11/2017	
24	10/16/18/25/28/34/35/38/47/48/50/55/58	Agricultural expert	1/11/2017	Pistachio Research Institute
25	3/4/12/13/19/28/31/35/38/43/47/50/53	Economic expert	4/11/2017	Azad University
26	2/3/4/6/11/12/13/14/15/20/22/31/36/51/53/54/56/60/61	Social, politician and urban planning expert	7/11/2017	Azad university
27	15/25/32/47/48/50/59	Agricultural expert	12/11/2017	Azad university
28	10/21/28/34/35/38/39/43/44/47/50/52/55/58/61	Agricultural expert and major agricultural landowner	3/1/2018	Pistachio Research Institute

29	6/8/9/21/23/25/28/32/34/35/38/39/43/44/47/48/50/52/53/55/58	Agricultural expert and major agricultural landowner	2/1/2018	Pistachio Research Institute
30	5/6/8/9/10/16/23/24/30/33/38/43/44/45/47/48/49/50/53/58/61	Agricultural expert	5/8/2018	Pistachio Research Institute
31	3/4/10/19/35/30/39/44/47/61	Economic and agricultural expert	6/9/2028	Agricultural bank
32	6/5/8/9/11/13/14/16/20/21/31/33/35/36/37/44/45/47/48/50/51/53/54/61	Agricultural, historical, Politian expert	12/9/2018	Municipality
33	13/14/20/31/32/33/35/36/37/46/47/53/61	Agricultural, social, economic and Politian expert	5/8/2018	Entrepreneurship Association
34	13/14/19/30/31/36/37/46/47/53/54/61	Social expert	11/9/2018	Azad university
35	History	Social, agricultural and historical expert, major land owner	10/10/2017	Uban company
36	History	Social, and historical expert	10/10/2017	Uban company
37	Pistachio	Farmer	10/10/2017	Pistachio Research Institute
38	Pistachio	Farmer	10/10/2017	Agricultural Jihad organization
39	Pistachio	Farmer	10/10/2017	Farm
40	Pistachio	Farmer	10/10/2017	Farm

Numbers of Actants: 1.Technical and professional organizations/ 2.Road and urbanization Administration/ 3.Agricultural bank/ 4.Other banks/ 5.Agricultural and Natural Resources Engineering Organization/ 6.Governorate/ 7.Department of Environment/ 8.Municipality/ 9.City Council/ 10.Agricultural-Jihad Organization/ 11.Water Organization/ 12.Power Department/ 13.Local newspapers/ 14.Local radio/ 15.Rafsanjan Universities/ 16.Natural Resources Organization/ 17.Advanced technologies incubator/ 18.Iran Pistachio Research Institute/ 19.Agricultural Insurance Fund/ 20.Co-operative, Labor and Social Welfare Office/ 21.The village office (Dehdari)/ 22.Gas office/ 23.Companies active in irrigation with a new method/ 24.Agricultural Laboratory/ 25.Agricultural Clinics/ 26.Fertilizers and poisons Companies/ 27.Companies active in hydroponic agriculture/ 28.Cooperative Pistachio Company/ 29.Greenhouses/ 30.Farmers, minor owner of agricultural land/ 31.People/ 32.University professors/ 33.Member of Parliament/ 34.Farmer advisors/ 35.Major Owners of agricultural lands/ 36.Graduates in Agriculture/ 37.Representative of the supreme leader (Imam of Friday prayer)/ 38.Experts who are Farmers Consultant/ 39.Agriculture equipment/ 40.Imported hydroponic technologies/ 41.Hydroponic Technologies of the Interior Industry/ 42.Greenhouse

equipment/ 43.Pistachio Process Houses/ 44.Pumps and water wells/ 45.Dried pistachio gardens/ 46.Agricultural products of greenhouses/ 47.Pistachio/ 48.water resources/ 49.Weather/ 50.Pistachio Gardens/ 51.Detailed design and land use plan/ 52.Export and import plans/ 53.Country Development Program/ 54.Foreign Relations Policies and Programs / 55.Fertilizer/ 56.Electricity/ 57.Laboratory materials/ 58.Poison/ 59.Seed/ 60.Gas/ 61. Urban and Regional Planning and Policy

3.7 Validity and reliability

3.7.1 Validity and reliability in quantitative research

To have reliable and valid results, we need to determine the reliability and validity of the used data collection tools. To check whether the findings of the research obtained using data collection tools are logically acceptable, we need to evaluate the validity of the used tool. In this study, the content validity, which indicates if the designed tool examines the main aims of the study, has been investigated by referring to the experts (Polit and Beck, 2006; Mohammadbeigi et al, 2015)

In the next step, we detect the reliability of the data collection tools to assess if the results are identical over time and under similar conditions compared to similar methods. In this study, the reliability of the qualitative tools has been calculated using a test-retest method which assumes that the measured variables will not change over time. To this aim, first, we evaluate the reliability value in a small group of individuals using the test-retest method. This step has been repeated two times under similar conditions. Finally, the correlation coefficient between the calculated scores obtained from two steps has been compared (Guttman, 1945; Trochim, 1989).

In the present research, we designed a questionnaire to study the familiarity of the residents of Rafsanjan with vertical and hydroponics agriculture and their tendency to invest in this field. This questionnaire encompasses 13 questions. The reliability of this questionnaire was calculated using the method of test-re-test (0/99). The number of population in Rafsanjan is 311,214, of whom 233,002 people were over 15 years, 138,348 lived in urban areas, 94,007 people lived in villages and 647 people lived in uncertain locations and did not have any permanent accommodation based on the Statistical Centre of Iran; In this calculation, we count them as rural populations. According to Cochran formula, 384 people were selected.

$$n = \frac{\frac{z^2 pq}{d^2}}{1 + \frac{1}{N}\left[\frac{z^2 pq}{d^2} - 1\right]}$$

N= population, n= sample size, d= margin of error (0/05), p= given percentage, we used 50%=0/5, q= 1 – p, z= value which was found in a Z table.

For sampling, according to the ratio of urban and rural areas, 228 and 156 were selected from urban and rural areas.

Furthermore, we designed a second questionnaire to study the attitude of people about the feasibility of the transition process from current agriculture to high-tech agriculture in Rafsanjan. According to the ratio of urban and rural areas, 228 were selected from urban areas and 156 from rural areas. The

reliability of the questionnaire, which includes 13 questions, has been evaluated using the test-retest method.

The population selection was not random, and people were chosen purposefully. To this aim, we selected one city and four villages per section of the County of Rafsanjan. Then, 46 and 8 people per city and village have been selected, respectively. We ignored 6 questionnaires from our analysis due to invalid responses.

3.7.2 Validity and reliability of qualitative data

In this study, the validity and reliability of the qualitative data have been assessed using Lincoln and Guba method (1982, 1985). Based on Lincoln and Guba method, four criteria including credibility, transferability, dependability and confirmability have been determined.

To determine the credibility of the current research, the objective and measurable questions and the process of the designed interviews have been verified by four experts. Moreover, to ensure proper interpretation, we used two experts to interpret the answer of the interviews. The two resulted interpretations were 85% similar to each other.

Additionally, to assess the transferability of the research, two specialists who were not involved in this research reviewed the findings of the surveys.

Finally, to ensure dependability and confirmability of all answers, we recorded all steps of the interview.

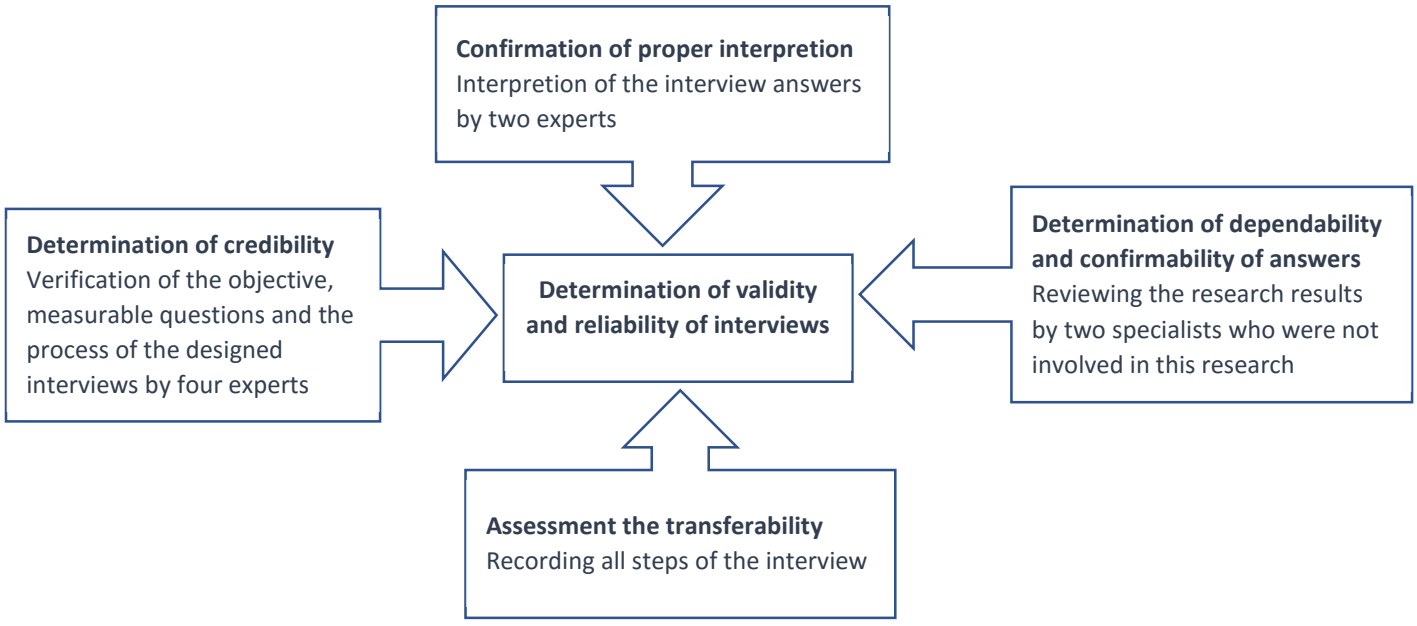


Figure 8. Determination of validity and reliability on interviews

3.8 Research steps

The order of current research steps which are explained in detail in the previous sections have been summarized in **Figure 9.**

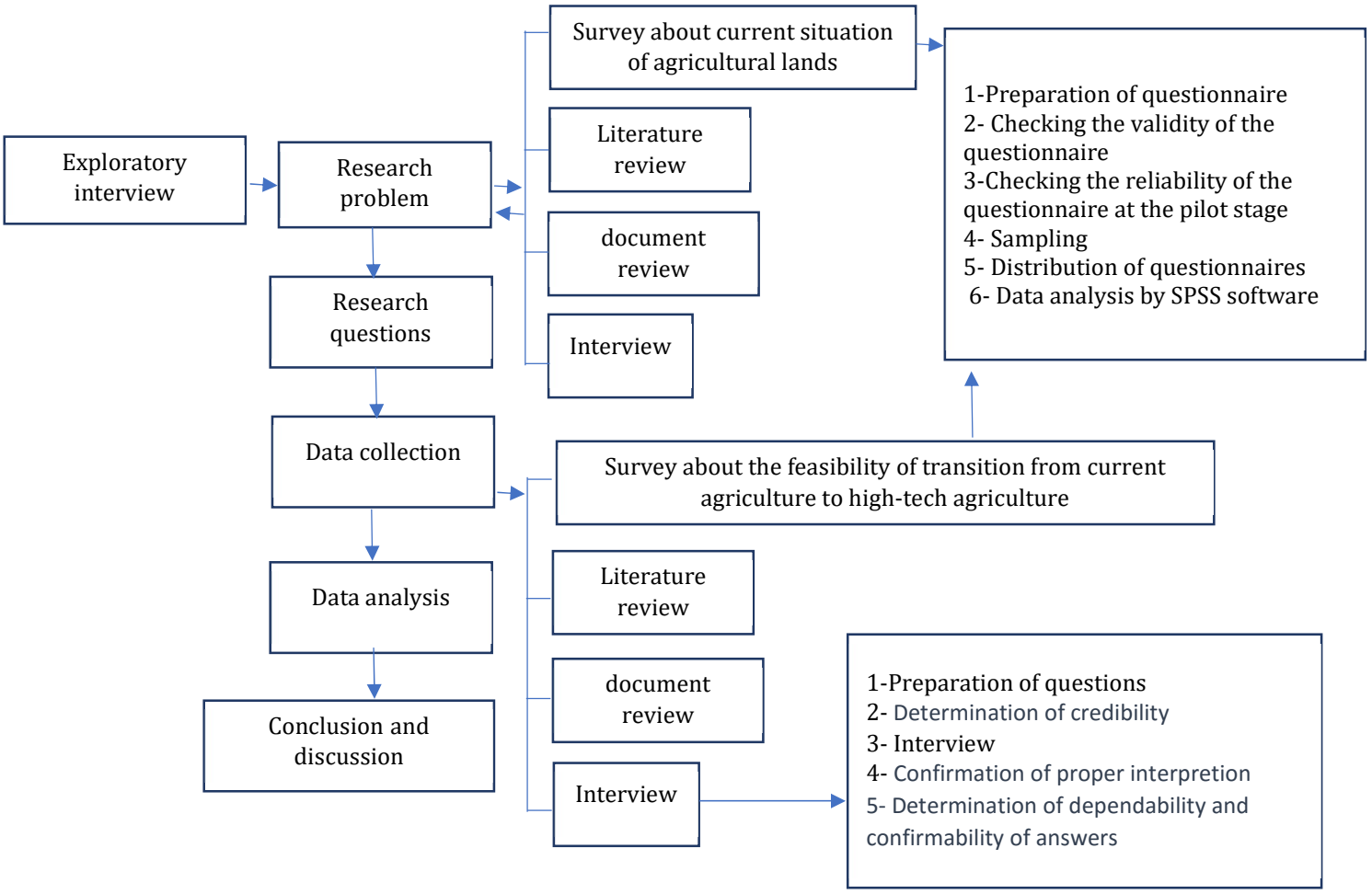
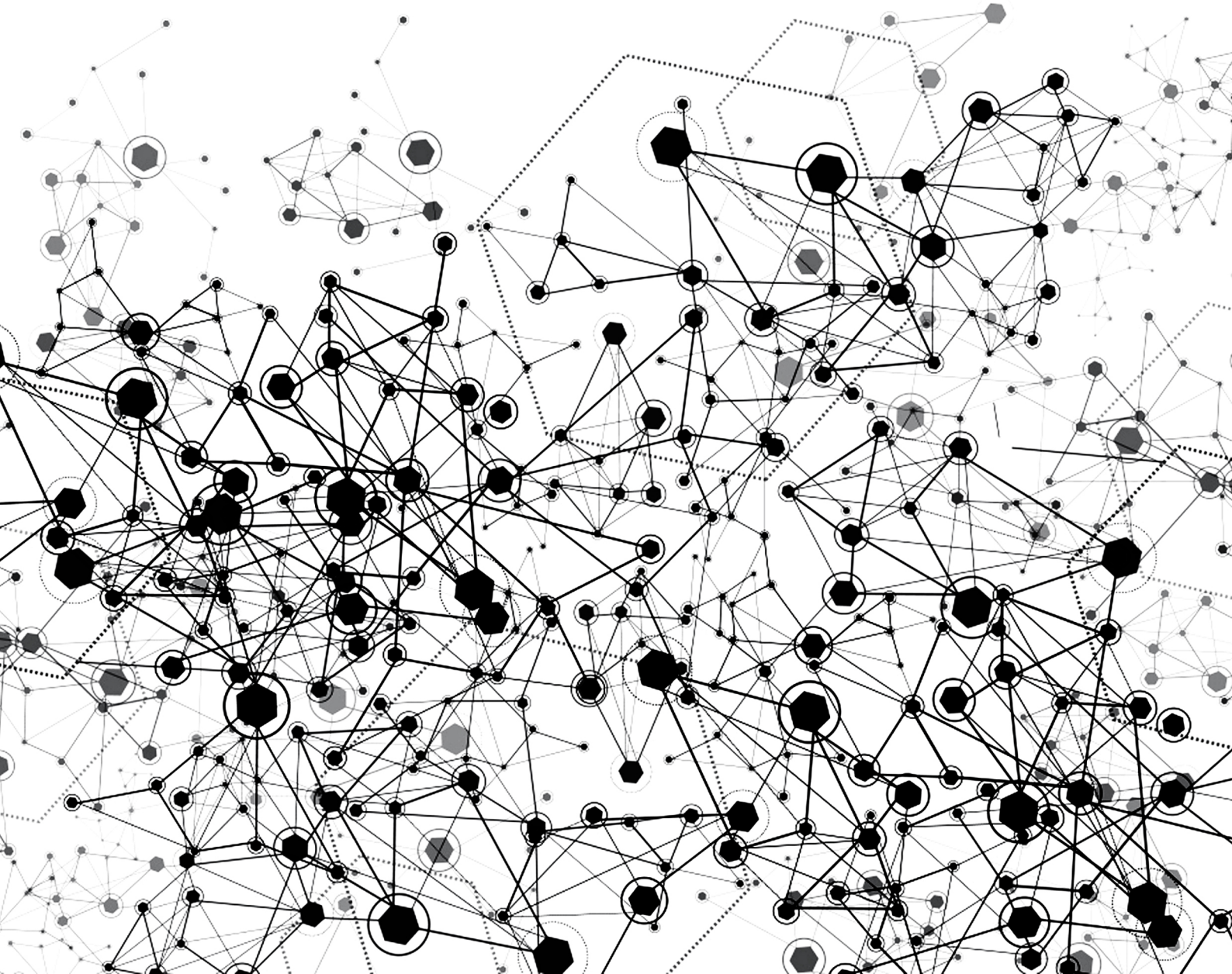


Figure 9. Research steps

Chapter 4

Case study of Rafsanjan



4.1 The County of Rafsanjan and its agricultural sector

After a short explanation about the geographical, social and economic aspects of the Rafsanjan County, this section presents a brief review of the history of the agricultural sector in the county.

4.1.1 Geographical aspects

The County of Rafsanjan, including 4 districts, 5 cities, 14 rural district and 1,019 villages, is located in the northwest of Kerman Province and south east of Iran (Figure 10) (Rahnama et al, 2016; Iranian Statistics Centre, 2017). The county is 12,421 square kilometres and is bordered by the City of Kerman to the east and the City of Yazd to the west. Mount Sarcheshmeh with highest peak of 3,000 meters, and Mount Davaran and Noogh with highest peak of ~2,745 meters are located in the southern and northern part of Rafsanjan, respectively (Abasnejad et al, 2011; Rahnama et al, 2016).

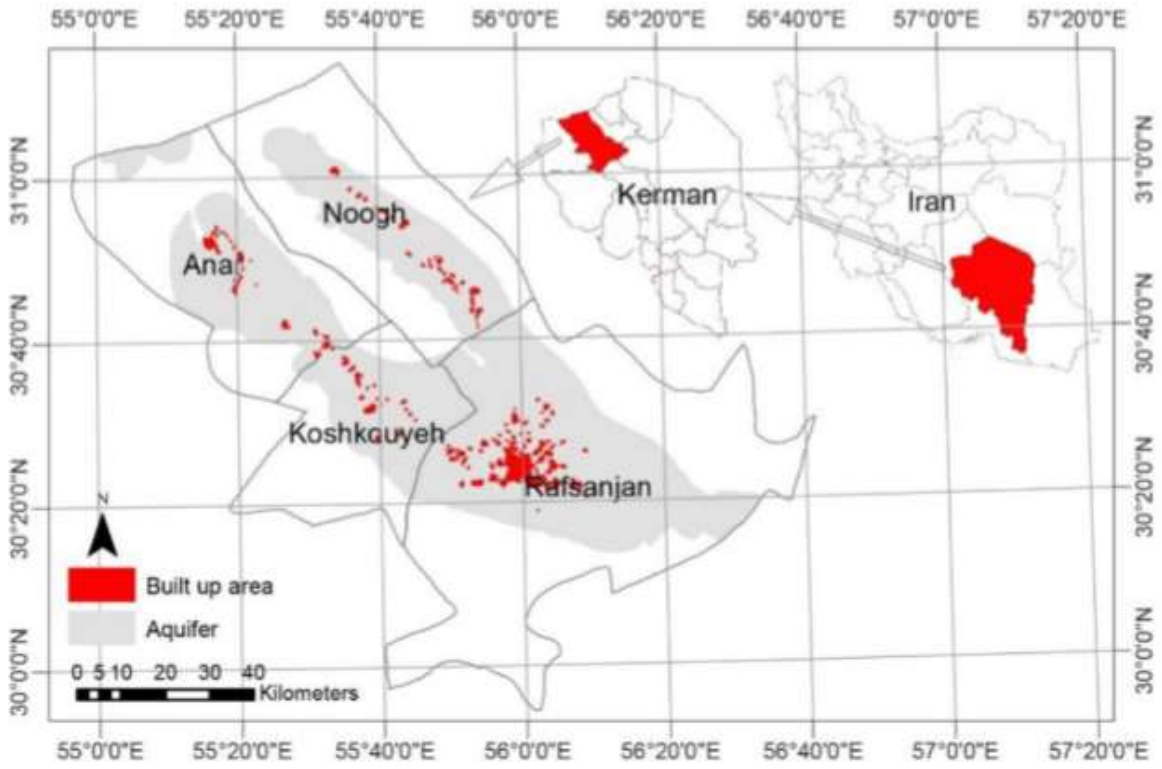


Figure 10. a) Geographical location of Kerman provinces in Iran map, b) Geographical location of Rafsanjan County in Kerman Province map and c) the map of Rafsanjan County

Geographically, Rafsanjan lies between longitude 54° 52′ to 56° 34′ E and latitude 29° 51 to 31° 31 ′ N. The city is located in a dry and semi-arid region that is 1,400 to 3,443 meters above sea level (Rahnama et al, 2016) (

).

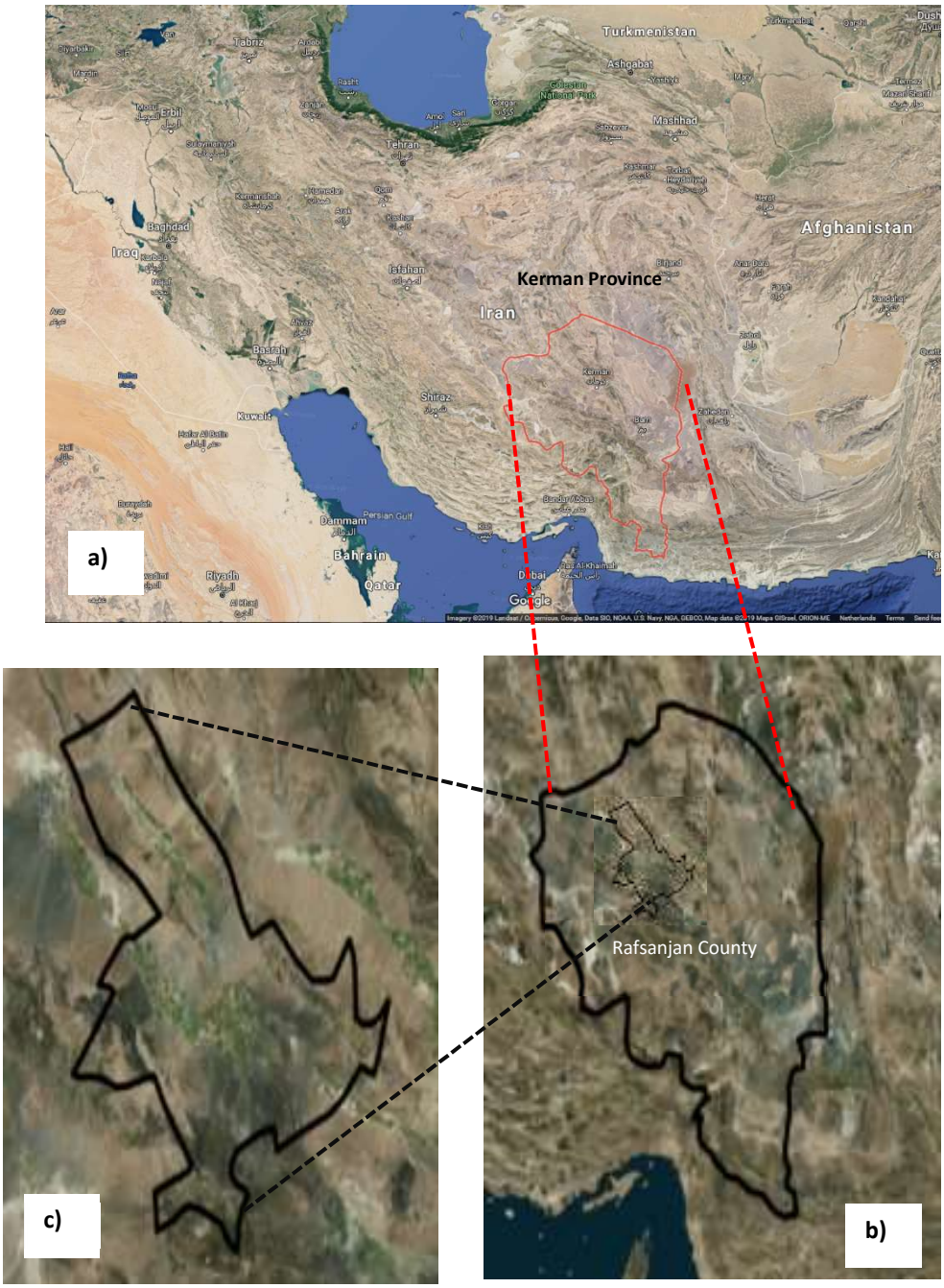


Figure 11. Location of Rafsanjan County in Kerman Province (Mehryar et al, 2016)

According to the watershed division, Rafsanjan is located in "Lut and Dar-e Anjir" secondary watershed areas (Figure 12) which are part of central Iranian plateau. The plateau area, which is ~5,0508 square kilometres, contains several mountain ranges (e.g. Alborz and Balochistan), rivers (e.g. Helmand and Halil) and plains (e.g. Kavir and Lut) (Iran Water Statistical Yearbook, 2014; Memariyan.K et al 2005).

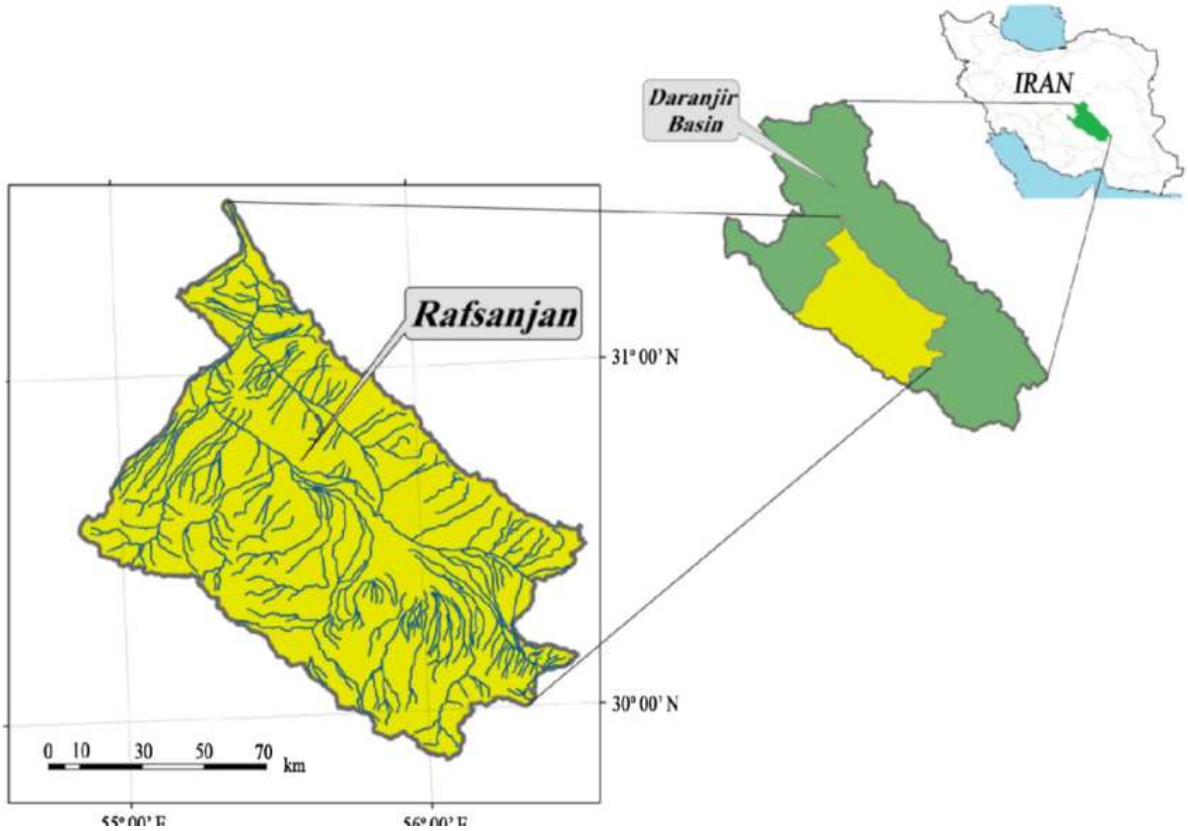


Figure 12. Location of Rafsanjan in watershed of "Lut and Dar-e Anjir" (Karamouz et al 2013)

4.1.2 Religion and population

The population of the County of Rafsanjan is 311,214, the majority of which like other Iranian people are Muslim. According to the Statistical Center of Iran, 183,263 and 127,222 people live in urban areas and villages, respectively, and 729 people do not have a permanent residence (Iranian Statistics Centre, 2017).

4.1.3 Economic situation of Rafsanjan

A well-known copper mine which is named "Sarcheshme" is located 50 km south of Rafsanjan, in the centre of Mount Zagros (Figure 13). This mine is one of the largest industrial complexes in the world and the largest copper producer in Iran which was discovered in 1928. According to available data and documents, the number of Rafsanjan's people working in private sectors (~35%) is more than other Iranian cities. Despite the existence of copper mines in Rafsanjan, agriculture is still the most important economic activity. Since the city has few industrial facilities (Rafsanjan Master Plan, Analysis and Inference from Surveys,2000), the majority of people is managing the agricultural business and industries or working in the areas of agricultural production, maintenance,

transportation, commercials or sales (Oraei et al., 2014; Arab et al., 2009). As a result, any factors which have a negative effect on the production of pistachio can change the economic situation of people and lead to social damage.

Figure 13. Sarcheshmeh copper mine in Rafsanjan

4.1.4 Rafsanjan pistachio: Production and exports

Pistachio is one of the most important exported products of Iran (**Error! Reference source not found.**). Despite being based on the global survey during the past years, Iran has been the biggest pistachio growers (Abdollahi et al. 2011; Iranian Statistics Centre, 2017). Since 2012, the United States has been ranked first in terms of annual production compared to Iran due to the fully scientific and mechanised pistachio production as opposed to semi-traditional production in most parts in Iran.

Other countries which are well-known as pistachio producer centres are Turkey, Syria, Greece and Italy (Abdollahi et al. 2011; Iranian Statistics Centre, 2017). The history of production and export of pistachio from 2002 to 2016 has been summarised in Table 2.

Figure 14. Pistachio farms in Rafsanjan (Alanandpan, 2010)

Rafsanjan, as the most important pistachio cultivation centre in Iran, has a share of 40% of the Iranian planted area. It produces 28% of Iran's pistachios and 17% of the world's pistachio. As a result, Rafsanjan has a significant effect on the global pistachio market (Abdollahi et al., 2011; Ebadzade et al, 2016) (Figure 15).

Table 2. History of production, consumption and export of Iranian pistachio from 2002 to 2016 (in 1000 tons)

Residual product	Total consumption	Exports	Internal consumption	Total available products	Production	Residues from the previous year	Year
3	167	118	40	170	153	17	2016
`17	197	139	32	214	210	4	2015
4	231	164	36	234	230	4	2014
4	182	126	24	186	170	16	2013

16	171	127	23	187	183	4	2012
4	182	126	24	168	160	8	2011
8	216	162	36	224	216	8	2010
8	180	130	30	188	184	4	2009
4	111	78	25	115	90	25	2008
25	252	207	35	277	267	10	2007
10	206	171	25	216	211	5	2006
5	186	160	20	191	176	15	2005
15	134	114	15	149	134	15	2004
15	193	161	25	208	173	35	2003
35	224	188	30	259	256	3	2002

Before the Islamic Revolution in Iran, the USA was the main customer of Iranian pistachios, importing approximately 42 percent of the product. In the past four decades, after cutting off diplomacy relationship with the USA, the most important destinations for Iranian pistachio were the United Arab Emirates, Japan, Italy and the United Kingdom. Although recently the East Asian countries of the former Soviet Union and China have also joined Iranian pistachio customers, European countries are still considered as the main pistachio customers of Iran. This is the reason why food safety roles and political relations formed by the European Union play an important role in the Iranian pistachio market (Abdollahi et al. 2011). On the other hand, after revolution in Iran, pressures from sanctions, tariffs, and restrictions created by European countries have caused serious problems for Iranian pistachio producers. Moreover, the nuclear agreement in 2015 led to the removal of some of sanctions and then exports of Iranian pistachio increased, but the abolition of the nuclear agreement from the US government and the return of sanctions created barriers to export this production.

Figure 15. Pistachio farm labourers in Rafsanjan (IEB, 2018)

4.1.5 History of agriculture in Rafsanjan

Although, there are many narratives about the emergence and history of Rafsanjan known as "Bahram Abad" in the past, it is not clear as to which of them is closer to reality. According to narratives and stories, the primary source of Bahram Abad refers to the government of Shapur Zolkataf (kings of Iran from 309 to 379 AD). However, Rafsanjan was considered as an important city because of its geographical situation. The city is located on an important road for merchants who wanted to trade between Kerman and Yazd cities.

In the late 16th and early 17th century, Rafsanjan was attacked twice first by the Afghans and then by Agha Mohammad Khan, King of Iran at the time, which resulted in destroying the roads and the city (Hemat, 2010). As a consequence, Rafsanjan did not have suitable economic and life conditions till the end of the 17th century when Fathali Shah attempted to re-build and develop the infrastructure of cities such as Rafsanjan. At that time, the majority of population of Rafsanjan lived in the villages. The most important source of rural income was agriculture products such as cereals, rubia and cotton.

During the 17th and 18th centuries, the Iranian society was divided into two main groups: landowners and farmers. In fact, farmers worked on other people's lands and instead of their work they received a small share of agricultural products to feed their families. Moreover, they usually had a very difficult life and did not have any additional products for exchanging (Interview No 35). While some parts of the agricultural crops were taken by the government as taxes and some other parts were stolen by robbers, landlords usually had extra products to exchange with equipment or other agricultural products. Therefore, to exchange the products and trade, several small centres were built in some

villages. Since most of the residents did not have enough products to sell due to bad economic situations, the trade centres developed too slowly (Interview No 7).

After the industrialisation of Europe, coincidently, by the development of the textile industry in the world, cotton became one of the most economic products. At that time, the USA was one of the biggest cotton producers and played an important role on the European markets. During the period between 1861 and 1865, cotton was not produced in the USA because of the American Civil War, which led to a dramatic increase in the prices of cotton worldwide. Rafsanjan was considered as one of the most important cotton producer centres in Kerman Province. After the economic situation was improved due to cotton trade, city centres were generated to exchange agricultural products of people who lived in the villages. As such, villages had an important role in developing the City of Rafsanjan as the markets for trading. Increasing the price of agricultural products, especially during the American Civil War made a major shift in the life style of Rafsanjan residents. Since then, a large city centre was formed to sell agricultural products and other equipment (Abtahi, 1999).

The urbanisation of the area led to residency of a lot of immigrants especially businessmen and sellers. During this period, businessmen in the absence of the necessary conditions for industrialisation, spent their collected capitals for buying lands. Although, successful businessmen turned into minor landowners, the social status of them was different from previous main landowners (Abtahi, 1999; Interview No 36).

4.1.5.1 Transformation of Rafsanjan and transition to pistachio production centre

Before 1891, the major agricultural products in Rafsanjan were cotton, cereals and Rubia while pistachio was rarely cultivated, and, for many years, farmers preferred to produce a variety of crops (Interview No 36). Rubia, which was an important crop in Rafsanhan, was used for dying. Since 1941, after the emergence of artificial colours, this product lost its importance (Interview No 35).

After the American Civil War and the re-entry of the United States into the European markets, Russia, which started to become industrialised after other European countries, became an important destination market for Iranian cotton instead of other European countries. Therefore, produced cotton of Rafsanjan was exported to Russia for several years. Due to the export of cotton as the most important exporting product as well as the urgent need of the government for foreign currency, cotton trade was nationalised in 1936. Due to cotton nationalisation, the economic condition of people of Rafsanjan improved. As such, in that period, a considerable number of people preferred to invest their collected capitals resulted from cotton production, for buying pistachio lands and producing pistachio.

According to the narrations, the pistachio production in Iran dates back several hundred years ago (~400) in one of the villages of Rafsanjan named "Taje Abad". Since 1891 when ~40,000 Ghasab (each Ghasab equals to 25 square meters) (100 hectares) of pistachio fields were cultivated, pistachios were among the notable products of Rafsanjan.

The relative increase in pistachio production resulted in the development of the agricultural science, the most important of which was the reduction of pistachio bearing

period fertility from 15 years to 8 years. In 1921, Rafsanjan pistachio, which until then had been exported mainly to India and Russia, became a market for the USA. According to the command of Kerman governor, "Amir Mofakhem Bakhtiari", in 1913, a wall was built around the City of Rafsanjan, some parts of which have still remained (Figure 16). This project gave credit to the city and made the business thrive in the city (Abtahi, 1999).

Figure 16. Historical remaining of Rafsanjan wall built in 1913 by command of Kerman governor (Rafsanjanir, 2018)

The oldest bank in Rafsanjan was Meli bank which was established in 1929. From 1931 onward, because of the increase in the price of pistachio as well as the problems that other agricultural products faced with, pistachio became even more important than before (Interview No 7). The increasing price of pistachio resulted in the development of Rafsanjan. From 1937 to 1938, Rafsanjan had good bazaars, merchants, telegraph houses, post offices, modern style schools and standard streets with intersections. A screenshot of the oldest square in Rafsanjan through the past 50 years is displayed in Figure 17. In 1945, after establishing the municipality, Rafsanjan became a city (Interview No 35).

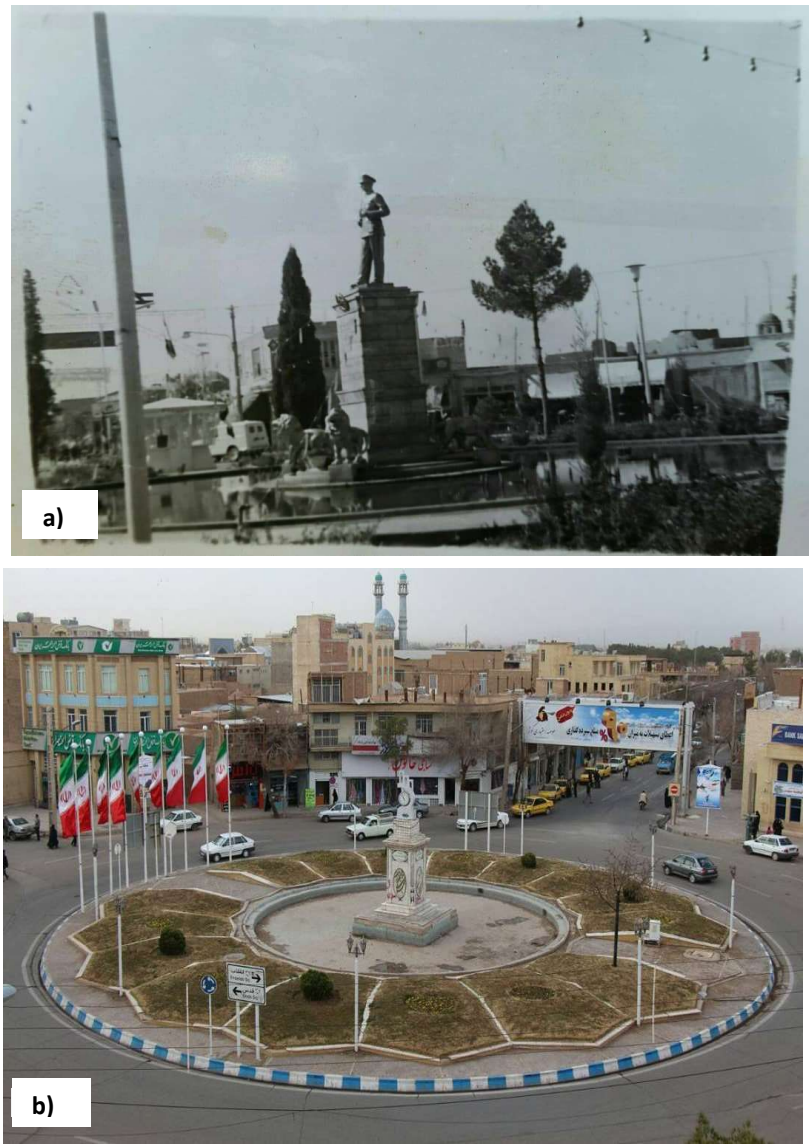


Figure 17. Square "Ibrahim", the oldest square in Rafsanjan, a) 50 years ago and b) current situation (Rafsanjan photo collection, 2016)

Since 1956, because of the increasing value of pistachio, governmental policies for dividing the lands based on a law named land reform which is explained later in this section and accessibility to adequate water by extracting the underground water using immobilisation instruments, pistachio was completely replaced with other agricultural products and, as a result, Rafsanjan was converted into a single-product agricultural region (Figure 18)(Abtahi, 1999).

Thus, increasing the cultivation of pistachio and development of agricultural activities created new job opportunities for people. After the emergence of motor pumps for extracting underground water, a considerable number of people was employed for the irrigation of the pistachio fields using these new systems. Furthermore, along with the growth of cities, a portion of the population was employed by the government and this number was regularly added for several years (Abtahi, 1999; Interview No 36).

Figure 18. Map of Rafsanjan in 50s (Rafsanjan photo collection, 2016)

Since 1961, the banks have been actively involved in the development of pistachio by providing various types of loans which had an important effect on the local economy. In many cases, farmers managed to provide water engines for pistachio cultivation using these types of loans (Abtahi, 1999).

In Iran, before 1961, farmers and workers who did not have good economic conditions, worked on the land of landowners. In 1962, the "land reform law" was implemented by the last king of Iran, "Mohammad Reza Pahlavi", to allocate the lands among people (Eslahi et al. 2003). It is believed that this idea was not just the king's idea or even his desire, but due to global changes and attempts of some politicians and generally internal pressure, the reform of the lands occurred (Lansaizadeh, 1991). Additionally, the economic, political, natural and social factors such as drought and water scarcity in agro-industrial units, rapid population growth in the 1951 and rising unemployment among people had an undeniable influence on the implementation of land reform (Amid, 2003).

However, the land reform in Iran was carried out in three stages:

The first stage of the Land Reform Law goes back to 1962. In this phase, owners of the property were obliged to choose one unit of their possessions in the country (one unit for every member of family of owner), and the rest of the properties should be given to the government for sale. Before the legal announcement of the Ministry of Agriculture, some owners attempted to sell their properties and gave them to their workers. Mechanised lands, fields and landmarks were not excluded of this law (Rezaei et al. 2003).

The second stage dates back to 1963 and was applied for remaining properties of landowners which were not divided in Phase I. According to the law, the landowners could sell their properties to the farmers or rent them for 30 years. Also, they could divide part of their land and water among farmers (Asadollahi, 2006; Amid, 2003).

The third stage was approved in 1968 (Asadlahi, 2006). This stage was implemented to remove the first two-stage defects. To this aim, the lands had to be shared between landowners and the farmers or the land had to be sold to the farmers with a reasonable price which was determined by the government. Furthermore, at this step to develop the production, several organisations such as rural co-operatives, agro-industry units, agricultural corporations and agricultural cooperative banks were established. Based on the law, farmers had to join in these cooperatives, and use the benefit of the facilities and their services (Azghandi, 2006; Asadollahi, 2006).

However, the land reform law was not fully completed in Rafsanjan like other cities of Iran due to several problems such as lack of cooperation among owners and farmers (Rezaei et al., 2003; Eslahi et al., 2003; Asadolahi, 2006). Despite being based on the law of land reform, landowners had to divide their agricultural lands among farmers; owners who had gardens instead of farms could ignore the land reform law. Based on the literature and documents, practically in Rafsanjan just one landowner divided their land based on the land reform law and others attempted to convert their farms to pistachio gardens to escape the law. As such, this law led to the conversion of most of the agricultural lands into pistachio fields and then pistachio cultivation development (Abtahi, 1999; Abtahi and Feyzi, 2012).

However, after the land reform law, the relation between landlords and farmers changed, so the landlords gave farmers a small amount of water and land (100 or 200 or 50 square). Since then, numerous small fields have been built in the countryside; so water and land in Rafsanjan were distributed among farmers which later played a significant role in the development of pistachio production (Interview No 7). The cultivation of trees and appearance of the fields have changed after dividing the field among farmers. While the trees in the fields of landlords had regular intervals, the farmers was merely trying to cultivate the tree in their small fields as much as possible (Abtahi and Feyzi, 2012; Interview No 7).

After the Islamic Revolution of Iran in 1979, the process of land reform underwent a general change. On 12th of July 1984, the Guardian of IRI Council ("Shoraye Negahban") disagreed with the land reform law and believed that the law was against Islamic religion. According to Islamic law, no authority has the right to transfer a property to others without the satisfaction of the owner. Therefore, the process of land reform was stopped which caused a considerable number of problems. Hence, eventually, the government accepted the legalisation of the land reform process in 1991 and then on 23rd January 2003, the process of determining the remaining issues of land reform was resumed (Rezaei et al, 2003).

The Ministry of Agriculture was obliged to identify the lands which were divided according to the land reform law and did not have any official documents. These lands had to be issued and legalised based on the law. Furthermore, in this case, the Ministry of Agriculture had to assign the applicant's owners to the nearest available land for agriculture. Currently, the "Land Affairs Organisation" is the sole authority responsible for determining the residual issue of land reform in Iran. The Land Affairs Organisation is part of the Ministry of Agriculture of the Islamic Republic of Iran. It deals with the

granting of land for agricultural and non-agricultural production schemes, such as agricultural and horticultural industries and protection (Rezaei et al, 2003; Amid, 2003; Azghandi, 2006).

As a result, performing the land reform law before and after the Islamic Revolution led to a dramatic expansion of the pistachio cultivation area from 1986 to 2014. The increasing pattern of pistachio cultivation area has been illustrated by Meryar et al. (2016) using data collected by Land satellite images (Figure 19). The results revealed that the most expansion of pistachio cultivation happened from 1998 to 2009.

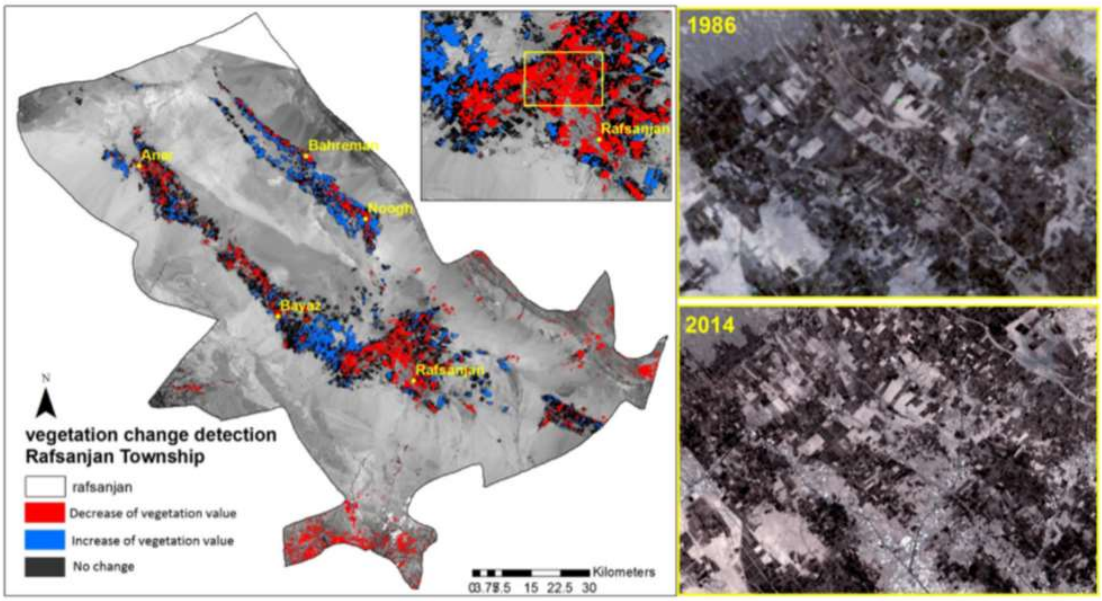


Figure 19. Planting area in Rafsanjan County from 1986 to 2014 (Mehryar et al, 2016)

4.1.6 Infrastructure

4.1.7 Infrastructure

Harvesting of pistachio in Rafsanjan, which is done by hand, is carried out in several stages including peeling, washing, separating, drying and grading of the product. Figure 21 shows the typical appearance of a pistachio field in Rafsanjan while Figure 22 shows the harvesting process in Rafsanjan.

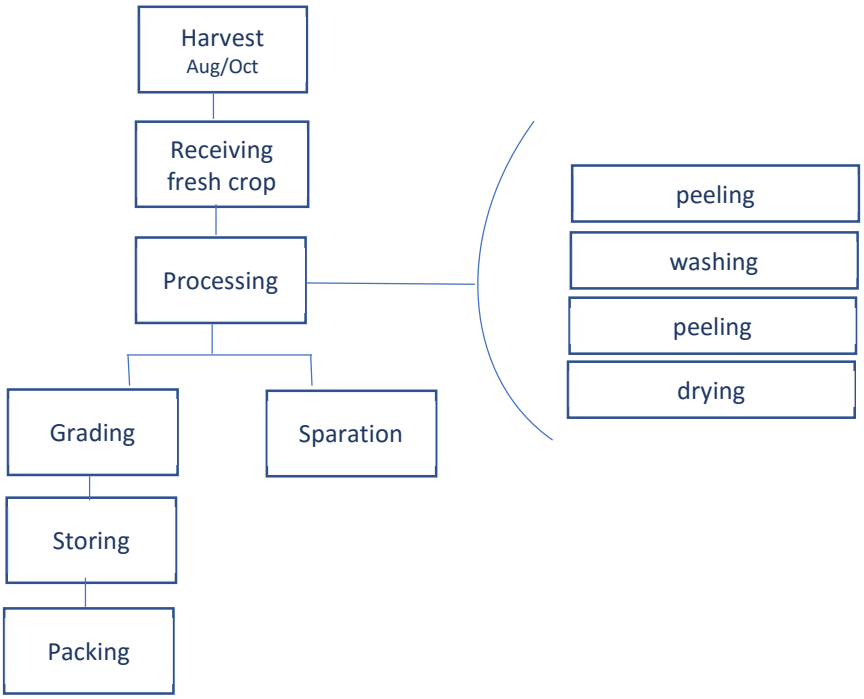


Figure 20. The steps of harvesting step of pistachio in Rafsanjan

Figure 21. A view of a typical pistachio field in Rafsanjan

Figure 22. Harvesting of pistachio in Rafsanjan which is done by hand

The post-harvesting process steps to prepare the product for marketing have been usually performed in big places which are known as pistachio houses. Nowadays, the post-harvesting perform using completely mechanised or with semi-mechanised systems (Figure 23). According to the director of agriculture in Rafsanjan, during harvest season, 6,000 pistachio houses are active, of which merely 140 ones are equipped with fully mechanised systems for the harvesting process. The first fully mechanised house was established in Rafsanjan in 1995 by one of the major pistachio landowners (Interview No 36).

Although the pistachio institute of Rafsanjan have projects to produce some industrial products using raw pistachio such as pistachio butter, Halva, charcoal, chocolate, pistachio milk the pistachio products mostly, export as raw pistachio because of lack of upgrading the conversion industries in Iran due to international sanctions to import new technologies from other countries.

Figure 23. Mechanized (down) and semi mechanised (up) pistachio process

The transferring of pistachio products from fields to villages or cities occurs through the roads which are covered by “Asphalt concrete”. Almost all pistachio fields in the County of Rafsanjan have a car way towards main roads (Figure 24).

Figure 24. Roads in Rafsanjan

4.2 Challenges of agricultural sector in Rafsanjan

The main challenges of the agricultural sector in Rafsanjan are the extreme drought in the region that is facing the farmers with lack of water for irrigation, declining quality of arable lands and increase salinity of soil and climate change. These three factors are explained in the following sections.

4.2.1 Water scarcity

In the most pistachio fields of Iran, the main source of irrigation is deep well pumps and in some rare cases "Qanat" which is explained later. The depth of first wells was around 15-20m which is increased gradually and now the depth of current wells in some area are around 400 m. In almost all Iranian pistachio fields, irrigation is carried out in a traditional hurricane or stack manner (Mohammadi and Sedaghaty, 2011).

Agriculture in the semi-arid parts of Iran was based on the exploitation of groundwater by the "Qanat" till the end of the 16th century (Agah, 2007). The Qanat consists of several wells and an underground tunnel connecting these wells together. It has sloped surfaces that guide water in the underground layers to the surface of earth. The flow of water, without the use of any type of energy, is naturally directed out of the underground. In other words, the Qanat is an underground channel that directs water from the underground to the surface (Figure 25) (Fedakar, 2009; Semsar and Sohrabi, 2004). According to Goblot (1979), Qanats originated in the northwest of present Iran, dating back to 600–800 B.C. and then (525 BC) was introduced to the southern coast of the Persian Gulf, Egypt (500 BC), Spain (750 AD), Southern Algeria (850 AD), Mexico and Los Angeles (1520 AD), Chile (1540 AD) and Turfan (1780 AD) (Semsar an Labbaf, 2017).

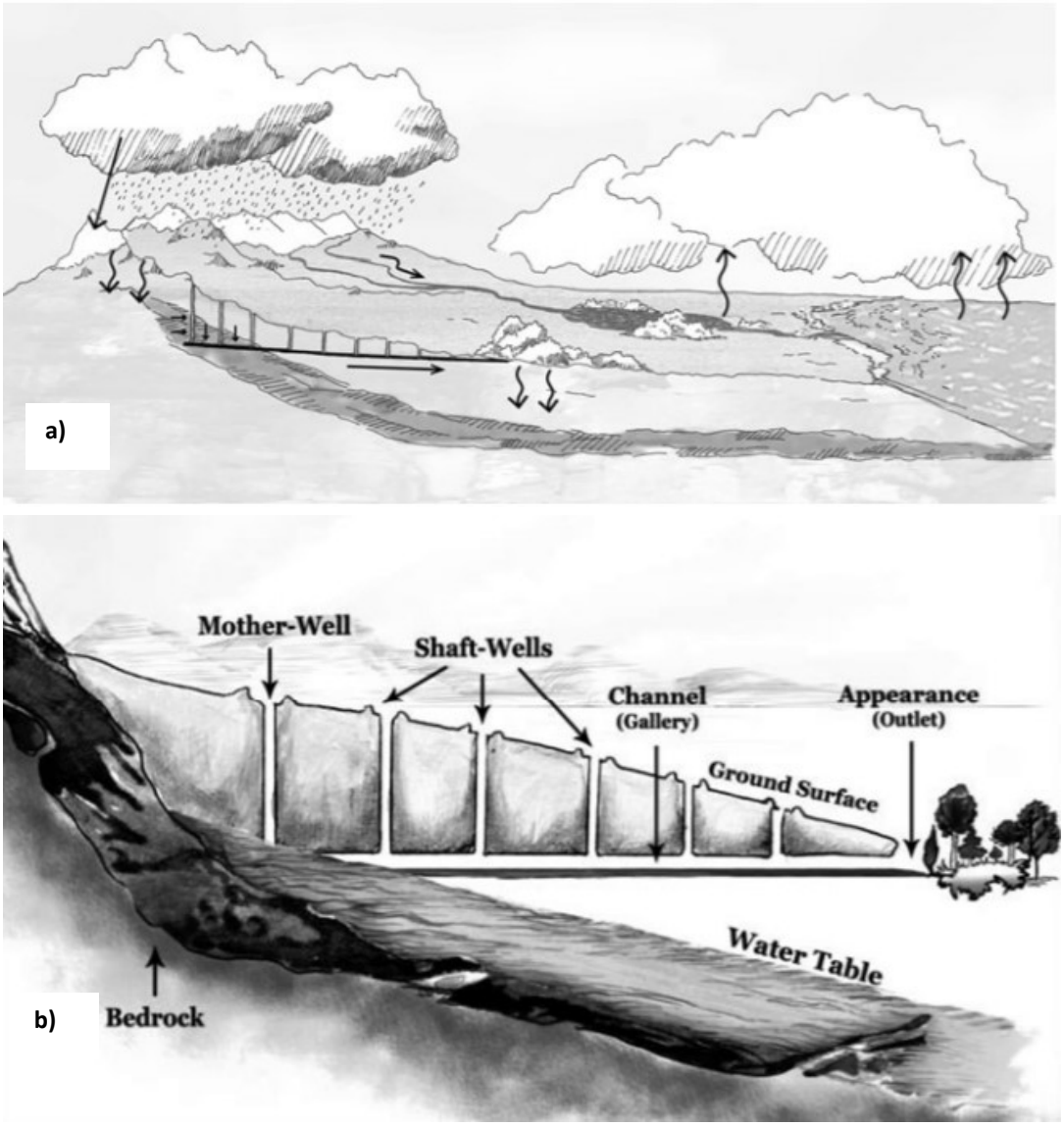


Figure 25. a) Position of Qanat in water cycle and b) Profile of typical Qanat (Semsar and Labbaf, 2017)

In the 16th century, Rafsanjan's agriculture relied on the exploitation of about 300 Qanats. In that time, people also extracted water for human and animal use by drilling handy wells. Withdrawal water from these traditional wells was not possible to reach even a few percent of the extraction of water by the Qanat. Hence, this type of well could not have an effect on the rate of water of Qanat. In the early of 20th century, new rules related to water management named nationalisation of water (see 5.2.2) have been implemented by the king of Iran, "Reza Pahlavi". Since then new technologies such as drilling machines and watering pumps have been used for extracting large amounta of water, so anyone even with low capital would have been able to dig and exploit the wells in a few days (Agah, 2007). Figure 26 shows the number of wells and Qanats from 1951 to 2015. As illustrated, the number of wells has been increased significantly after 1974 but the number of Qanats reduced after 1982.

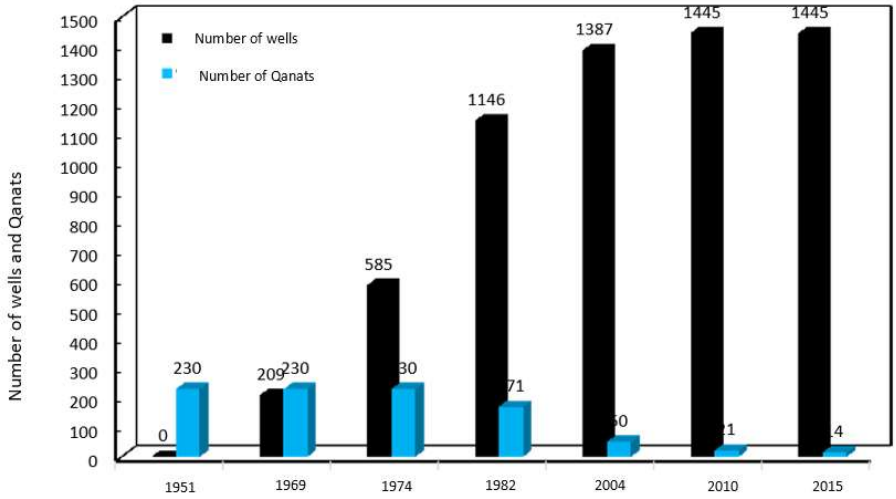


Figure 26. Number of wells and Qanat created in agricultural lands of Rafsanjan during

According to available data, Mahryar et al. (2015) constructed two maps showing the current status of well discharge rate and well depth in Rafsanjan County which are illustrated in the

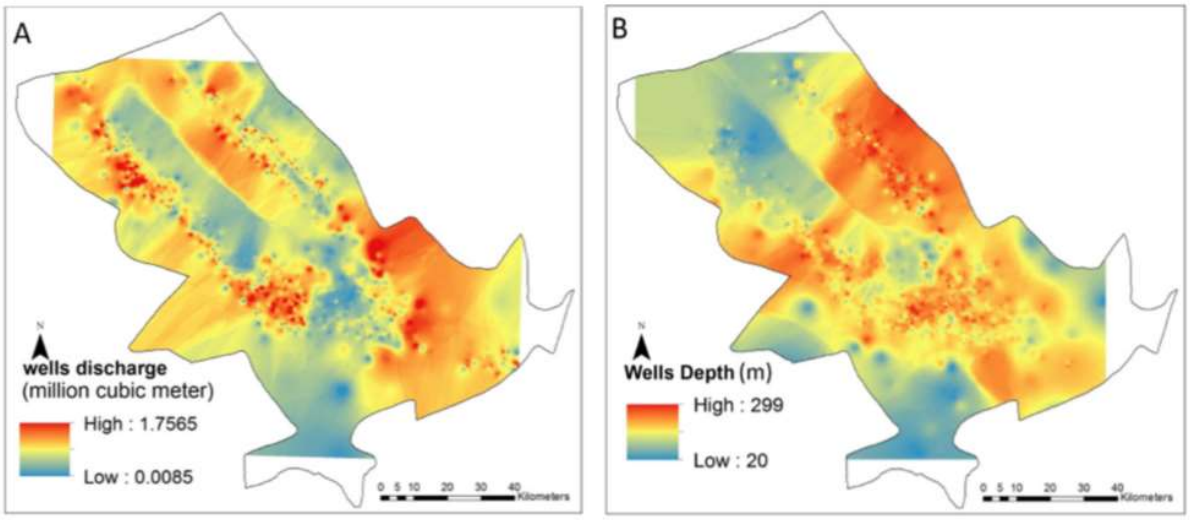


Figure 27.

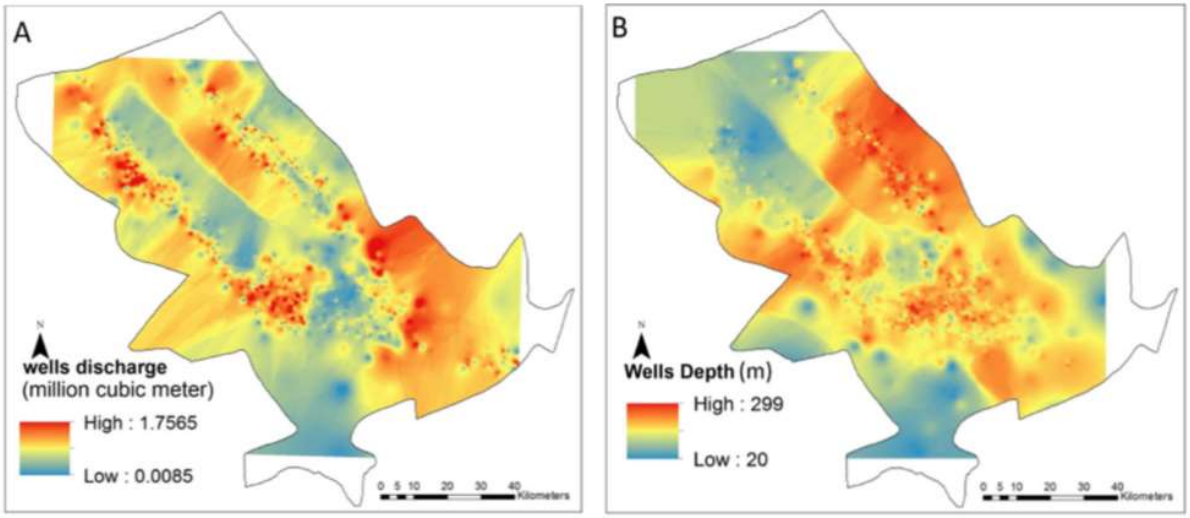


Figure 27. A) Well discharge rate, B) Well depth in Rafsanjan county (Mehryar et al. 2015)

The first deep well of Rafsanjan was built using engines in 1946 in a rural area called "Heydarabad" whose only Qanat was dried several years ago (Abtahi and Feyzi, 2012). After the emergence of the first deep well, people who had permission for drilling handy well attempted to drill deep wells in their lands which resulted in the decrease of the total volume of the underground water. To solve this problem, government nationalised water sources to manage water properly (see 5.2.2) (Agah, 2007). Despite setting new rules, since 1962, the extraction of water by pumping engines has expanded rapidly. Since it was possible to use the extracted water by only one pumping engine for several lands, the participant investment was rapidly accepted, and several individuals and farmers collaboratively, established engines (Abtahi, 1999). Then the government was forced to forbid operating any deep well in 1974 to manage water resources (Agah, 2007; Mortrzevi et al., 2010).

From the begging of the Islamic Revolution (1978), there was not enough control on the agricultural process, the number of pumping engines increased even more than before. After the Islamic Revolution, a large number of exploitation licenses was issued under the name of a "committee". The committee issued water licences without any limitation and regardless of any criteria for underground water abstraction and considering the water scarcity situation per each area.

As a result, the number of water extraction units which were limited to about 160 “Qanats” before the propagation of engines, are nowadays more than 1500 units of engines (Abtahi, 1999). According to a survey conducted by Motagh et al. (2017), the number of water table wells has been increased dramatically during the past 50 years. As indicated in Figure 28, of more than 1300 wells in 2000s the depth of more than 600 water tables wells are 160-350 m.

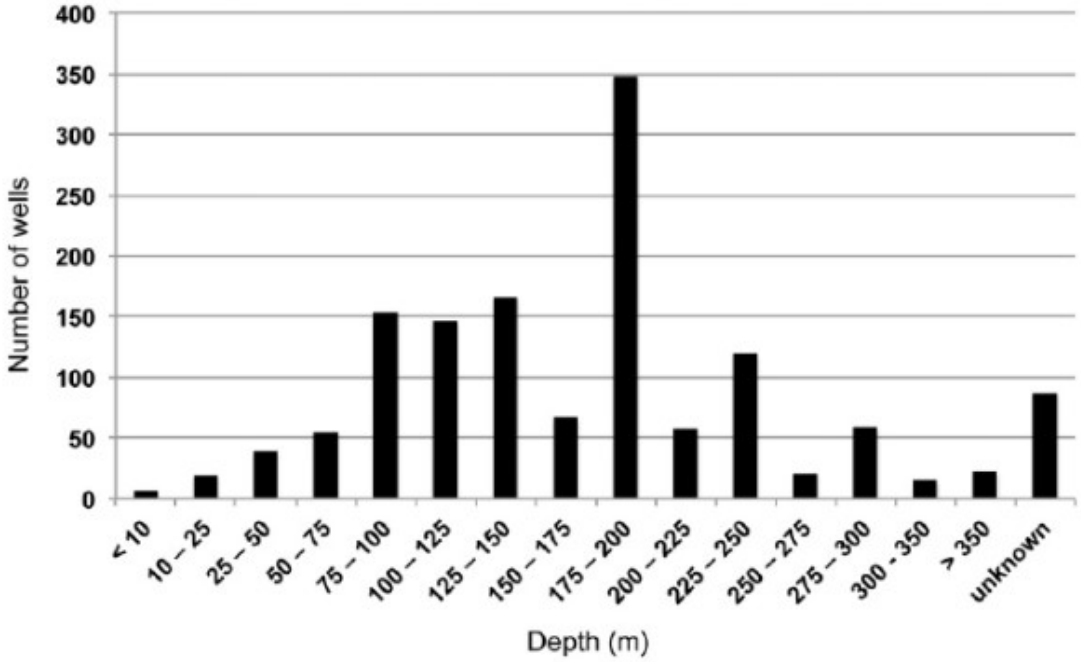


Figure 28. The number of ground water wells and depth distribution in Rafsanjan (Motagh et al. 2017)

Based on the Department of Energy, there are 1,303 active deep and semi-deep water wells (1241 deep wells and 62 semi deep wells) and also 112 Qanats with a total drainage of about 737 million cubic metres of water in the region. Because of water extraction, more than 154 million cubic metres and decreasing the average annual of groundwater level to 0.75 metres, establishing the wells and Qanat in Rafsanjan County is forbidden (Mirzai and Chizari, 2004). Figure 29 indicates the level of underground water changes in Rafsanjan and Figure 30 shows the distribution of wells in the area which are prepared by Ebrahimi (2009) and Rahnama et al. (2016), respectively.

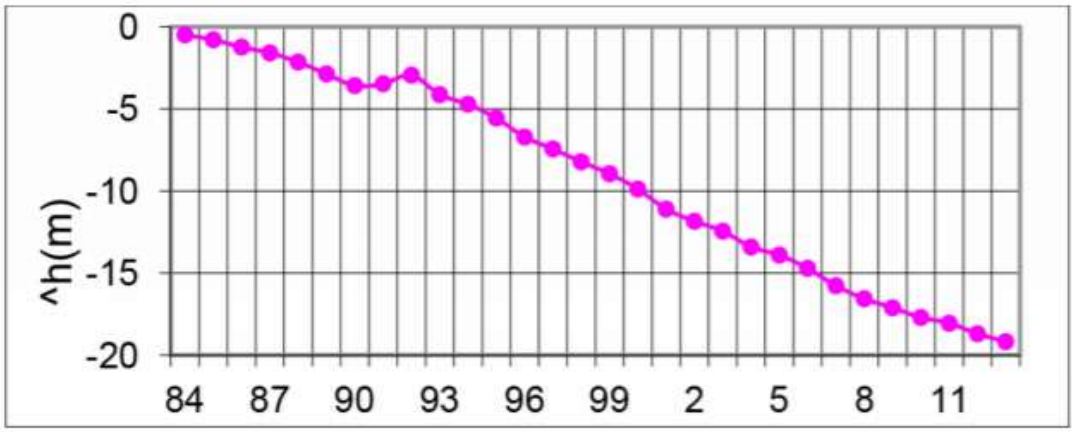


Figure 29. Ground water hydrograph of Rafsanjan plain from 1983 to 2013 (Mehryar et al, 2016)

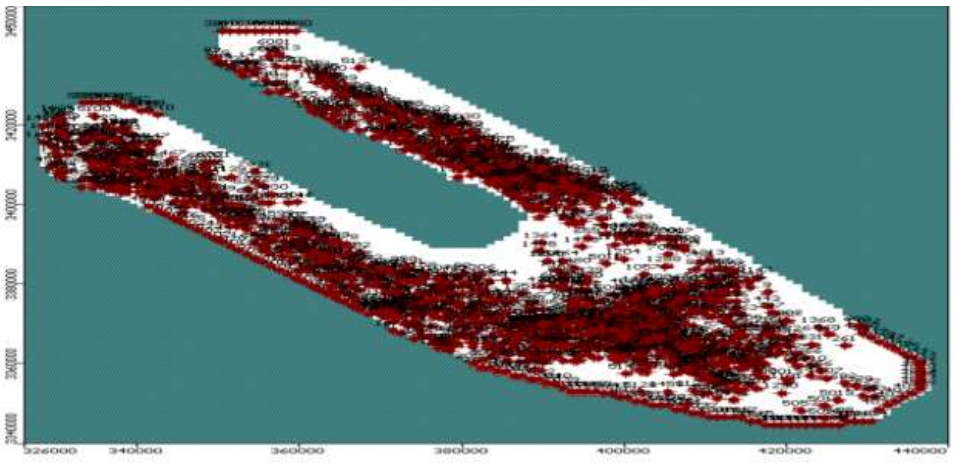


Figure 30. Distribution of wells in the area (Rahnama et al, 2016)

Although pistachio has been considered as a resistant plant against drought shocks, the studies show that increasing the irrigation period and decreasing the consumed water led to multiple stresses and sometimes caused serious damage to the plants which depended on condition and plant variety (Moazenpour, 1994; Shariati, 1996; Mohammadi and Sedaghaty, 2011). The high economic value of water and the lack of an appropriate plan for protecting groundwater resources have intensified the extracting of groundwater aquifers (Javanshah et al. 2005). Uncontrolled extraction of underground water in Rafsanjan has reduced the quantity of these resources. According to the latest report (Javanshah et al. 2005), the annual rate of water loss in this city is 0.75 m^2 and the negative balance sheet is 249 million cubic metres per year (Javanshah et al. 2005).

4.2.2 Salinity of water and soil

The problem of soil salinity in agricultural land of arid and semi-arid regions, such as Rafsanjan where evaporation exceed the amount of rainfall, has significantly reduced the crop production (Brady & Weil, 1996; Abrol et al, 1988; De Paz et al., 2011). According to the surveys, climate and geopolitical conditions are considered as the main causes of the salinity development in arid and semi-arid areas (Momeny, 2007; Owji & kamali, 2013).

Due to the high rate of evaporation and appearance of deep salts to the surface of the soil and low amount of precipitation which is not enough to wash the salt in the soil and remove it from the roots, the salinity of the soil layer in this area is constantly increasing. While studies have indicated that pistachio is a salt-tolerant plant, its yield is strongly influenced by high salinity (Abtahi and Karimian, 1995). A greenhouse study which is performed by Abtahi and Karimian (1995) shows that high salinity level of the soil decreases the growth of pistachio plant, stems and leaves.

Moreover, the gradual quality of groundwater is also falling due to the influx of saline fronts. Maximum salinity in some cases is reported up to 20,000 micro MOs per cm and water EC is more than 20 dS which led to a reduction in the pistachio yields. Therefore, due to the limited availability of suitable agricultural water resources in the region and the increasing number of pistachio fields as well as high water prices in Rafsanjan, the imbalance between supply and demand for water is greatly increasing (Abdollahi and Javanshah, 2006; Sedaghati and Mohammadi, 2009; Abdolahi, 2007).

Based on annual reports of Uban, water and soil analysis laboratory and research conducted by Pourmohammadali et al. (2019), only some parts of Rafsanjan have fertilised soil and sufficient water with high quality and thus are suitable for pistachio cultivation. Hence, according to the result of the soil and water analysis performed by Uban laboratory, Ferdos and Noogh (located in the north of Rafsanjan) and Kabootarkhan (located in around the western-south of Rafsanjan) have the highest production compared to other regions. Thus, the pistachio fields which are located in other areas, particularly those inside the city, do not have an appropriate condition for pistachio cultivation.

4.2.3 Climate change and decline in productivity

As mentioned earlier, Rafsanjan is located in a dry and semi-arid region. The average annual temperature in Rafsanjan is about 17.6 ° C. (Table 4.2, Figure 31), the average annual precipitation is 126 mm and the average annual evaporation is ~3,436 mm. Most precipitation falls have been recorded in January, with an average of 29 mm. The difference between precipitation in the driest and wettest months is ~29 mm over a year (Abasnejad et al, 2011; Mehryar et al, 2016).

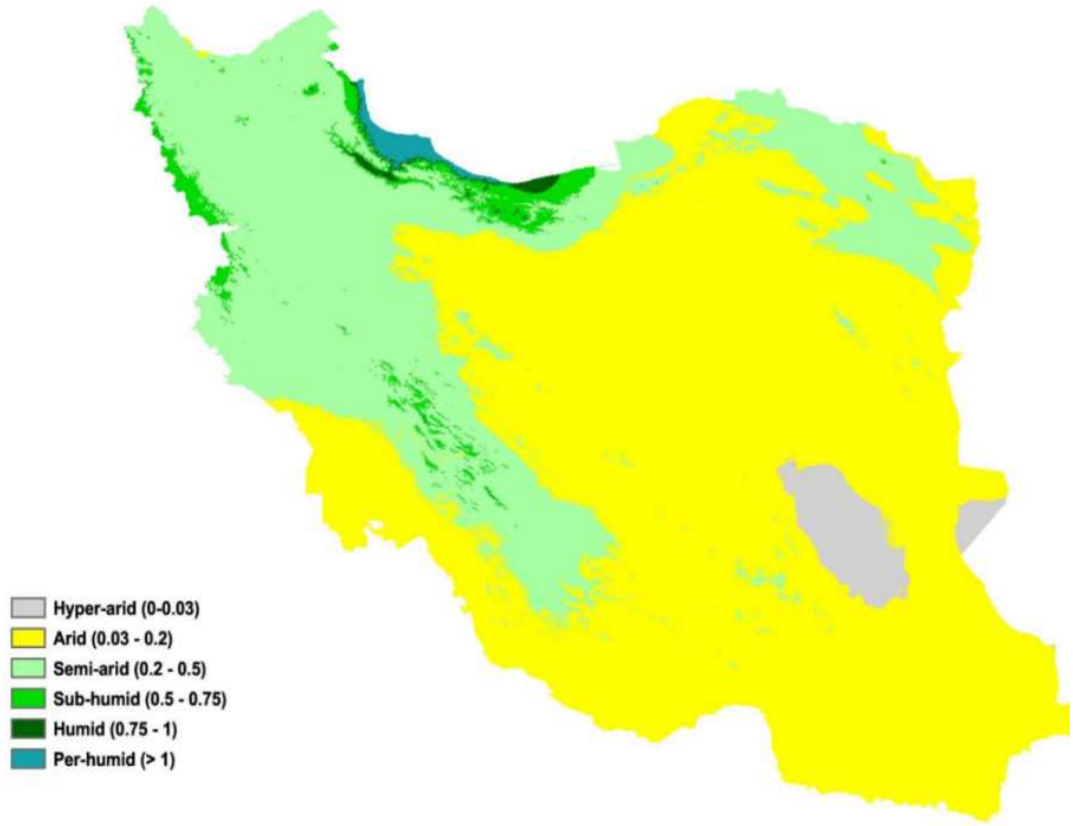


Figure 31. Aridity index of Iran (De Pauw et al, 2004)

Table 3. Average monthly temperature Rafsanjan (irimo.ir, 2018)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
2011	-	-	-	-	-	-	-	-	-	-	14	6.6
2012	7.8	7.9	13.7	19.1	25.8	28.1	30.7	27.7	25.2	18.8	13.1	8.3
2013	8.8	11.1	16.1	18.6	24.3	30.9	32.1	29.1	26.7	20.4	13.1	7.9
2014	6	5.5	13.9	20.9	24.4	29.9	31.1	28.9	27.1	20	11.3	8.2
2015	9.6	11.1	13	22	25.7	30.5	29.4	28.2	23.4	21.6	12.1	7.5
2016	9.5	11.1	15.8	18.9	26.5	28.9	32.3	26.7	27.8	20.1	11.9	13.4
2017	9.1	9	14.4	21.8	25.7	31.1	29.6	27.3	23.6	20.6	13.3	8.6

In order to have optimal pistachio products, pistachio trees need warm-dry summers and mild cold winters. Moreover, pistachio trees are sensitive to either high temperature or the temperature below zero at the beginning of spring. Stormy and dusty environment has a very negative effect on the quality and quantity of pistachio as well (Hokmabadi, 2011).

During the past years, several serious damages caused by climate change have been recorded in the County of Rafsanjan. The cold weather in the spring of 2014 has destroyed several farms and had significantly reduced their productivity. The high temperature in 2014 and 2018 reduced more than 70% and 85% of the products, respectively (Jamalizade, 2014). Figure 32 and Figure 33 are related to two different pistachio fields which were destroyed due to storm and drought climate, respectively.

Figure 32. The loss of 100% of pistachio products in 2004 in some areas of Rafsanjan due to the storm (Hokmabadi, 2011)

Figure 33. The effect of drought and climate changes on a pistachio field

4.3 The agriculture-related issues in Rafsanjan

The agricultural sector affects the City of Rafsanjan in different ways. The expansion of the city, traditions, the local cuisines and the source of incomes of majority of citizens are dependent or affected by the agricultural sector (pistachio farms and processes). But the agricultural sector is also having several negative impacts on the city. The agricultural-related issues in the City of Rafsanjan are explained in the next sections.

4.3.1 The presence of Arsenic in drinking water

Studies show that the amount of heavy metals such as arsenic, lead and cadmium in the sources of drinking water in Rafsanjan and some villages exceeds the standard rate (Malakutiyan and Khashi, 2014). Heavy metal in drinking water in high doses cause various diseases such as cancer and heart diseases. The origin of heavy metal in the water resources of Rafsanjan might be related to high percentage of sulphide in the soil of the county. High concentration of Sulphide can result in heavy traffic in the Kerman-Yazd main road or widely used pesticides included of Arsenic which are used to control the insects to increase the productivity of pistachio (Abasnejad and Khajepur, 2008; Malakutiyan and Khashi, 2014).

Creation of cracks in buildings due to the land's subsidence in Rafsanjan

Land's subsidence occurs due to depletion of the underground water due to deformation and displacement in the underlying layers of the soil. In 80% of the cases, the main cause of the subsidence is the excessive extraction of water from groundwater aquifers (Galloway et al, 1999).

Subsidence and cracks of the lands which slowly and gradually develop are irreversible, costly, destructive and cause serious problems such as the destruction of irrigation systems, agricultural soils, buildings and supply lines (e.g. gas and sewage) (Ruzban et al, 2016). The shape of cracks from groundwater extraction is usually similar to natural faults formed by groundwater fluctuations (Tabatabai and Mohseninesab, 2015).

Rafsanjan, more than any other agricultural region in the country, has possibly been adversely affected by land subsidence due to the destruction of underground water resource (Motagh et al, 2017; Rahnama et al, 2016). Although in Rafsanjan the rate of land's subsidence is between 0-4 mm per 7 months. According to the previous surveys, the highest amount of land's subsidence occurs in the areas where water extraction wells are located (Mortazavi et al., 2011). The reducing of water underground extraction is considered as the best way to prevent the land's subsidence (Tabatabai and Mohseninesab, 2015). Figure 34 shows the land's subsidence occurred in a pistachio field.

Figure 34. Subsidence phenomenon in a pistachio field (Ebrahimi, 2009)

4.3.2 Social problems caused by abandoned pistachio lands

4.3.2.1 Insecurity

One of the social problems in Rafsanjan, especially during the harvest season, is the arrival of domestic and foreign workers (sometimes without residence permit) which causes insecurity in the city (Jauhiainen and Eyvazlu, 2018). Furthermore, the fields and their guard room, especially in residential areas, are suitable places for the accumulation of drug addicts which causes insecurity for residence as well.

4.3.2.2 Stray dogs

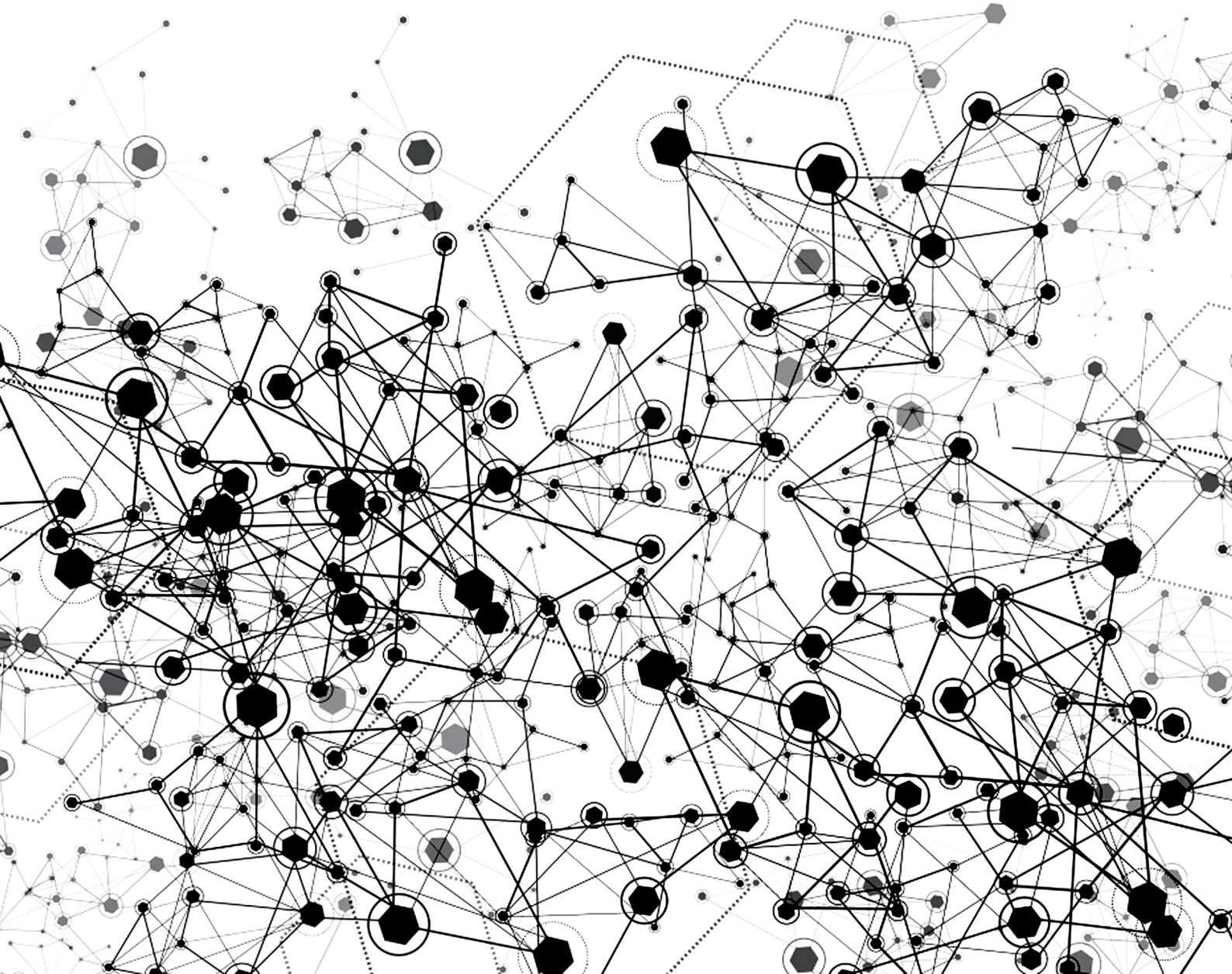
Another social problem which is considered as the consequence of the presence of pistachio gardens, especially in residential areas, is stray dogs. Most Iranian people are not interested in keeping dogs at home due to religious and cultural reasons. Thus, usually a considerable number of stray dogs is living in empty fields and pistachio gardens. Stray dogs are often vector of pathogens such as rabies because of their inadequate living conditions.

4.3.3 Excessive use of chemical pesticides

One of the most prominent consumers of poisons in Kerman province is pistachio farmers of Rafsanjan. It is estimated that ~800-1,000 tons of pesticides are consumed annually by farmers in this region (Rezaei and Hayati, 2013). Although, controlling the harmful factors using chemical pesticides in the agricultural sector is useful, excessive use of pesticides causes poisoning and diseases. The result of surveys revealed that cancer growth in Kerman province is ~6% higher than the average country's (Dehhajipur and mirzaei, 2016, 2014). Additionally, the excessive use of chemical pesticides has a very harmful effect on the environment.

Chapter 5

Relationship between public policies, planning and agriculture in Rafsanjan



Introduction

In this section we are trying to answer the first sub question of our research which as it is mentioned in the first chapter: What regional development plans and policies affect the transition process? To this aim firstly we gathered information about regional plans an policies of Iranian government, specilally some parts which are related to the topic of our projects, from documents and literature. Then, we will study the effect of the present policies and plans on the transiotion process from cureenct agriculture to high technology.

5.1 Government and political institutions in Iran

The “Islamic Republic of Iran” is the name given to current government of Iran which is adopted after the Iranian Revolution in 1979. Thus, the political system of Iran changed from the Iranian imperial system to the Islamic Republic of Iran. This Islamic republic government, ruled by Twelver Shia Islamic laws, has a republic system which is based on public voting (Arasta, 2012; Hashemi, 2007). According to the Twelver Shia Islamic religion, in the absence of the last Imam (who is still alive based on Shia beliefs and will appear one day), the leader of the revolution or the “Supreme Leader" is a representative of the last Imam. The Supreme Leader has unlimited power to determine overall policies of the system. He controls the military intelligence and security operations and appoints the head of the judiciary, the commanders of the police and military forces, the state radio and television networks, the head of the members of the “Guardian Council” and member of "Expediency Discernment Council".

The “Expediency Discernment Council" consists of the president, the head of the judiciary and one of the jurists of the Guardian Council. It can advise the leader to determine the overall policies and also is the reference point for resolving disputes between the “Guardian Council” and the Leadership Selection Council. It is also responsible for the 20-year perspective program (from 2005 to 2025) and oversees its implementation.

The Supreme Leader, who is responsible for the supervision of the country, is elected by the “Assembly of Experts” (Hashemi, 2007). The Members of the Council of Leadership Experts have been elected by the people. The candidate participating in the election should be approved by the Guardian Council.

The Guardian Council is composed of twelve members, six of which are jurists who are introduced by the head of the judiciary and elected by the Islamic Parliament. Other six members are jurisprudents who are appointed directly by the leader. In addition to approve the eligibility of candidates for the elections (Presidential, Islamic Parliament, and Council of Leadership Experts), they review all laws which are elected by the parliament to ensure if they are based on Islamic rules and have harmony with the constitution.

The Islamic Consultation Assembly or the Iranian Parliament, which is the legislative council of Iran, has currently 290 representatives from different cities of Iran. Around 5% of the parliament members are non-Muslims. The members of the Islamic Parliament, who are approved by the Guardian Council, are elected by people for 4 years.

The President of Iran, the head of the government and the highest official in the country, is elected by people for 4 years. However, the president also requires the approval of the Guardian Council and the leader, before being introduced as a candidate and before being sworn in the parliament. Furthermore, the president appoints almost all ministers apart from the ministries of defence,

intelligence and foreign affairs which are chosen by the leader. To finalise the selecting process, the president should subject the ministry candidates to the approval of parliament (Hashemi, 2007). The political and governmental structure of the Islamic Republic of Iran is displayed in Figure 35.

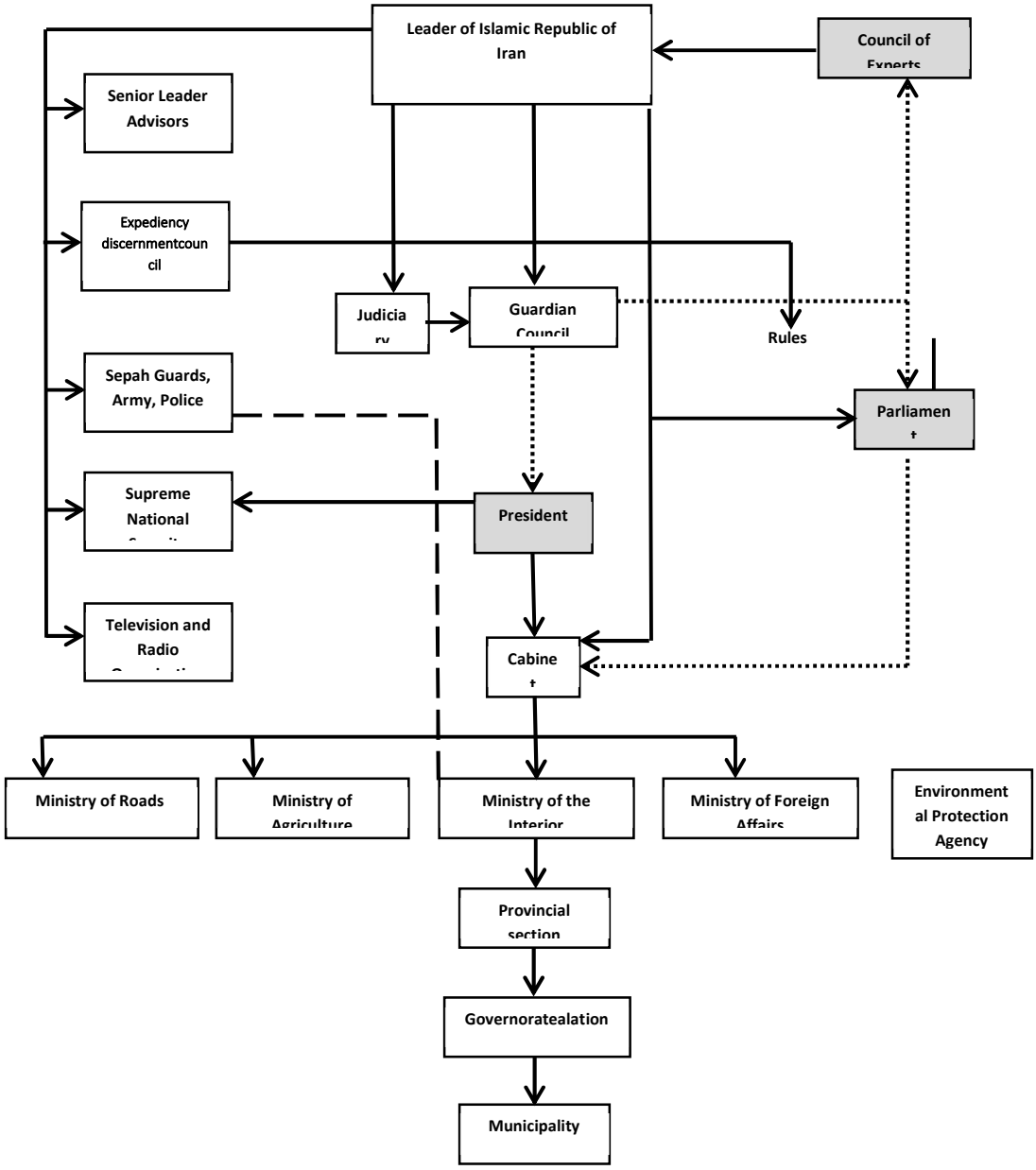


Figure 35. Power classes in the political system of Iran

5.2 Land and water ownership in Iran

Land and water ownership in Iran follow special rules which are based on the Islamic law. In this part, land and water ownership of Iran are described briefly.

5.2.1 Land ownership

Ownership of land in Iran can be divided into four categories:

Public ownership: Public lands are types of land that belong to everyone. Some public lands are state property that is devoted to public interests and the government only governs them, such as the museums. Additionally, there are some other public lands without any functions which do not have any private owner.

Governmental ownership: The lands that are usually acquired by the government through the enforcement of laws or purchased by the state.

Private ownership: Private lands, owned by private owners and non-state entities, are transferred through contracts or inheritances. This type of land may have one or more owners.

"Vaghf" ownership: "Vaghf" lands are the charitable lands whose benefit has been spent based on the Islamic law. This land cannot be sold; it can only be rented temporarily. Based on the "Vagh" organisation report, 70 percent of Rafsanjan lands are "Vaghf" lands (https://kerman.oghaf.ir/).

5.2.2 Water ownership

According to the literature and documents, water ownerships and the water right system were dependent on land ownership until the year 1963. The owner did not need any permission and based on the Islamic law, every land owner who extracted water for the first time and applied it in their land was considered as the owner. At that time, a group of local people, selected by the residents of each region, was in charge of the establishment and repair of the irrigation system. The law of nationalisation of water was executed in 1963 and, then, according to the law, the traditional system of water ownership was abolished.

After the Islamic Revolution in Iran, according to the Constitution of the Islamic Republic of Iran and the new water ownership law, the government became responsible for maintaining, permitting and supervising the exploitation of water resources. Accordingly, for any activity associated with water irrigation systems, people have to get permission from the government.

The process of protecting underground water resources is both at the decision-making and executive level of the Ministry of Energy. Although this ministry plays a key role in the water and groundwater conservation sector, the Ministry of Agricultural Jihad has an important effect on the water consumption aspect. However, the Ministries of Energy and Agricultural Jihad disagree on the issue of water management due to different purposes that they have. The Ministry of Energy focuses on water consumption and environment protection, whereas the Ministry of Agricultural Jihad mainly aims to develop the agricultural sector.

However, because of the deficiency of the law and the weakness of the government in executing and supervising the water ownership law, the water price is too cheap which resulted in competing for a greater share of available water by people (Mirnezami and Bagheri, 2017; Masumi and Lotfi, 2017).

5.3 Types of urban and regional development projects in Iran's planning system

As mentioned earlier, the political system of Iran has a top-down structure, as such all planning systems should be accepted by the government. The Supreme Council of Urbanism and Architecture of Iran is the highest policy reference and approval of urban development projects in Iran. The supreme council consists of the ministers of interior, agriculture, culture and Islamic guidance, industries, energy, construction Jihad, defines and support of the army, the head of the planning and budget organisation, the head of the environmental protection agency, and one of the members of the commission of housing and urban planning and transportation of the Islamic Parliament as a supervisor. This organisation has been working under the chairmanship of the minister of roads and urban development supervision (Ahmadpur, 2007). The roads and urban development organisation determines regional development plan and make effort to use of land resources such as soil and water in the best way (Ahmadpur, 2007).

Urban and regional development plans in the urban planning system of Iran have been summarised in Figure 36. The expansion of Rafsanjan city during 1986-2014 (Mehryar et al. 2015)

Figure 37. Population change in Rafsanjan city and Rafsanjan county (Mehryar et al. 2015)

(Ahmadpur, 2007; law of renamed of ministry of the development and housing to the housing and urban development). In the County of Rafsanjan, each city has its own master or guided plan and detail plan. Additionally, 70% of villages have guide plans. All these urban and rural development plans are determined for 10-15 years based on the social, environmental and economic each region. The expansion and population growth of Rafsanjan from 1986 to 2014 which has been studied by Mehryar et al. (2015are illustrated in Figure 36 and Figure 37. According to this survey, the urban area of Rafsanjan increased from 42 km^2 to 110 km^2 with an average expansion rate of 2.4 km2 per year during 1986–2014. The city of Rafsanjan showed the highest expansion rate (~83%) and population growth rate (~48%) during 1986-1998. Additionally, based on the results of the later study, due to the decline of pistachio crops, the immigration rate from rural area to urban area increased during the studied period.

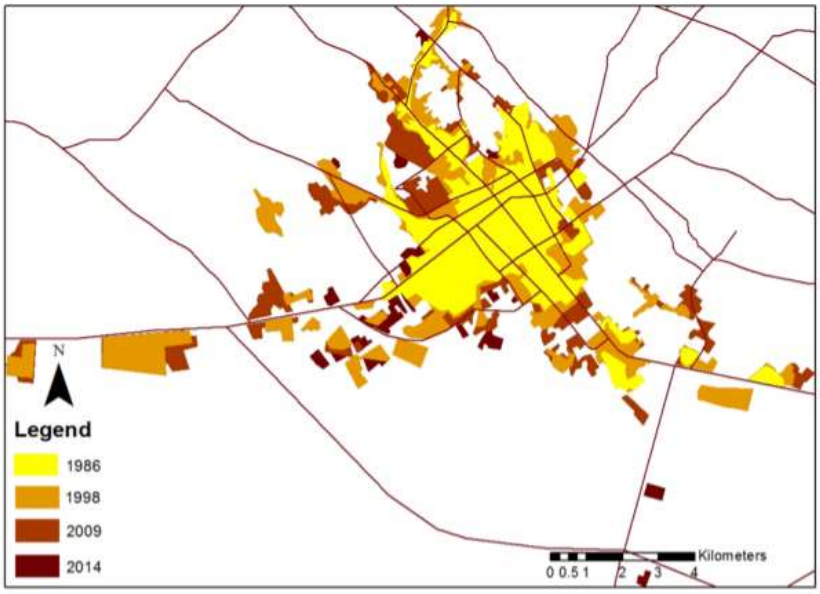


Figure 36. The expansion of Rafsanjan city during 1986-2014 (Mehryar et al. 2015)

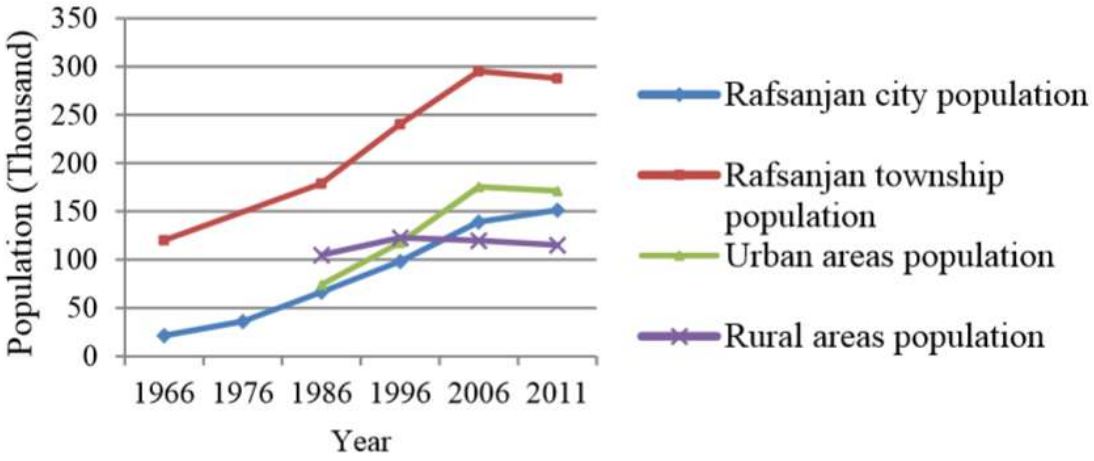


Figure 37. Population change in Rafsanjan city and Rafsanjan county (Mehryar et al. 2015)

Table 4. Planning hierarchy in Iran

Level	Plan/ The relevant organization
National level	Five-year economic, social and cultural plans
	National body design / Ministry of road and urban development
	Land management plan / Management and planning organization
	The laws approved by the parliament, the council of ministers and the guidelines approved by the supreme council of urbanism and architecture
	Comprehensive plans such as comprehensive agriculture plan
Regional level (Large region)	Regional Plans / Ministry of road and urban development
	Provincial regional plans / organization of management and planning
Area level (small region)	Area or county master plan / Ministry of road and urban development
	Urban collection Plan for Metropolis / Ministry of road and urban development
	Master plan for large and medium-sized cities / Ministry of road and urban development
	Detailed plan for large and medium-sized cities / Ministry of road and urban development
	Urban guide plan for cities below 50,000 people / Ministry of Interior
	Rural guide plan / Organization of housing and Islamic revolution*
	New town/city plan / Development of new towns/cities Company
	Planning for development of the city / Ministry of road and urban development

	Plan of reconstruction and renovation of old region of city / Urban development and reconstruction company, Ministry of road and urban development Local level

* This organization has been established in the framework of the policies and programs of the Government of the Islamic Republic of Iran in order to provide house for poor people and development of villages and the construction of residential units in cities.

5.4 Agriculture and national/local policies

The national and local policies have an influential role on the agricultural sectors in Rafsanjan. The local policies are in line with the national long-term policies and development plans. The public polices for the agricultural sector in Iran focus on resolving issues such as water scarcity and modernisation of the agricultural sector. These following sections describe these two goals of public policies.

5.4.1 Public policies for water scarcity challenges

Water scarcity is one of the main challenges of Iran. Extreme drought in threatening not only agriculture but also liveability of many cities in Iran. Local and national government are seeking to find solutions to deal with water scarcity challenges. The main strategies that are undertaken by authorities in Iran to resolve the water scarcity issues for agricultural sector are describe below.

5.4.1.1 Transferring water to drought-affected areas

One of the suggested ways to solve the problem of Rafsanjan related to water shortage was transferring the water from other parts of the country to Rafsanjan for agricultural purposes. The project suggested was the transfer of water from one of the branches of Karoon River (The largest river in Iran) located in one of the villages (Sulgan) of “Chaharmahal and Bakhtiari” province in southwester of Iran, to the city of Rafsanjan (Abdolahi, 2007).

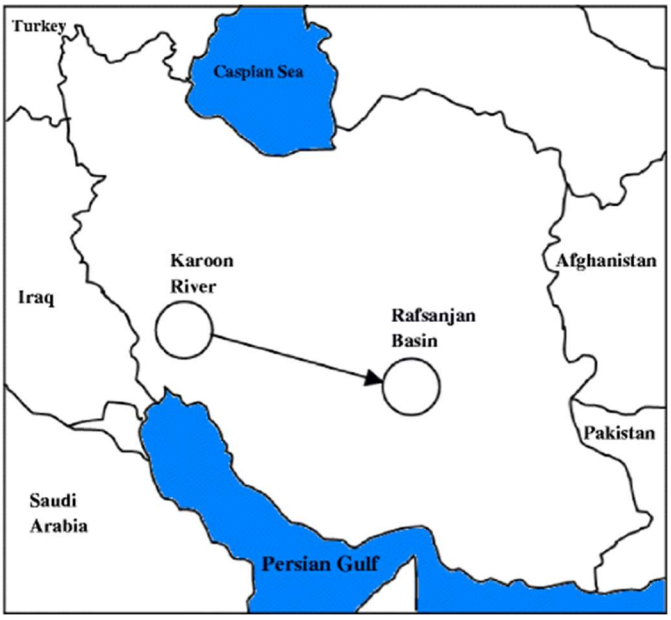


Figure 38. The map of Iran indicating the route of transfering water from Karoon to Rafsanjan

This plan was approved 18 years ago when "Hashemi Rafsanjani" was the president of Iran. Although, after the presidential term of "Hashemi Rafsanjani", the plan suspended, now it is on the agenda of the current president of Iran "President Rouhani". But despite of the government's statement that the government does not pay for this project and the budget is provided by several farmers of Rafsanjan, there is much opposition from environmentalists, experts and people living in the area from where water will transfer. Opponents refer to the plan as a political plan and view it as non-scientist, non-economic and anti-environmental project, because the transferring process leads to water shortage in the region. As a result, lack of enough water itself creates several problems such as destroying the agriculture industry in the region, reducing the soil quality as well as increasing the dust in the air because of diminishing the plant cover in the region. The transfer of water from Karoon to increase the supply of water, in comparison with water supply from the aquifers, costs highly, so that the cost (Figure 39) of production per cubic meter is 15 times more than the cost for producing the supply of water from underground aquifers (Abdolahi, 2007).

Another present water transferring project is transferring the water from Oman Sea (south of Iran) which is planned in three phases. In the first phase, water will be transferred to "Gol Gohar" iron mine, located in the City of Sirjan, ~150 km from Rafsanjan, then, in the second phase, the water will be transferred from "Gol Gohar" to "Sarcheshmeh" copper mine and, finally, in the last phase, the water will be transferred from "Sarchashmeh" to the "Chadormalu" mine located in Yazd city, ~300 km from Rafsanjan. The project has been launched since 2013 by Kerman Development Organisation. The first step of the project is expected to be finished by the end of 2020 (Torabi et al, 2009).

Figure 40. The route of transfering water from Oman to Sarcheshmeh

5.4.2 Applying new technologies for irrigation systems

The development of new irrigation methods can be considered as a very effective approach for water management in agricultural systems. New irrigation techniques that are currently used for the irrigation of pistachio trees in Rafsanjan are pressure irrigation systems including sub-surface drip irrigation and bubbler irrigation (Vatanperast, 2017; Abdolahi et al., 2005).

The people who want to set up the new irrigation systems can take advantages of government grants and loans (Interview No 4). Although traditional systems have low performance, they have very low costs compared to new ones. Therefore, due to the high cost of new irrigation systems, most farmers in Rafsanjan still prefer to use traditional systems (Qureshi et al., 2001). High inflation rates and the declining value of Iran's currency due to international sanction lead to economic instability. As a result, in such economic conditions, the private sector prefers to maximise profit in the short term, so they do not want to invest their money for the new irrigation systems which do not have any economic effect on the productivity of pistachio (Abdolahi et al., 2005).

In spite of the mentioned limitations, the new irrigation systems have been currently used by some farmers. According to surveys, 80% of users have a diploma or higher degree; they have close links with agricultural promoters and agricultural cooperatives. Furthermore, most of the users are major owners of the land and have their own deep well or more than 68% of a deep well for irrigation. In such circumstances, the owners have enough power to make decisions for adjusting their irrigation systems. Most users waste the water saved due to the application of new irrigation methods either for creating new fields or increasing the irrigation volume. Thus, practically, they have not been able to reduce the exploitation of underground water (Mohammadi and Sedaghaty, 2011).

Assessing the level of satisfaction of the users of new irrigation systems shows that 82% of them are satisfied with the systems. The main motivations of the beneficiaries are water shortage, increased irrigation efficiency, increased cultivation area and reduced irrigation costs. The problems that users face are poor quality of used equipment, insecurity and theft of irrigation supplies, financial problems, lack of technician for the installation and operation of new irrigation systems and lack of knowledge related to modern irrigation systems (Abdolahi et al., 2005; Mohammadi and Sedaghaty, 2011).

As mentioned earlier, the USA has recently been ranked first in the production of pistachio. This mostly happened because of producing pistachio based on scientific research using modern technologies especially for irrigation systems in the USA. According to the literature, although the number of pistachio trees per hectare in Iranian pistachio fields is twice or even three times more than that in the USA, the average consumed water per hectare of pistachio fields in the USA is more than 2.8 times than that in Iran. However, the used water per dry a kilogram of pistachio is 5.76 m3 and 2.55 m3 in Iran and the USA, respectively. In other words, the efficiency of irrigation systems per kilogram of dry pistachio in American pistachio is much more than in Iranian fields (Goldhamer,2005; Yaghoubi,2013; Razavi, 2010).

5.4.3 Transformation of agricultural sector and products

Due to disadvantages of monoculture farming such as loss of biodiversity, environmental pollution, susceptibility of pests and high use of fertilisers, scientists and the government try to outpace the region from being a single-product by holding conferences and promotional classes as well as allocating loans to applicants. The Jihad-e-Agriculture Organisation, in collaboration with Vali-e-Asr University and the Resistance Development Economic authorities, is developing alternative cultivation in Rafsanjan.

Polyculture farming is the most popular method to grow mixture of plants using different methods which has several advantages compared to monoculture systems, such as higher efficiency of irrigation and energy systems, less number of pests and diseases because of growing different plant varieties, increasing soil fertility due to existence of different types of roots and having stable income for farmers because of different types of production.

Due to water shortage and environmental conditions, some products such as Saffron, medical herbs, barberry and Damask rose are suggested to be cultivated in Rafsanjan. Each of the suggested plant can be cultivated in a special part of Rafsanjan. for instance, the mountainous areas of Rafsanjan are suitable for the cultivation of saffron which is the most popular alternative crop. Because of the economic importance of saffron the cultivation area of this product which is now ~35 hectares, is increasing.

Moreover, to grow a wide variety of plants without considering the environmental condition as limitation, several greenhouses have recently been established in Rafsanjan. The goal of creating of these greenhouses is to bring a part of the agriculture from open spaces into closed and controlled greenhouses, in order to increase the yield per hectare while consuming less water. Since these greenhouses are created in the cities and villages, farmers should not spend much time, energy and money for transportation.

5.4.4 High-tech greenhouses

Recently, many greenhouses have been established in Rafsanjan to cultivate fresh fruit and vegetables inside the city. In Rafsanjan, like other cities of Iran, due to some special advantages (having good natural light, cheap labour, etc.), restrictions (especially high quality water shortages in many parts of the country) or for certain specific purposes (such as sustainable employment), the number of greenhouses is rapidly expanding (Delshad, 2006).

Two types of greenhouses have been established in Rafsanjan, the greenhouses with soil substrates (Figure 41) and hydroponic systems (Figure 5.3). Soil substrate in the greenhouse conditions create some problems such as distribution of plant diseases and lowering the quality and quantity of products due to contact with the soil as well as dis-absorption of the elements due to inappropriate pH. The mentioned disadvantages of such systems have led to the use of hydroponic cultivating systems (Roosta, 2017).

Hydroponics is the science of cultivating the plants without soil, the roots are in the air, which should be kept very wet, or in water that should be well ventilated or in some solids other than the soil that holds moisture. The water around the roots that supplies food and oxygen contains balanced ingredients of nutrient elements. Cultivating the off-season plants, using water and fertilisers optimally, and maximising the use of land, is one of the main advantages of non-soil systems in comparison with open agricultural systems (farms or gardens) (Porterfield and Banks). By using hydroponic systems, farmers are able to harvest products with high quality and quantity. The workload in hydroponic greenhouses is lower than other types of greenhouses because weed control and crop rotation are no more required. The plant growth uniformity, minimum water dissipation, non-competition of plants for water and nutrients less use of chemicals and, consequently, healthier crop production are other pros of using hydroponic systems (Miceli et al, 2003; Takede, 2000; Jaenaksorn and Ikeda, 2003).

The first modern hydroponic greenhouse of Rafsanjan was established in 2012 by a private sector. After the first one, several hydroponic greenhouses were created mostly by private sectors and just a few ones were built by the government. The largest hydroponic greenhouse of the southeast of Iran with an area of 13,000 square meters is under construction in the County of Rafsanjan.

Figure 41. A greenhouses with soil-substrate in Rafsanjan

Figure 42 High tech urban agriculture practices in Rafsanjan

5.4.5 Supporting innovation-oriented business

One of the government's policies to support companies with new and modern technologies is to create a centre known as the "advanced technologies incubator". This centre is an organisation which attempts to improve knowledge transfer between research centres such as universities and research institute and industries and link the inventors and innovators to markets. The centre facilitates developing of knowledge-based companies with supportive processes. The “Develop and Technology” centre of Rafsanjan University (Vali-e-Asr univesity of Rafsanjan) was established in 2012 after the approval of the Ministry of Science.

5.5 Agriculture and planning practices

5.5.1 Agricultural lands in land use plan of Rafsanjan

The City of Rafsanjan is divided into seven distinct areas according to various existing activities: settlement zone, industries and mines area, agricultural activities area, natural resources area, military activities area, lands of restricted (stone outcropping, fault area, sloping lands, nether lands, flood lands and area of sand dunes), and abandoned land area. The mentioned lands can be used for residential, educational, health and medical, residential-commercial, historical, cultural, religious, administrative, touristic and catering, sports, park and green space, industrial workshop, facilities and equipment Urban, transportation and warehouses, empty and dried agricultural lands and gardens and agricultural purposes (The Law on the Conservation of Agricultural Land and Gardens; Comprehensive Plan of Rafsanjan City, Building Regulations and Urban Planning, 2000).

Agricultural activities area can be used for all agricultural activities such as traditional cultivation, high technology agriculture, agricultural research activities and establishment of industries and facilities related to agricultural production. According to the Ministry of Agriculture Jihad, due to population growth, construction in the rural area located in the area of agricultural activities is permissible (Rafsanjan Master Plan, Terms and Conditions, 2000). The map of agricultural lands in the city centre of Rafsanjan is displayed in Figure 43.

The highest changes of vegetation transformation of Rafsanjan happened during the past 28 years (1986-2014). Although there was high expansion of the planted area from 1986 to 2009, around 40% of these planted areas lost their vegetation after 1998. Additionally, the level of vegetation in ~30% of Rafsanjan planted areas has decreased. The decreasing of vegetation can be related to land use change around Rafsanjan or drought condition due to decrease of green vegetation. From 2009 to 2014, only a decrease of vegetation value without any gain is observed (Mehryar et al, 2016). Figure 44 which is prepared by Mehryar et al. is map of Rafsanjan, indicating some area where there is an decrease in vegetation value, increase in vegetation value or did not change during the period from 1986 to 2014. The mentioned areas are marked in red, blue and black, respectively.

Figure 43. Agricultural lands in the city centre of Rafsanjan (Google map, 2018)

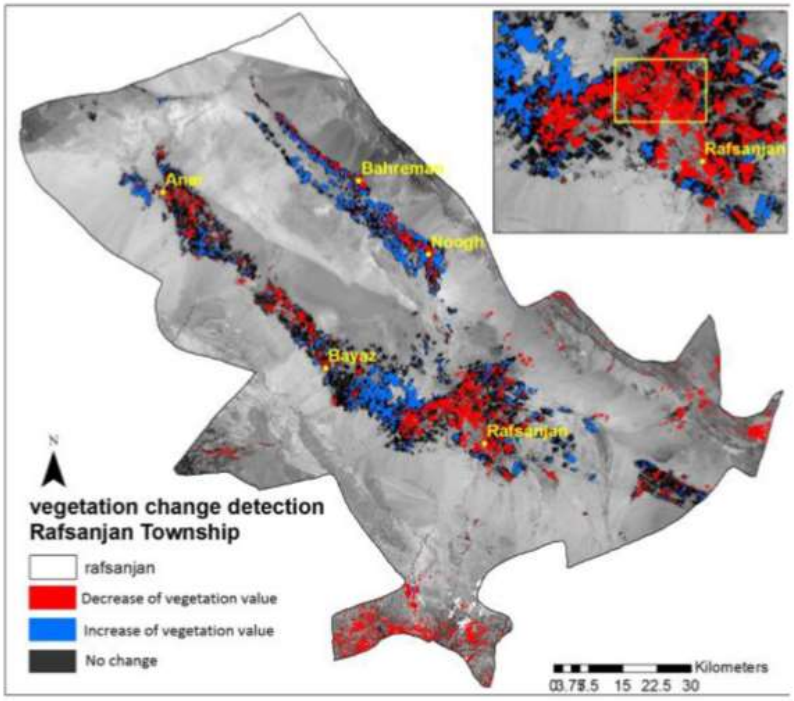


Figure 44. Vegetation change detection in Rafsanjan county between 1986 and 2014 (Mehryar et al, 2016)

5.5.2 Conversion of agricultural lands

To prevent the change of land use and agricultural fields which are located outside the border of cities and towns, "The conversion of agricultural land and fields" law was implemented in 1995. According to the law, the land use change is prohibited except for some special cases which should be approved by a commission, whose members are representatives of the Ministries of Agriculture, Housing and Urban Development, the Organisation of construction Jihad, the Environmental Protection Agency and the Governorate. This is under the supervision of the Ministry of Agriculture in each province. The conversion of agricultural land and field's law for villages can be changed after getting permission from Agriculture Jihad organisation. According to the law, agricultural land owners should pay taxes which is 80% of the price of lands for changing the use of land. However, as an exception changing of agricultural lands of low-income owners who live in small towns and villages are tax-free (Land use change law, national plan). Furthermore, changing plan for the use of lands which are located inside the city have been mentioned in the comprehensive plan of Rafsanjan. Accordingly, since existing pistachio lands located inside urban area create a number of problems, particularly environmental pollution (Section 4.2) due to pesticides and fertilisers, and also because of the feature of pistachio trees which do not increase the value of green space, the use of agricultural land inside city can be changed easily in a short process.

Figure 45 shows the agricultural lands which are located in urban areas and now are converting to residential places.

Figure 45. Conversion of agricultural lands in urban area

According to a survey performed in the present study (See Appendix B), among 234 respondents who participated in this survey from Rafsanjan, 73 (31.2%) changed all or part of their agricultural land in the last 10 years, and 161 (68.8%) did not change their agricultural land use. Among the 73 people who changed their agricultural land, 49 (67.1%) of their agricultural lands are in urban areas, 21 (28.8%) of them are in rural areas and 3 (1.4%) of agricultural lands are out of residential areas.

5.6 Transition to high tech agriculture

5.6.1 Planning for transition of agricultural sector in Rafsanjan

The most important policies which have had a major impact on the transition to high-tech agriculture and have been implemented by the government are described in the following sections. In summary, the first policy revolves around getting permission to the establishment of small-scale greenhouses that have been able to attract small funds for high-tech agriculture and the second policy is creating relationship between the private sector and the university through knowledge-based companies.

5.6.1.1 Small greenhouse law and land use change

The expansion of urban margins and commercial and residential areas continues even after the implementation of the agricultural land use laws. In Rafsanjan, owners, who want to get permission to change the use of their pistachio fields legally, let the trees be dried by stopping the irrigating. According to a survey conducted in this study (see Appendix B), people of Rafsanjan consider the following reasons for change of agricultural land use: reducing agricultural profits in the recent years, water scarcity and its impact on agriculture, difference between attitude of current owner (who inherit their parents' land) and their parents and increasing the price of residential or commercial land in compare to agricultural land.

Although, according to the land use rules, people cannot change the agricultural fields, owners can do any agricultural activity including the construction of greenhouses, livestock, poultry and fish farming in their lands without any legal permission. Due to this law and other issues such as water shortage and special environmental conditions of Rafsanjan which are both described in the previous chapter, constructing the greenhouses especially hydroponic greenhouses can be considered as an economic and proper option for the owners who want to change their land use.

As a result, the numbers of applicants for greenhouse construction in Rafsanjan like other cities of Iran are increasing. Based on the greenhouses construction law, the applicants for the establishment and receipt of greenhouse licenses must have minimum of 3,874 square meters' land and take a long process to obtain licenses from several organisations. The establishment of small-scale greenhouses (less than 3,000 square meters) in the rural and urban areas is one of the policies recently launched by the Ministry of Agriculture to establish the greenhouses in a short time which led to increase the number of greenhouses in Iran.

5.6.1.2 Relations between the private sector and the university

As mentioned in the previous sections, one of the government's policies is to develop and support the private sector through universities. In Rafsanjan, Vali-eAsr University is known as the most active academic centre of Rafsanjan which has an undeniable effect on agricultural development in the city.

Vali-e-Asr University of Rafsanjan has a lot of research groups which are active in different fields of agriculture. Indeed, the university has made a very effective contribution to bring new agricultural technologies by performing research and surveys and collaborative projects with industries or private investors. At the present, the university is equipped with hydroponic and aquaponics greenhouses for scientific purposes (Figure 46).

Figure 46. Hydroponic greenhouse of Vali-eAsr University of Rafsanjan

However, around 50 science-based companies are active in the "Advanced technologies incubator of Rafsanjan", which are supported by the university by providing the place and equipment and advertising. Among science-based companies in Rafsanjan University, three of them are working in the field of high agricultural technology like the production of small urban hydroponics, the construction of hydroponics greenhouse, advice on hydroponics greenhouses. These three companies are managed and supervised by faculty members of horticulture and soil science department of the university and try to transfer the archived knowledge from scientific surveys conducting by PhD and MSc students of Vali-e-Asr University to their companies and private sector.

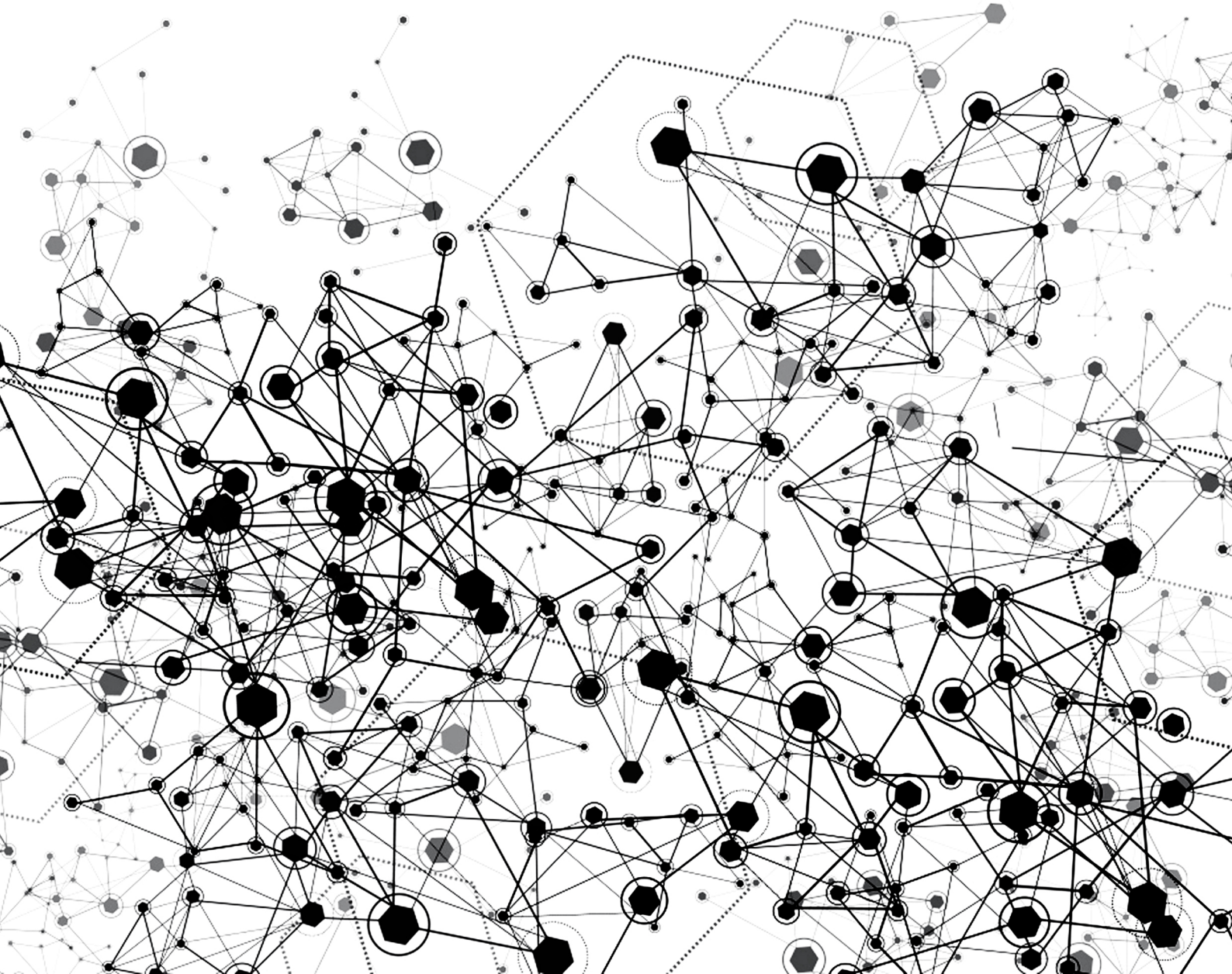
One of present companies named "Uban Green Land Company" has a collaborative work with a hydroponic company in the Netherlands named "Vegger" to import hydroponic equipment and manufacture and adjust their equipment with Rafsanjan environment. Vegger with the aim of promoting a sustainable world to live, designs, develops and manufactures equipment for the automated indoor cultivation of vegetables and herb (Figure 47). The driving principle of Vegger is to change the way people acquire and appreciate their daily vegetables and customers use technologically advanced, easy-to-use, and safe systems for indoor vertical gardening. Additionally, Uban Company with collaboration with Vegger and under their supervision are trying to present

indoor gardening services with full support for frequent harvesting and maintenance to public and healthcare centres and provides services for indoor gardening projects.

Figure 47. Hydroponic systems of Vegger-Uban Company

Chapter 6

Transition of conventional agriculture to high-tech agriculture in Rafsanjan



Introduction

In the first part of chapter 6, we studied the feasibility of our studies by collecting data using quantitive and qualitive analysis. Furthermore, we tried to find the existence constraints and barierers to the transition of conventional agriculture to high technology agriculture in Rafsanjan. In the second part of this section we used the available data to answer the second sub question in our research (see first chapter), to determine the role of human and non-uman actants in the transition process using a framework named "TT framework"designed by Hosseini et al. (2019) (see second chapter).

6.1 Feasibility of technology-driven transition in Rafsanjan

In this section, we aim to find whether the transition process to high-tech agriculture is feasible by investigating the availability of knowledge and technology, compatibility with regulations, policies and development plans and adoption of new agricultural methods by society, culture and market.

6.1.1 Availability of knowledge and technology

According to the interviews conducted in this study, the accessibility of experts and researchers to the new knowledge about high agricultural technology is acceptable. Based on our interviews, the most important barrier for experts and researchers to acquire new knowledge is the difficulty of participation in international communities and conferences. In this research, there are 29 interviewees, of whom 17.2%, 24.1% and 41.4% answered that access to new knowledge about new agricultural technologies is 'very good, 'good, and 'moderate', respectively. However, 17.2% of interviewees believed that accessibility to knowledge is bad.

Moreover, the results of the interviews indicate that of all participants, 30.8%, 26.9%, 19.2% believe that the level of collaboration between experts and local authorities is 'very good', 'good' and 'average', respectively, whereas 19.2% and 3.8% believed that experts and local authorities have 'bad' and 'very bad' collaboration. The collected data reveals setting the meetings is the most effective way for gathering and communication of experts and authorities.

6.1.2 Compatibility with regulations, policies and development plans

In this part, compatibility of transition to high-tech agriculture with long-term development plans and national and local policies was investigated.

6.1.2.1 Compatibility with long term development plans

The 20-year national vision of Iran is a document issued by the "Expediency Discernment Council" (see 0) under the supervision of the leader, in 2005. This document outlines a general plant for Iran economic, political, social and cultural developments during the next twenty years. Based on the national vision, Iran supposed to be an advanced country and rank first among all Middle East and Southeast Asian countries in economy, science, process of technology, by 2025.

To this aim, a 5-year plan is suggested by the government every five years and should be approved by the parliament. At this moment, the sixth plan has been accepted and is in process, one section of which is related to the development of agriculture with the aim of securing food and achieving the self-sufficiency in all aspects of agriculture. In order to achieve these goals, several programs have been implemented such as the investment for research and providing modern agricultural systems, supporting science-based companies, the establishment of agricultural institute, cultivation of healthy products without pesticides, fertilisers and controlling the quality of agricultural products and supporting the small business. Attracting knowledge and innovation from technology-rich countries and providing legal, financial, and institutional support for the development of knowledge and innovative projects is an important part of the plan which is mentioned is sixth five-year law. Furthermore, to improve the knowledge all executive agencies have to spend one percent (1%) of their allocated credits for research and technology development.

Additionally, based on another section of the 5-year plan, the government has to deal with water shortage and protect the environment for land sustainability. However, since the development and establishment of greenhouses especially hydroponic greenhouses lead to economic growth by creating new job vacancies and high income, they are consistent with the goals of national development plan of Iran. Thus, based on the law, the government has to support people who want to establish greenhouses to transfer of cultivation from open space to controlled space and for water management.

The development of greenhouse cultivation is also supported by a "resistance economy policy" which has been executed by the Iranian government from 2011. For the first time, the name of resistance economy has been used by the leader of Iran after issuing new sanctions against Iran. The Ministry of Agricultural Jihad is one of the most important section to play a key role to execute this policy by setting new rules to decrease the food and crop imports (Karim et.al 1393). One of these new policies are associated to increasing the number of greenhouses during 10 years which is known as a 10-year greenhouses development plan and has been approved by the Economic Council, headquarters of the Resistance Economics and Food Security and Food Production Strategic Group. The 10-year plan which is started from 2016 will be continued till 2025. During this time, the government supports the people who are interested in establishing greenhouses using new technologies, financially. They aim to set up around 48,355 hectares of greenhouses in all parts of the country by the end of 2025. The program and construction of greenhouses have been supervised by gardening management of the Agriculture Jihad Organisation, the agricultural engineering and natural resources organisation, and the agricultural bank (Karim et.al 1393).

6.1.3 Compatibility with national and local policies

The land management system in Kerman province like other Iranian provinces is a top-down approach to policy decision which consists of four levels; national (central government), regional (province), micro-regional (county, district etc.) and local (city, town and village) levels.

The “Greenhouse Development Project” which is mentioned in the sixth 5-year plan (see Section 6.1.2) is being pursued by the Ministry of Agriculture Jihad at national level. The Governor’s Office which is the representative of the government and all ministries including the Ministry of Agriculture Jihad, is the most important organisation of each county such as Rafsanjan. The governor controls all

agricultural activities performed in the county by another organisation named the Agriculture Jihad Organization which is located at regional and micro regional level.

The current Ministry of Agriculture Jihad is composed of two previous ministries named the Ministry of Jihad of Construction and the Ministry of Agriculture. After the Iranian Revolution (1976), the Ministry of Jihad of Construction was created for country development and construction which is suggested by the founder and leader of the Islamic republic of Iran, "Khomeini". At the beginning of the revolution, a considerable number of people joined Jihad organisations which was running under Jihad Ministry, most of the participants worked as volunteers. Jihad Organisation played a very important role in the re-building and construction of the country especially after the 8-year war between Iran and Iraq, development of villages, building the bridges and roads and performing agricultural activities and food production. Since the Ministry of Jihad and Ministry of Agriculture tasks overlapped, the government merged these to ministries approved by the parliament.

Another organisation associated with the agricultural sector is the agricultural and natural resources engineering organisation, which is a non-governmental organisation. All Iranian nationals who graduated from agricultural and natural resource majors and disciplines can be members of the organisation. The Minister of Agriculture Jihad is a member of the supreme supervisory board in this organisation. The central council of this organisation has elected and appointed members; appointed members are representatives of the ministry of Jihad agriculture and ministry of science and research. One of the goals of the establishment of this organisation is the promotion of knowledge, the development of new technology in agriculture and related fields.

6.1.4 Adoption of new agricultural methods by society, culture and market

One of the most important factors in the transition to high-tech agriculture is the adoption of the methods by society which is studied by conducting a survey in the next section.

Involvement of resident

According to the survey, of 384 individuals, 244 persons (63.5%) believed that the current agriculture has a negative impact on the region, 72 (18.8%) did not have this idea, and 68 (17.7%) did not have any idea regarding this subject (Table 5).

Table 5. Negative impact of current agricultural practices on the region

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	244	63.5	63.5	63.5
	No	72	18.8	18.8	82.3
	No viewpoint	68	17.7	17.7	100.0
	Total	384	100.0	100.0	

Moreover, although of 384 individuals, 206 (53.6%) persons thought that high-tech agriculture can be as a solution for current agriculture problems in Rafsanjan, 63 (16.4%) did not believe in high-tech agriculture and 115 (29.9%) did not have any idea (Table 6).

Table 6. High-tech agriculture as a solution for current problems of agriculture

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	206	53.6	53.6	53.6
	No	63	16.4	16.4	70.1
	No viewpoint	115	29.9	29.9	100.0
	Total	384	100.0	100.0	

Water shortage, air and water pollution (caused by fertilisers and pesticides), economic benefit and successful experiences of people who worked in this field are the reasons why some people are agree with transition of current to high tech agriculture.

Moreover, of 384 participants, 40 (10.4%) and 94 (24.5%) were very familiar and familiar with vertical and hydroponic agriculture. Level of the knowledge of 99 (25.8%) was acceptable, 83 (21.6%) had poor knowledge about this type of farming, and 68 (17.7%) had very poor or no knowledge with agricultural and vertical hydroponics (Table 7).

Table 7. Distribution of the level of knowledge with vertical and hydroponics agriculture

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very poor	68	17.7	17.7	17.7
	Poor	83	21.6	21.6	39.3
	Acceptable	99	25.8	25.8	65.1
	Good	94	24.5	24.5	89.6
	Very good	40	10.4	10.4	100.0
	Total	384	100.0	100.0	

Of the 384 individuals, 267 (69.5%) believed that the current agriculture of Rafsanjan needs to convert to hydroponic or vertical agriculture, whereas 77(20.1%) did not have this idea, and 40 (10.4%) did not have any idea about this topic (Table 8).

Table 8. Importance of transition toward hydroponic agriculture

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	267	69.5	69.5	69.5
	No	77	20.1	20.1	89.6
	No viewpoint	40	10.4	10.4	100.0
	Total	384	100.0	100.0	

Thus, we attempted to see if there is any relationship between working in the field of agriculture and the workers' desire for hydroponic system by a Chi square test. In this test, statistical hypotheses are as follows:

H0: Having the agricultural activity and the workers' desire for the transition toward hydroponic agriculture is independent

H1: Having the agricultural activity and the workers' desire for the transition toward hydroponic agriculture is dependent.

The results revealed that calculated p value is less than 0.05, therefore, at this level, H0 is rejected, which indicates that there is a significant relationship between having agricultural activity the desire for hydroponic agriculture. It means that people who are working in the field of agriculture has more interest in hydroponic systems (Table 9, Figure 48).

Table 9. Chi-Square tests for analysing the agricultural activity and affirming the importance of transition

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	21.522[a]	2	.000
Likelihood Ratio	19.316	2	.000
Linear-by-Linear Association	14.971	1	.000
N of Valid Cases	384		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 11.46.

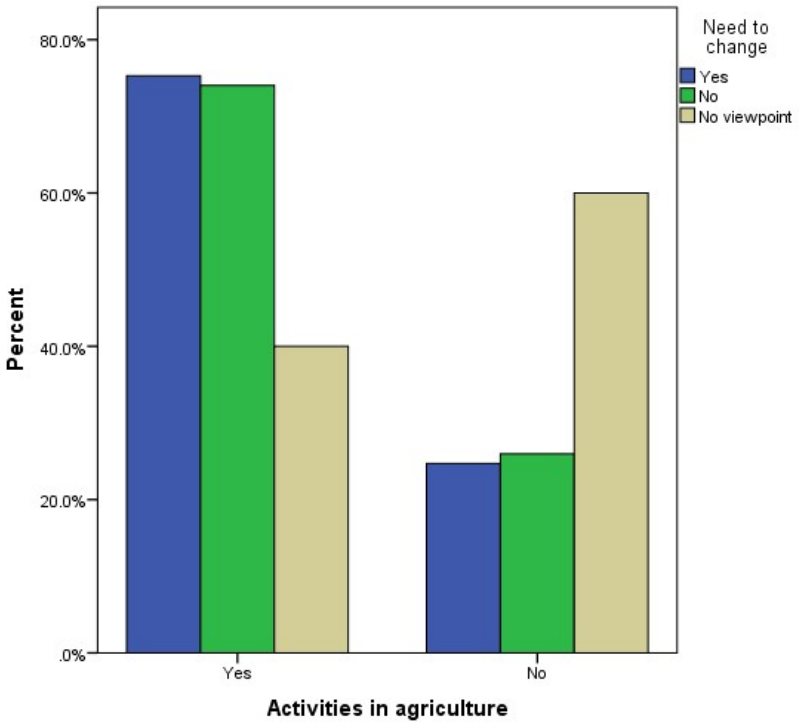


Figure 48. Distribution of the agricultural activity and affirming the importance of transition

To see if there is any relationship between the level of education and interest in hydroponic agriculture, a Chi square test estimation has been performed and the two following statistical hypotheses have been defined:

H0: The level of education and interest in hydroponic agriculture is independent.

H1: The level of education and interest in hydroponic agriculture is dependent.

Considering that the calculated p value is less than 0.05, at this level, H0 is rejected, which means that there is a significant relationship between the level of education and interest in hydroponic agriculture (Figure 49, Table 10).

Table 10. Chi-Square tests for analysing the level of education and affirming the importance of transition

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	22.082[a]	10	.015
Likelihood Ratio	24.134	10	.007
Linear-by-Linear Association	.320	1	.572
N of Valid Cases	384		

a. 2 cells (11.1%) have expected count less than 5. The minimum expected count is .94.

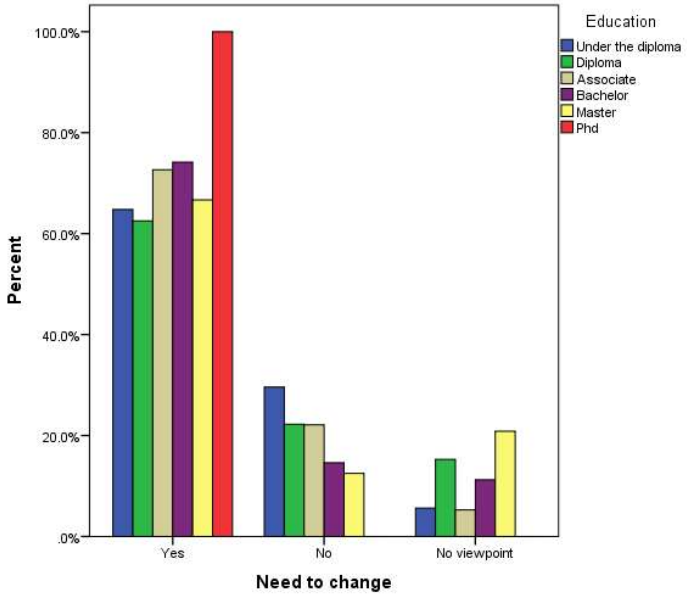


Figure 49. Distribution of the level of education and affirming the importance of transition

Furthermore, we analysed the relationship between the negative impacts of current agriculture and preference for hydroponic agriculture using Chi Square test with the following statistical hypothesis:

H0: The negative impact of current agriculture and preference for hydroponic agriculture is independent.

H1: The negative impact of current agriculture and preference for hydroponic agriculture is dependent.

Since the calculated p value is less than 0.05 in, therefore, at this level, H0 is rejected, which means that there is a significant relationship between the negative impacts of current agriculture and preference for hydroponic agriculture (Table 11, Figure 50).

Table 11. Chi-Square tests for analysing the negative impact of current agriculture on the region and affirming the importance of transition toward hydroponic agriculture

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	11.416[a]	4	.022
Likelihood Ratio	11.629	4	.020
Linear-by-Linear Association	.769	1	.381
N of Valid Cases	384		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 7.08.

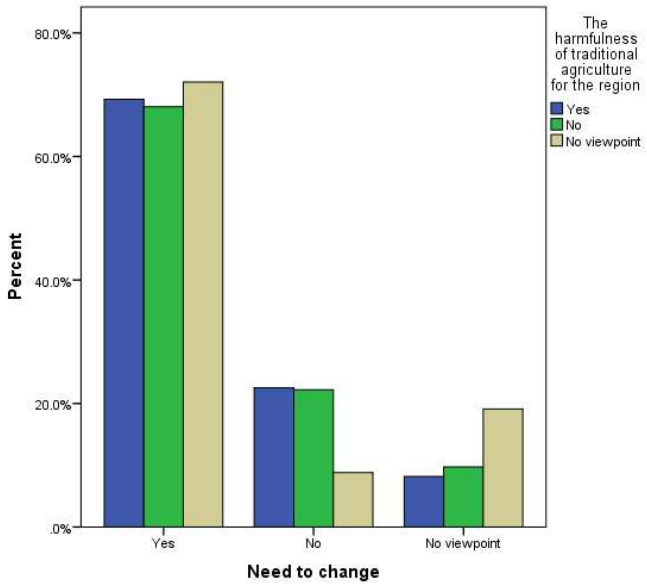


Figure 50. Distribution of the negative impact of current agriculture on the region and affirming the importance of transition toward hydroponic agriculture

Of 384 individuals, 188 (49.0%) tend to invest in hydroponic or vertical agriculture, 164 (42.7%) did not want to do this kind of investment, and 32 (8.3%) did not have any idea about investment in this activity (Table 12).

Table 12. Distribution of the desire to invest in vertical or hydroponic agriculture

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	188	49.0	49.0	49.0
	No	164	42.7	42.7	91.7
	No viewpoint	32	8.3	8.3	100.0
	Total	384	100.0	100.0	

Then to find if there is any relationship pre-knowledge of people and their interest to investment in hydroponic agriculture by Chi square test, we defined the following hypothesis:

H0: The desire to investment in vertical and hydroponic agriculture and having information is independent.

H1: The desire to investment in vertical and hydroponic agriculture and having information is dependent.

The calculated p value was less than 0.05 in the test, therefore, at this level H0 is rejected, so there is a significant relationship between desire to investment and having information about vertical and hydroponic agriculture (Table 13, Figure 51).

Table 13. Chi-Square test for analysing the relationship between desire and knowledge about hydroponic

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	147.659[a]	8	.000
Likelihood Ratio	167.944	8	.000
Linear-by-Linear Association	63.573	1	.000
N of Valid Cases	384		

a. 1 cells (6.7%) have expected count less than 5. The minimum expected count is 3.33.

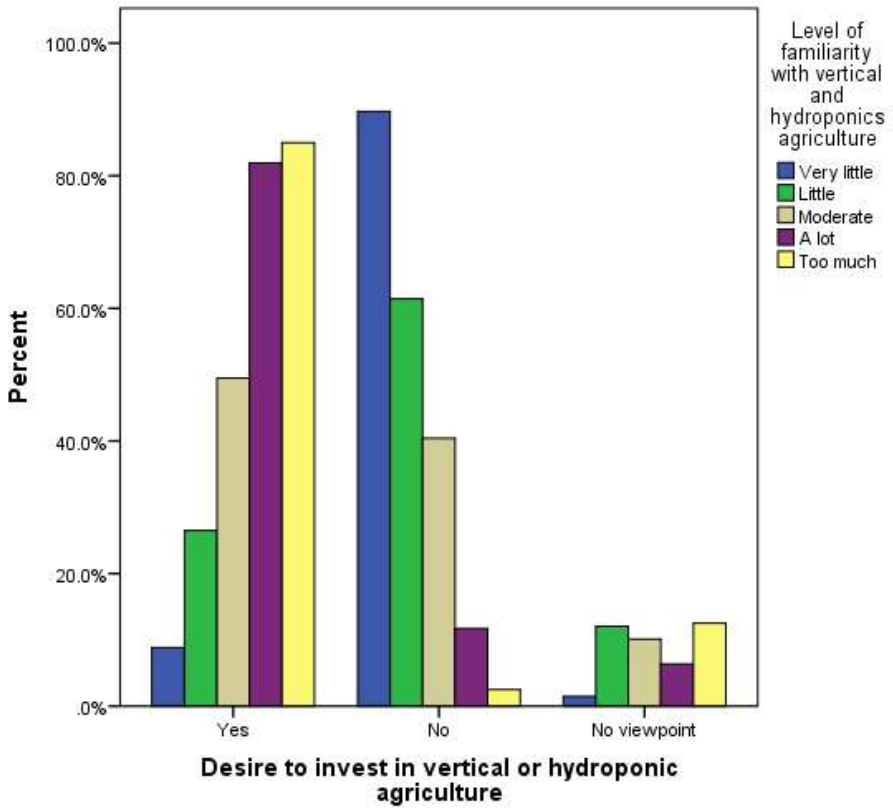


Figure 51. Distribution of the relationship between desire and knowledge about hydroponic

To analyse the relationship between desire to investment in hydroponic agriculture and age, we conducted a Spearman's rho with the following hypothesis:

H0: $\rho = 0$

H1: $\rho \neq 0$

The calculated p value was 0.000 which is less than 0.05 and 0.01, and then this correlation coefficient is significant at the level of 0.05 as well as 0.01. As a result, H0 is rejected, so it can be concluded that there is a relationship between desire to investment in hydroponic agriculture and age.

Spearman correlation coefficient varies from 1 to 1+. 1 indicates perfect relationship, whereas 0 means lack of relationship. The + and – just shows the direct of relationship. In this research, this value estimated to be +0.260. The positive sign of the correlation coefficient indicates that the relationships are in the same direction. Also due to the relative low level of correlation coefficient, there is a small relationship between the desire to investment in hydroponic agriculture and age (Figure 52, Table 14).

Table 14. Chi-Square and Spearman's rho tests for analysing negative impacts of the desire to invest in vertical or hydroponic agriculture and age

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	228.022[a]	138	.000
Likelihood Ratio	217.600	138	.000
Linear-by-Linear Association	14.337	1	.000
N of Valid Cases	384		

a. 187 cells (89.0%) have expected count less than 5. The minimum expected count is .08.

			Age	Desire to invest in vertical or hydroponic agriculture
Spearman's rho	Age	Correlation Coefficient	1.000	.260**
		Sig. (2-tailed)	.	.000
		N	384	384
	Desire to invest in vertical or hydroponic agriculture	Correlation Coefficient	.260**	1.000
		Sig. (2-tailed)	.000	.
		N	384	384

**. Correlation is significant at the 0.01 level (2-tailed).

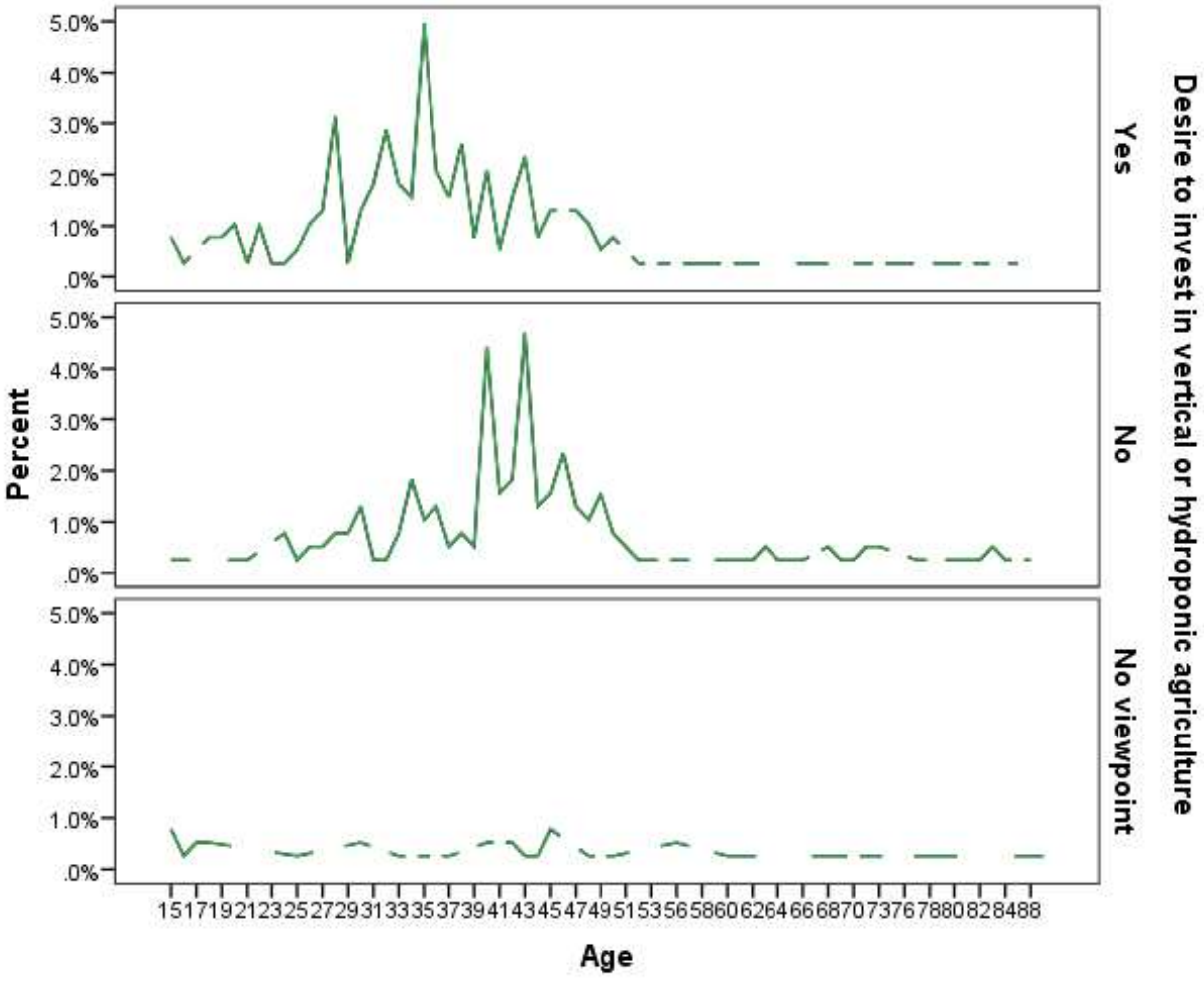


Figure 52. Diagram of the desire to invest in vertical or hydroponic agriculture and age

Of the 384 individuals, 172 (44.8%) have knowledge about governmental rules and laws associated to the establishment of hydroponic greenhouses, 106(27.6%) did not have enough information (Table 15).

Table 15. Knowledge about governmental rules and laws

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	203	52.9	52.9	52.9
	No	181	47.1	47.1	100.0
	Total	384	100.0	100.0	

Of 384 participants, 113 (29.4%) and 126(32.8%) believed that the implemented laws associated to hydroponic greenhouses establishment are 'very bad' and 'bad', respectively. 103 (26.8%) and 9 (2.3%) persons considered them as 'acceptable' and 'very good' laws (Table 16). These negative attitude towards governmental rules and law are due to some barriers for plan execution which are explained in detail in Section 6.2.

Table 16. The effectively of rules and laws associated to hydroponic greenhouses

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very bad	113	29.4	29.4	29.4
	Bad	126	32.8	32.8	62.2
	Moderate	103	26.8	26.8	89.1
	Good	33	8.6	8.6	97.7
	Very good	9	2.3	2.3	100.0
	Total	384	100.0	100.0	

6.1.4.1 Popularity of the products of high-tech agriculture in the market

We conducted a survey to ask whether people of Rafsanjan are interested in buying high-tech products or not. The results indicate that of 384 participants, 263 (68.5%) prefer to use crops which are produced by the hydroponics methods, whereas 46 (12.0%) did not desire for such products. Also, for 75 (19.5%) participants, it does not matter which method has been used for preparing the products (Table 17, Figure 53).

Table 17. Tendency to use of hydroponic production

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	263	68.5	68.5	68.5
	No	46	12.0	12.0	80.5
	No different	75	19.5	19.5	100.0
	Total	384	100.0	100.0	

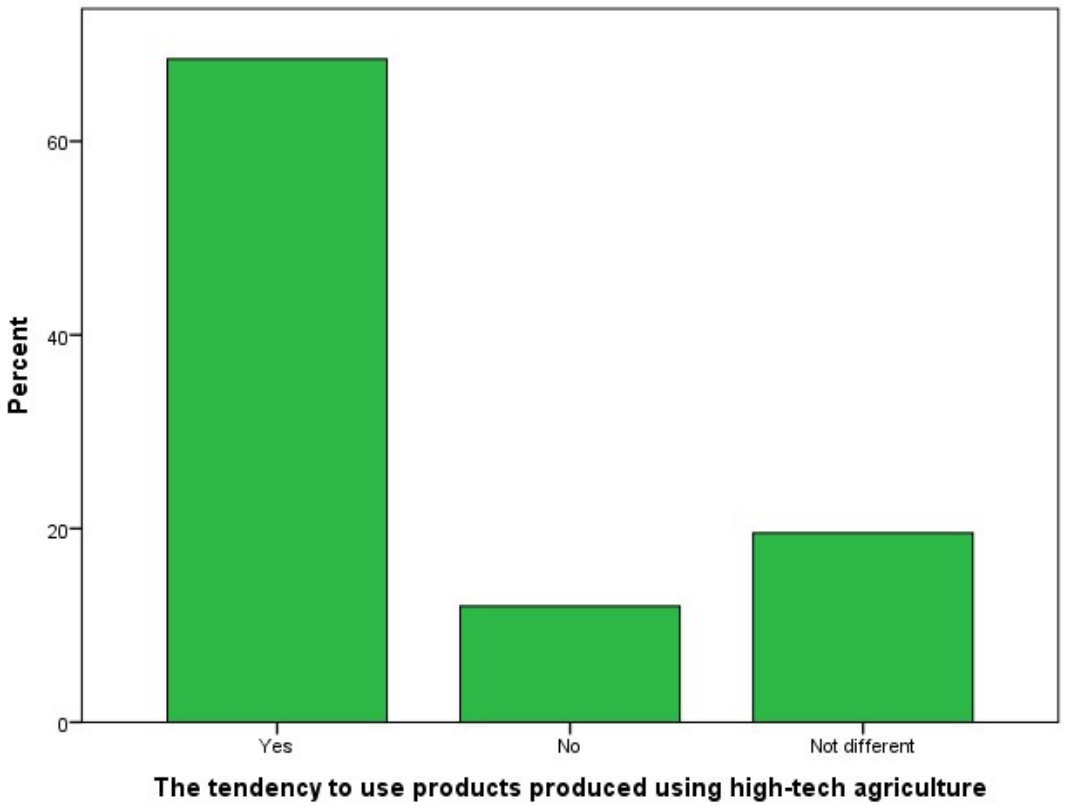


Figure 53. Tendency to use of hydroponic production

The production of healthier crops by hydroponic methods is the reason why the majority of people are interested in hydroponic products. Even some people do not desire for the crops produce by hydroponic methods, they think that hydroponic products are healthier.

6.2 Organisational barriers to the transition of conventional agriculture to high technology agriculture in Rafsanjan

In the present study, the information needed to find the organisational barriers to the transition of conventional agricultural to high technology agriculture, was gathered through in-depth interviews.

To begin with, a semi-structured interview was conducted from informed individuals. The questions continued until the researcher, in response to questions, reached saturation. Then the analysis was started by sorting out the interviews. After collecting the data from the interviews, the data were analysed in the form of three steps: open coding, axial coding and selective coding.

At the **open coding stage**, the data was analysed line-by-line. In this way, data was identified in the form of concepts. The coding in this step was done in two ways, using the interviewee's vocabulary and through the researcher based on the concepts contained in the data (Table 18).

At the **axial coding stage**, the extracted concepts were compared with one another, and each of them was also identified. Then similar concepts were placed in the same class, and thus the subcategories were identified (Table 19).

Finally, at the **selective coding stage**, the main line of the story and the relationship of the main category to other categories were detected (Figure 54).

Table 18. Category of interview statements in open coding stage

1	Lack of a perspective/outlook about the agricultural transfer	7	Ideal and unrealistic attitude of authorities towards the issue	13	Different ideas of authorities about the agricultural transfer	19	Lack of knowledge in the run issue
2	Lack of institutional framework to support for transfer to high tech agriculture in region	8	Lack of flexibility of the executive section at different stages of the plan	14	lack of responsiveness of the executive section	20	Failure to properly implement plans
3	Non-coordinating the plans	9	Administrative corruption (economic and information)	15	The lack of communication between executives	21	Bureaucratic structure
4	The lack of effectivable communication between civil society and private society	10	Non-cooperation and coordination of relevant organizations	16	lack of attention to the Participatory Behaviors	22	
5	Lack of effective communication between local and national levels	11	Incredibly unstable and numerous conditions governing society	17	Emphase on the elements of the rules, more than the main goals		
6	Lack of attention to the development of knowledge and skills	12	Lack of trust of people to the government	18	The lack of communication between the authorities and the private sector for planning, deciding and running issues		

Table 19. Category of interview statements in axial coding stage

Classes	Subcategories
Lack of a perspective/outlook about the agricultural transfer, ideal and unrealistic attitude of authorities towards the issue, different ideas of authorities about the agricultural transfer	**Attitudes of managers and authorities**
Lack of knowledge in the run issues, lack of long-term regional documents, lack of attention to the development of knowledge and skills	**Knowledge of managers and authorities**
Lack of institutional framework to support for transfer to high-tech agriculture in region-Lack of flexibility of the executive section at different stages of the plan-lack of responsiveness of the executive section-, failure to properly implement plans, non-coordinating the plans, administrative corruption (economic and information),- Emphasis on the elements of the rules, more than the main goals	**Organisational behaviour of the executive sector**
Lack of communication between executives,- bureaucratic structure, lack of effectible communication between civil society and private society, non-cooperation and coordination of relevant organizations, lack of attention to the Participatory Behaviours, lack of communication between authorities and the private sector for planning, deciding and running issues, lack of effectible communication between local and national levels	**Cooperation between actors**
Incredibly unstable and numerous conditions governing society, lack of trust of people to the government	**Impacts and conditions of the community**

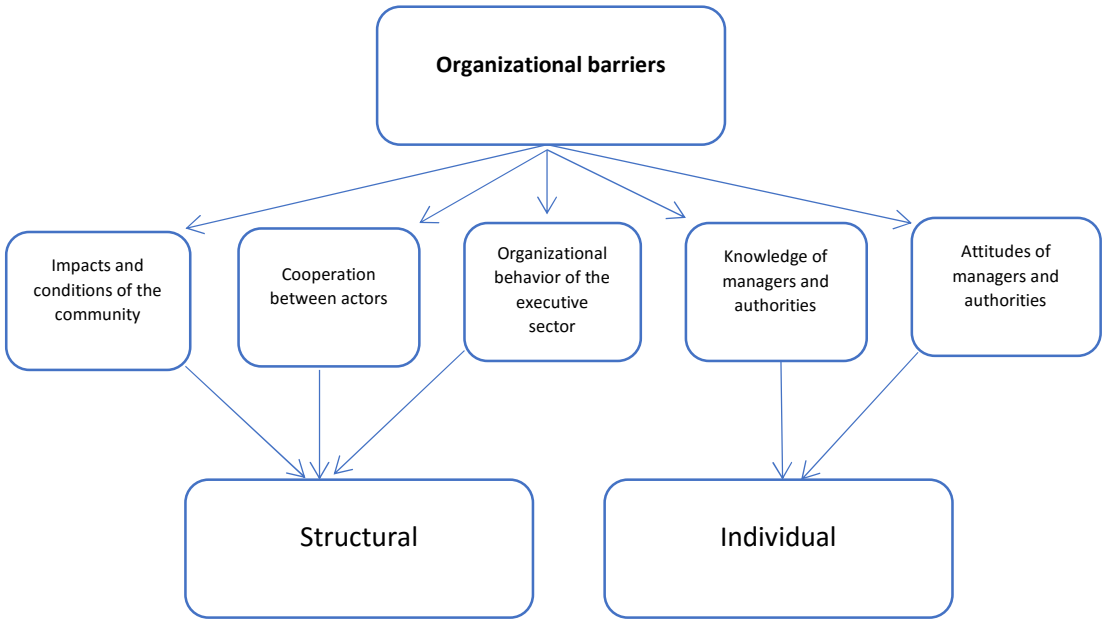


Figure 54. Category of interview statements in selective coding stage

6.3 Transition to high technology agriculture in Rafsanjan

In this part of the study, the transition to high technology agriculture in Rafsanjan is analysed using the TT framework (see Chapter 2). The transition process in the TT framework is divided into three stages: disentanglement, punctualisation, and re-entanglement.

6.3.1 Disentanglement

Disentanglement in current agricultural practices in Rafsanjan is defined in three steps: landscape pressures, social technical regime and niche pressure. The existing sociotechnical regime faces the pressures from actants which cause instability in the current regime. These pressures make up by landscape including location of the region, plans and policies as well as niches which try to fix the sociotechnical technical regime. In this study, high technology agriculture enters the sociotechnical regime of Rafsanjan and can reconstruct the current agricultural system.

6.3.1.1 Landscape pressure

The pressure from sociotechnical landscape is the result of water shortage, destruction of soil and water quality, decreasing arable lands and agricultural production in Rafsanjan. This pressure occurred due to dried and semi-dried environment and climate change of the Rafsanjan region which has worsened the drought situation in recent decades. Furthermore, extraordinary use of natural resources due to agricultural activities during past years can be considered as another factor which led to landscape pressure. As a result, the pressure creates unsustainable social technical regimes, so the development plan and resistance economy policy cannot be successful to achieve their aims and make extra pressure on the sociotechnical technical regime.

6.3.1.2 Instability of the regime

Since irrigation is a necessary factor for agricultural activities of Rafsanjan region, water crisis is the most important issue that the region is facing. Due to water shortage, the agricultural products declined dramatically during the past years and also caused other problems such as land's subsidence in Rafsanjan and creating cracks in buildings and lands, decreasing the quality of water and soil and increasing the level of arsenic in the drink water. Because of these issues, the farmers have to use chemical fertilisers to improve the quality of soil which can result in polluted environment. Furthermore, because of reducing the quality of water and soil as the natural resources, in Rafsanjan which completely depends on agriculture economically and socially, the agricultural activities are decreasing significantly. As a result, the regime converts to an instable and unsustainable sociotechnical regime.

Niche pressures

In Rafsanjan, to solve the problems created by landscape pressures and due to instable sociotechnical regimes, several niches such as new irrigation method, cultivation of new crops and construction of hydroponics and aquaponics greenhouses have been applied in the regime. According to this study, the niches which are considered as the solution for solving the mentioned problems, create extra pressure on the current regime and will result in more instability (Figure 55).

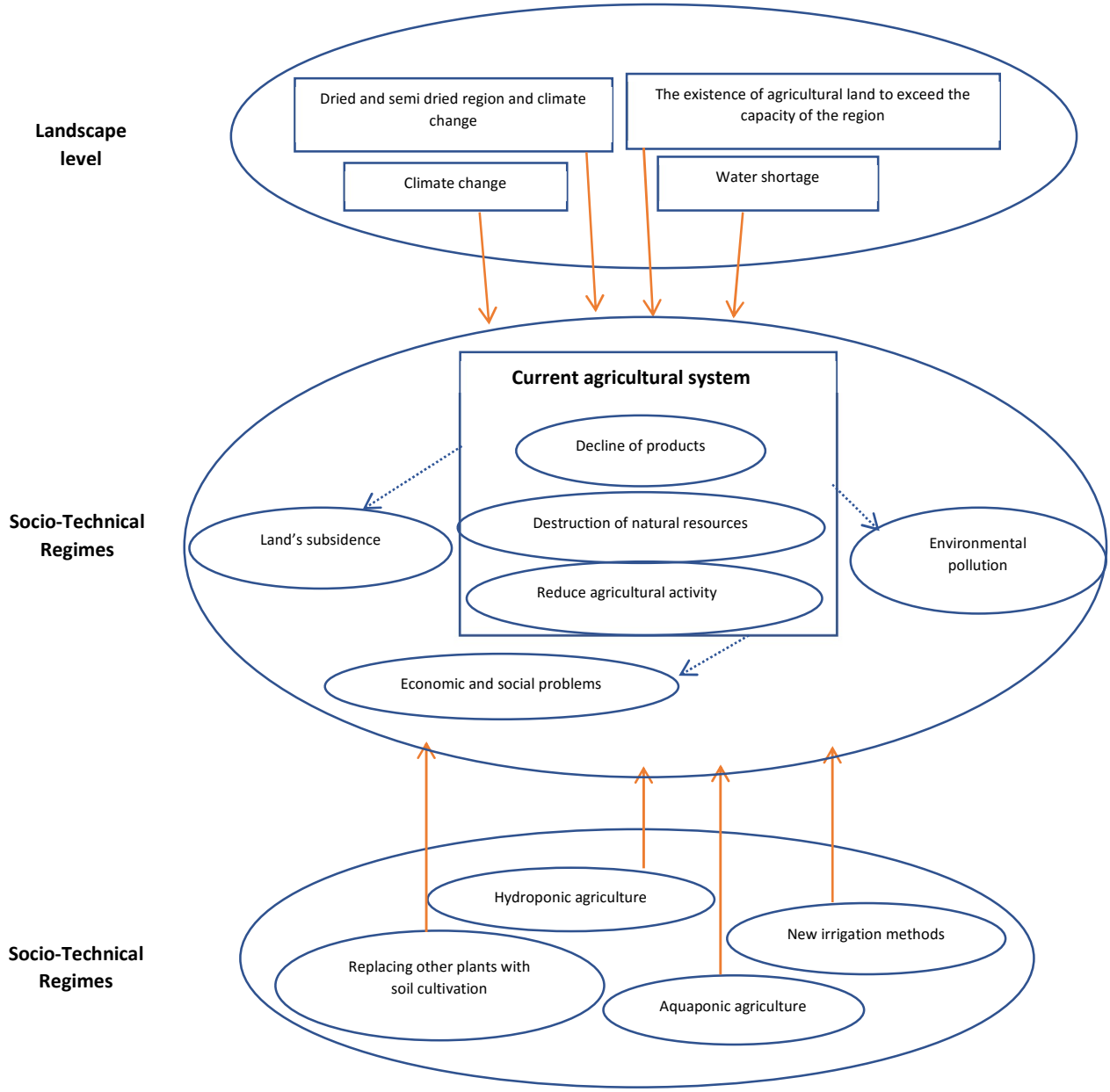


Figure 55. Pressures on socio-technical regimes

6.3.2 Punctualisation

Punctualisation of new technologies for the transition to high-tech agriculture is located in the second level of TT. In this level, social and material entities including technologies, plans, and policies which affect or are affected by technology-driven transition in the agricultural sector in Rafsanjn, shape a network of aligned actants. In this section, the involved actants (human and non-human) are identified and their relationships are analysed; then the configuration of interactions between entities involved in technology-driven transition is discussed. Configuring interactions for creating a

network of aligned interests for the transition to high-tech agriculture in Rafsanjan is described through the four moments of the ANT translation process.

6.3.2.1 Problematisation

The problematisation moment in the TT framework refers to the advent of a focal actant, which defines the problems caused by disentanglement of the current sociotechnical regime. It attempts to convince other actants to join forces for the transition towards a new regime and defines an OPP for all involved actants to make itself indispensable and define the identities and roles in the network.

In this study, to define actants and entities in the problematisation step of the TT framework, we conducted an interview with 30 selected interviewees (included of experts, investors, major owners, authorities who were working in hydroponic agriculture field), to determine social and material actors involved in the transition of current to high-tech agriculture. The interviewees have been selected using the snowball method.

According to the previous interviews and available documents, we prepared a list of potential actors and asked the interviewees to give us their idea about them by writing down their comments and determining the importance of each actors by scoring them (1-5). Additionally, they could add other new actors if they wanted (**Error! Not a valid bookmark self-reference.**).

Table 20. Average score (graded by interviewees) of degree of importance associated to determined actors involved in the transition of current to high-tech agriculture in Rafsanjan

		Actants	Degree of importance
Human	**Public**	1*Technical and professional organization	3.95
		Road and urbanization organization	4.93
		Agricultural bank	3.98
		Other banks	1.98
		Agricultural and Natural Resources Engineering Organization	4.90
		Governorate	4.88
		2*Department of Environment	4.85
		Municipality	3.98
		3*City Council	4.93
		Agricultural-Jihad Organization	5.00
		Water Organization	2.03
		Power Department	2.05
		Local newspapers	2.05
		Local radio	1.10
		Rafsanjan Universities	4.90
		4*Natural Resources Organization	3.08
		Advanced technologies incubator	4.75
		Iran Pistachio Research Institute	3.03
		Agricultural Insurance Fund	3.95
		5*Co-operative, Labor and Social Welfare Office	2.03
		6*The village office (Dehdari)	3.03
		Gas office	2.00

	7*Private company	Companies active in irrigation with a new method	1.98
		Agricultural Laboratory	4.00
		Agricultural Clinics	3.00
		Fertilizers and pesticide distributer companies	3.00
		Companies active in hydroponic agriculture	5.00
		Cooperative Pistachio Company	1.98
		Greenhouses	4.88
	Individual	Farmers, minor owner of agricultural land	3.90
		People	3.90
		University professors	4.00
		Member of Parliament	4.78
		8*Farmer advisors	2.03
		Major Owners of agricultural lands	4.90
		Graduates in Agriculture	2.00
		9*Representative of the supreme leader (Imam of Friday prayer)	2.95
		8*Experts who are Farmers Consultant	3.00
Nonhuman	Technology	10*Agriculture equipment	4.70
		11*Imported hydroponic technologies	4.88
		11*Hydroponic Technologies of the Interior Industry	4.98
		11*Greenhouse equipment	4.93
	Infrastructure	Pistachio Process Centers	4.95
		Pumps and water wells	2.95
		Dried pistachio gardens	4.93
	Representative nature	Agricultural products of greenhouses	4.88
		Pistachio	3.03
		water resources	4.93
		Weather	4.93
		Pistachio agricultural land	2.95
	Rules and regulations	Detailed design and land use plan	3.95
		Country Development Program	4.98
		10-years development high tech agriculture plan	5.00
		12*Foreign Relations Policies and Programs	4.85
	Material	Fertilizer	4.85
		Electricity	2.10
		Laboratory materials	2.03
		Pesticide	3.98
		Seed	3.93
		Gas	3.98

1* Technical and professional organisation has been set up to train skilled workers. This organisation perform its duties under the Ministry of Cooperative, Labour and Social Welfare and is responsible for short-term technical and professional training in various fields, including high technology agricultural education.

2* Department of Environment is responsible for protecting the environment which is one of the most important reason for applying the transition process from current agriculture to high-tech agriculture.

3* The purpose of forming the city council is to involve local people in running their own affairs, but this council does not have enough power for decision-making or in control of public affairs. However, this council can play the role of guidance, counselling, identification, encouragement, protection and suggestion in resolving regional agricultural problems, including the transition to high-tech agriculture.

4* The natural resources organisation is responsible for the conservation, protection, restoration and development and protection of natural resources.

5*Agricultural issues have exacerbated the problem of unemployment and other social problems in the region, and the transition to high-tech agriculture will create jobs so this transition is linked to the co-operative, labour and social welfare office.

6* The village offices (Dehdari) are responsible for developing and resolving rural issues. The village offices can establish hydroponic greenhouses as a solution for current issues in the region. These offices can get loans through entrepreneurship and economic development.

7* Private agricultural companies, which are active in the pistachio sector or in the hydroponics sector, can play an important role in this transition. Companies operating in the pistachio sector can be effective with awareness and consulting, and some of these companies have embarked on high-tech agriculture, which has had an impact on farmers' familiarity with hydroponic agriculture.

8* In the agricultural sector of Rafsanjan, farmers usually traditionally hire advisors for their agricultural issues, which are usually empirical. Nowadays, expert consultants with scientific knowledge also advise farmers along with traditional advisors. Farmers have trust to both groups and they are affected in the decision making of farmers.

9* Representative of the supreme leader (Imam of Friday prayer) is a religious figure appointed by the Supreme Leader and also has cultural, educational, supervisory duties within the agricultural jihad organisation.

10* Since the region has been a pistachio agricultural area for a long time, the region's agricultural materials and equipment are mostly for pistachio cultivation. These materials and equipment can have both positive and negative effects on the transition to high-tech agriculture. The negative impact is that farmers want to use available equipment and material that is sometimes not compatible with hydroponic farming.

11* Accessibility and quality of equipment structure of greenhouses and equipment and materials which are needed for hydroponic cultivation are influential in the development of high-tech agriculture. Thus, relations with other countries and economic sanctions as well as interior Industry and quality of them have an effect on transition to high-tech agriculture.

12* One of the most important reasons for the foreign relations policies' attention to this transition is to counteract sanctions and resistance economy policy.

To have a better understanding of the relationship between involved actors in this study, we used UCInet software version 6 (Everett et al. 2002). To this aim, we used the list of involved actors in the transition process of current agriculture to high-tech agriculture, which is determined in Section

6.3.2.1(Table 1). We graded the relationship of each actor with others, 1 to 3, based on the available documents, interviews and surveys performed in the present study. In our grading system, 1, 2 and 3 mean direct, indirect and no relationship. We asked the 34 selected interviewees (see Section 6.3.2.1) to review our actors and their associated grade and give us their feedback to see if they are agreeing with us or have different opinions. Moreover, we asked them to write down their explanation about some parts which are in conflict with their idea.

Considering all comments and explanations, we prepared the final list including the actors and their associated grades. Finally, the betweeness, closeness and centrality between different involved actors have been calculated and then the actor network of the transition process has been visualised by the used program (Table 21, Figure 56).

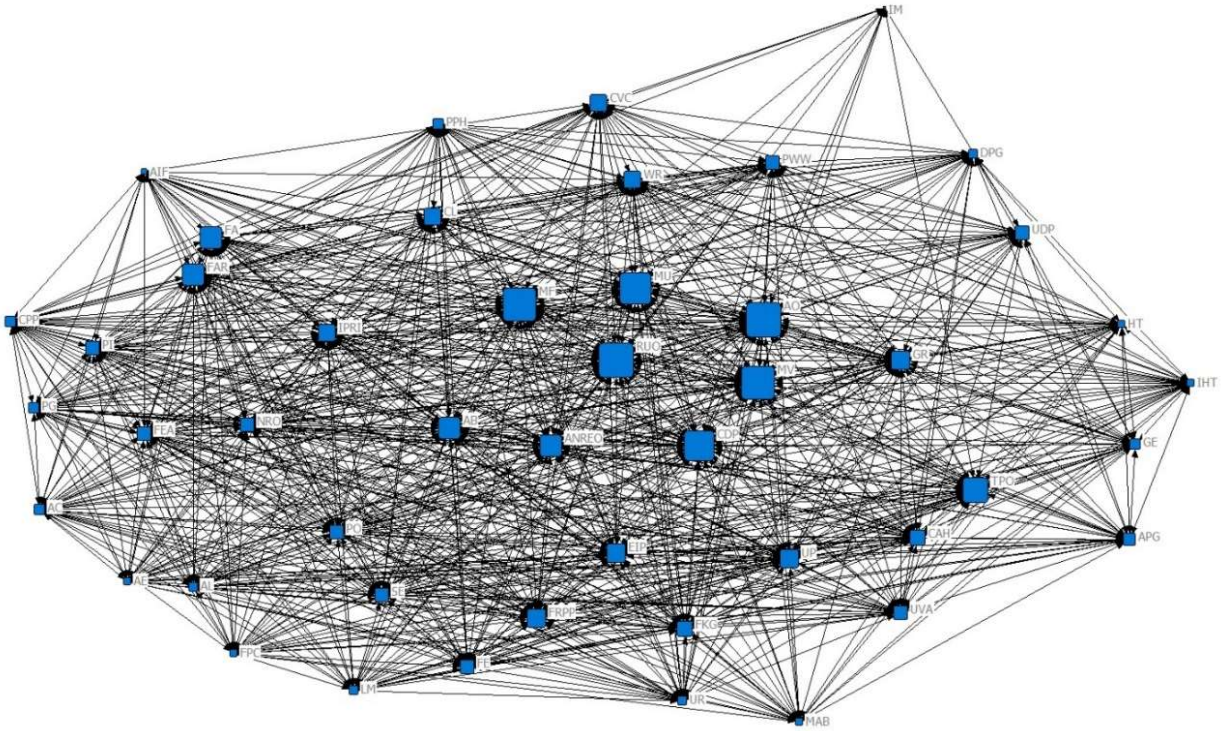


Figure 56. Illustration of actor network of transition process by UCInet

Table 21. Multiple centrality measures of actors involved in transition calculated by UCInet

		1 OutDeg	2 Indeg	3 Out2local	4 In2local	5 OutBetaCe	6 InBetaCen	7 Out2Step	8 In2Step	9 OutARD	10 InARD	11 OutClose	12 InClose	13 OutEigen	14 InEigen	15 Between	16 2StepBet
1	TPO	120.000	120.000	14640.000	14640.000	23367.057	23376.727	46.000	46.000	42.500	42.500	53.000	53.000	0.668	0.668	16.069	16.069
2	AB	148.000	148.000	18308.000	18308.000	29331.729	29310.947	46.000	46.000	44.500	44.500	49.000	49.000	0.838	0.838	13.299	13.299
3	MAB	80.000	80.000	10464.000	10464.000	16583.477	16600.783	46.000	46.000	37.000	37.000	64.000	64.000	0.474	0.475	3.971	3.971
4	ANREO	150.000	150.000	18488.000	18488.000	29605.789	29597.340	46.000	46.000	45.000	45.000	48.000	48.000	0.846	0.846	13.950	13.950
5	RUO	134.000	134.000	16440.000	16440.000	26220.887	26227.424	46.000	46.000	46.000	46.000	46.000	46.000	0.749	0.750	22.880	22.880
6	NRO	120.000	120.000	15288.000	15288.000	24314.449	24306.238	46.000	46.000	42.000	42.000	54.000	54.000	0.695	0.695	8.535	8.535
7	MU	150.000	150.000	18300.000	18300.000	29264.648	29248.561	46.000	46.000	45.000	45.000	48.000	48.000	0.836	0.836	20.730	20.730
8	MV	148.000	148.000	17920.000	17920.000	28701.684	28677.293	46.000	46.000	45.500	45.500	47.000	47.000	0.820	0.820	22.259	22.259
9	AO	184.000	184.000	21816.000	21816.000	34990.938	34990.938	46.000	46.000	46.000	46.000	46.000	46.000	1.000	1.000	22.880	22.880
10	UVA	118.000	118.000	14712.000	14712.000	23449.629	23511.590	46.000	46.000	41.500	41.500	55.000	55.000	0.670	0.672	8.343	8.343
11	UR	100.000	100.000	12912.000	12912.000	20511.180	20568.740	46.000	46.000	39.000	39.000	60.000	60.000	0.586	0.588	4.516	4.516
12	FKG	100.000	100.000	12584.000	12584.000	20036.514	20085.840	46.000	46.000	42.500	42.500	53.000	53.000	0.573	0.574	8.750	8.750
13	IPRI	138.000	138.000	17464.000	17464.000	27941.953	27938.750	46.000	46.000	43.500	43.500	51.000	51.000	0.799	0.799	10.178	10.178
14	AIF	78.000	78.000	10756.000	10756.000	16999.754	16986.668	46.000	46.000	37.000	37.000	64.000	64.000	0.486	0.486	2.424	2.424
15	CVC	90.000	82.000	11268.000	11268.000	17872.264	16334.438	46.000	46.000	39.000	39.000	60.000	60.000	0.511	0.467	10.453	10.453
16	AL	116.000	116.000	15100.000	15100.000	24056.377	24075.760	46.000	46.000	40.500	40.500	57.000	57.000	0.688	0.688	4.393	4.393
17	AC	120.000	120.000	15328.000	15328.000	24571.436	24579.234	46.000	46.000	41.000	41.000	56.000	56.000	0.702	0.703	5.616	5.616
18	FPC	112.000	112.000	14800.000	14800.000	23565.354	23570.318	46.000	46.000	40.000	40.000	58.000	58.000	0.674	0.674	4.024	4.024
19	CPP	118.000	114.000	15276.000	15276.000	24412.383	23793.844	46.000	46.000	40.000	39.000	58.000	60.000	0.698	0.680	5.015	5.015
20	CAH	124.000	124.000	15620.000	15620.000	24896.357	24929.021	46.000	46.000	41.500	41.500	55.000	55.000	0.712	0.713	8.694	8.694
21	GR	156.000	156.000	18944.000	18944.000	30270.166	30304.643	46.000	46.000	43.000	43.000	52.000	52.000	0.865	0.866	11.352	11.352
22	FAR	142.000	142.000	17620.000	17620.000	28246.895	28239.072	46.000	46.000	42.000	42.000	54.000	54.000	0.807	0.807	13.918	13.918
23	FA	134.000	132.000	16860.000	16860.000	26991.785	26573.996	46.000	46.000	42.000	42.000	54.000	54.000	0.772	0.760	13.282	13.282
24	FEA	134.000	134.000	17104.000	17104.000	27357.371	27345.068	46.000	46.000	42.500	42.500	53.000	53.000	0.782	0.782	8.680	8.680
25	UP	106.000	108.000	13132.000	13132.000	20968.234	21382.258	46.000	46.000	42.500	43.000	53.000	52.000	0.599	0.611	10.646	10.646
26	MF	162.000	162.000	19544.000	19544.000	31341.268	31340.938	46.000	46.000	45.500	45.500	47.000	47.000	0.896	0.896	22.011	22.011
27	IM	36.000	36.000	4996.000	4996.000	7793.685	7744.984	46.000	46.000	28.500	28.500	81.000	81.000	0.223	0.221	0.207	0.207
28	AE	110.000	110.000	14524.000	14524.000	23030.850	23029.119	46.000	46.000	38.500	38.500	61.000	61.000	0.658	0.658	3.854	3.854
29	IHT	94.000	94.000	12080.000	12080.000	19072.072	19098.736	46.000	46.000	37.500	37.500	63.000	63.000	0.545	0.546	3.793	3.793
30	HT	102.000	102.000	12980.000	12980.000	20524.953	20552.273	46.000	46.000	38.000	38.000	62.000	62.000	0.587	0.587	4.090	4.090
31	GE	108.000	108.000	13432.000	13432.000	21305.449	21339.205	46.000	46.000	39.000	39.000	60.000	60.000	0.609	0.610	5.837	5.837
32	PPH	100.000	100.000	13116.000	13116.000	20840.238	20852.320	46.000	46.000	39.000	39.000	60.000	60.000	0.596	0.596	6.196	6.196
33	PWW	116.000	116.000	14748.000	14748.000	23442.811	23432.092	46.000	46.000	40.500	40.500	57.000	57.000	0.670	0.670	8.456	8.456
34	DPG	88.000	88.000	11256.000	11256.000	17832.871	17834.553	46.000	46.000	36.500	36.500	65.000	65.000	0.510	0.510	4.338	4.338
35	APG	98.000	98.000	12228.000	12228.000	19444.273	19468.406	46.000	46.000	38.500	38.500	61.000	61.000	0.556	0.556	6.559	6.559
36	PI	126.000	126.000	15916.000	15916.000	25496.520	25496.281	46.000	46.000	41.500	41.500	55.000	55.000	0.729	0.729	7.940	7.940
37	WR	130.000	132.000	15996.000	15996.000	25527.059	25777.344	46.000	46.000	42.000	42.000	54.000	54.000	0.730	0.737	10.963	10.963
38	CL	130.000	130.000	16336.000	16336.000	26106.752	26115.863	46.000	46.000	42.500	42.500	53.000	53.000	0.746	0.747	10.723	10.723
39	PG	132.000	134.000	16732.000	16732.000	26786.494	27039.076	46.000	46.000	41.500	41.500	55.000	55.000	0.766	0.773	6.422	6.422
40	UDP	80.000	84.000	10240.000	10240.000	16157.907	16815.078	46.000	46.000	37.500	38.000	63.000	62.000	0.462	0.481	7.992	7.992
41	EIP	130.000	132.000	15992.000	15992.000	25588.529	26003.219	46.000	46.000	43.000	43.000	52.000	52.000	0.731	0.743	11.625	11.625
42	CDP	144.000	146.000	17476.000	17476.000	27956.650	28224.906	46.000	46.000	45.000	45.000	48.000	48.000	0.799	0.807	19.736	19.736
43	FRPP	150.000	150.000	18476.000	18476.000	29543.885	29551.383	46.000	46.000	43.500	43.500	51.000	51.000	0.844	0.845	12.137	12.137
44	FE	132.000	132.000	16840.000	16840.000	26852.760	26861.619	46.000	46.000	41.500	41.500	55.000	55.000	0.768	0.768	7.972	7.972
45	PO	132.000	132.000	16840.000	16840.000	26852.760	26861.619	46.000	46.000	41.500	41.500	55.000	55.000	0.768	0.768	7.972	7.972
46	SE	132.000	132.000	16912.000	16912.000	26946.396	26955.154	46.000	46.000	42.000	42.000	54.000	54.000	0.770	0.771	8.026	8.026
47	LM	86.000	86.000	11312.000	11312.000	17959.857	17982.684	46.000	46.000	40.000	40.000	58.000	58.000	0.513	0.514	4.295	4.295

The multiple centrality measures from the diagram and the UCINET out can be analysed as follows:

First of all, with respect to the degree of centrality (Column 1 and 2), AO (Governorate), MF (Agricultural-Jihad Organisation), GR (Agricultural and Natural Resources Engineering Organization), FRPP (10-years development high technology plan) and MU (Country Development Program) have the greatest degree, which means that they might be regarded as the most influential.

Secondly, regarding betweenness centrality (Column 5 and 6), MF (Agricultural-Jihad Organisation), AO (Governorate), GR, (Agricultural and Natural Resources Engineering Organization) AB (Road and urbanization Administration) and FRPP (10-year development high technology plan) are in a favoured positions to the extent that the actant falls on the geodesic paths between other pairs of actants in the network. In other words, dependency of other actants on these specific actants to make connections with others, increase their power in the actor-network. It can also be seen in the diagram. High betweenness centrality can be interpreted as control over flows. Therefore, MF (Agricultural-Jihad Organisation), AO (Governorate), GR (Agricultural and Natural Resources Engineering Organisation), AB (Road and urbanisation Administration) and FRPP (10-year development high technology plan) can be seen as the most influential node in terms of control over flows of regulations, connections and immutable mobiles.

Next, according to the definition of Freeman, large numbers of closeness (Column 11 and 12) indicate that a node is highly peripheral DPG (Dried pistachio gardens), PPH (Pistachio Process Houses), GE (Greenhouse equipment), HT (Hydroponic Technologies of the Interior Industry), IHT (Imported hydroponic technologies), MAB (Agricultural bank) and FKG (Advanced technologies incubator), while small numbers indicate that a node is more central (AO(Governorate), CDP (Foreign Relations Policies and Programs), MF(Agricultural-Jihad Organisation), RUO (Major Owners of agricultural lands), ANREO (Greenhouses)). The peripheral actors are more isolated than central nodes. Closeness is a measure of the degree to which an actor is near all other actors in a network. It is the inverse of the sum of the shortest distances between each node and every other node in the network.

Finally, eigenvector centrality (Column 13 and 14), shows which nodes with high priority are connected to nodes that are well connected to other nodes in network. It is often interpreted as popularity or status: Hence, the actor with high eigenvector centrality not only has many connections, it has also ties to many well-connected others. The scores show that state government, AO (Governorate), MF (Agricultural-Jihad Organisation), FRPP (10-year development high technology plan), AB (Road and urbanisation Administration) and GR (Agricultural and Natural Resources Engineering Organisation) are connected to other nodes that are themselves well connected. The results and interpretations of the actor-network will be used in the next section to analyse the technology-driven transition trajectory in the case study of Rafsanjan.

Furthermore, the impact of involved actors in the transition of current agriculture to high-tech technology based on power and benefits indexes was analysed. Here, power means the accessibility to financial, political and legal resources for supporting the transition process towards high-tech agriculture. Moreover, benefits refer to financial, professional and social profit of this transition process achieved by organisation or people.

The list of potential involved actors from the previous survey was used for this survey. At first, the actors with a low priority value (less than 2.50) were not considered as the main focus of the research. However, the influence of all actors involved and their agency in configuration of relationships among actors were taken into consideration. The interviewees were asked to rate the power and benefits of each actors (actors that were selected in Section 6.3.2.1) by grading them 1 to

4, which is selected. Additionally, we asked the interviewees for non-human actors to grade power and benefit of the actor for its owner, organisation or agencies (Table 22).

Table 22. Degree of power and benefit of involved actors

		Actants	power	benefit
Human	**Public**	Technical and professional organizations	1.15	3.95
		Governorate	4.00	3.03
		Agricultural Bank	2.03	2.98
		Agricultural and Natural Resources Engineering Organization	3.88	2.03
		Road and urbanization Administration	3.88	3.03
		Department of Environment	3.93	3.93
		Municipality	3.88	3.00
		City Council	3.85	3.95
		Agricultural-Jihad Organization	3.85	3.93
		Rafsanjan Universities	1.00	2.95
		Natural Resources Organization	3.93	3.95
		Advanced technologies incubator	1.90	2.93
		Iran Pistachio Research Institute	1.13	1.05
		Agricultural Insurance Fund	3.08	3.00
		The village office (Dehdari)	2.00	3.93
	Private company	Agricultural Laboratory	1.05	3.95
		Agricultural Clinics	1.05	3.93
		Fertilizers and pesticide distributer companies	1.05	3.95
		Companies active in hydroponic agriculture	1.03	3.88
		Greenhouses	3.93	3.85
	Individual	Farmers, minor owner of agricultural land	2.03	3.98
		People	1.05	4.00
		University professors	1.10	3.00
		Member of Parliament	3.10	4.00
		Major Owners of agricultural lands	3.03	4.00

		Representative of the supreme leader (Imam of Friday prayer)	1.08	1.00
Nonhuman	**Technology**	Agriculture equipment	2.03	4.00
		Imported hydroponic technologies	3.95	4.00
		Hydroponic Technologies of the Interior Industry	3.85	3.98
		Greenhouse equipment	3.85	3.95
	Infrastructure	Pistachio Process Centers	3.93	3.90
		Dried pistachio gardens	3.90	1.03
		Pumps and water wells	2.88	3.95
	Representative nature	Agricultural products of greenhouses	3.95	1.05
		Pistachio	3.83	3.90
		water resources	3.85	3.98
		Weather	3.95	1.98
		Pistachio Gardens	1.05	3.93
	Rules and regulations	Detailed design and land use plan	3.90	1.03
		Country Development Program	3.93	3.98
		10-years development high tech agriculture plan	4.00	3.98
		Foreign Relations Policies and Programs	3.90	3.93
	Material	Fertilizer	3.90	1.05
		Pesticide	2.95	1.05
		Seed	3.90	2.98
		Gas	2.88	1.05

According to this study, agricultural Jihad organisation has been defined as the focal actor for the transition to high-tech agriculture in Rafsanjan. The activities of the Jihad-Agriculture Organisation are need assessment, planning, preparation, implementation and evaluation of plans and holding the training courses. Agricultural Jihad organisation presented a 10-year plan for the development of greenhouses in the country (2016-2025) as an obligatory passage point (see Chapter 2) for the transition to high technology agriculture. This plan like other plans and policies of Iran is a top-down process, so the highest and lowest authority are associated to the headquarters of the region and country's greenhouses, respectively which are supervised under the horticulture department of agricultural Jihad ministry. The national standard for the construction of greenhouse, the rules and regulation of greenhouse design and modification, the 10-year plan website management (horticulture.maj.ir) are explained in the 10-year greenhouse development plan.

The regional executor of the 10-year plan is responsible for following up the allocated credit based on the plan to establish pilot projects particularly the projects with innovation idea related to new technologies which aim to optimise water and energy consumption. Additionally, the regional greenhouse development executors inform, identify and direct applicants and investors, investigate and introduce competent financial and technical applicants, interact with the provincial governors and other related organisations to solve any problems related to greenhouse development, provide proper models for greenhouse cultivation and hold training and high technology agriculture science courses.

Interessement

The identified entities in the transition to high technology agriculture in Rafsanjan are public organisation, private companies, natural resources, technologies, infra-structure, national/local plans and policies and niche developers. In the interessement moment, the 10-year greenhouse development plan uses intermedia to attract the actants involved in the transition to high-tech agriculture. The 10-year development high-tech agriculture plan as a focal actor has to make other actors interested in transitioning to high-tech agriculture. Since all governmental actants, including Road and urbanisation administration and detailed design plan need to follow the Country Development Plan, they are interested in this transition. Improving the agricultural sector is one of the most important parts of the Country Development Plan.

Moreover, other actants such as Governorate, Municipality, Agricultural and Natural Resources Engineering Organization and Agricultural Bank are responsible for agricultural planning, controlling and delivering facilities in local scale. The latter actants can merely work after getting permission from the Agricultural Jihad Organisation. Foreign Relations Policies are interested in this plan as well because of the resistance economy policy.

Eliminating barriers to develop greenhouses, greenhouse construction without paying tax, holding the exhibitions related to greenhouse, providing facilities, giving export consulting, holding training courses, workshops and meetings, giving permission to establish small greenhouse inside of residential areas and supporting of agricultural knowledge-based companies that are active in high-tech agriculture are mentioned as intermedia in the 10-year plan.

Enrolment

The third moment of puncualisaition is named the enrolment moment. In this moment, actants enrol in the network and accept their roles through negotiations with the executor of the 10-year greenhouse development plan and the plan defines the way that actants relate to one another within the actor-network. Involved actants in the transition process would only become enrolled in the network if they find out that their interests align with others within it, handing over the power to the focal actant to act, control, and co-ordinate actions of the network to achieve their goals. The enrolment of the actants occurred through the facilitation of processes of greenhouses development, giving facilities and loan to establish and develop greenhouses and after presenting their plan.

6.3.2.2 Mobilisation

In the last step of punctualisation, actants require a representative to speak on their behalf. This representative candidate should interpret the interests of human and non-human actors. In this

study, the public relation office of the Jihad Agriculture Organisation which attempts to create interaction among involved actants, is defined as the representative. The public relation office as a member of the public relations committee and public institutions have several tasks such as communication with the media, authorities and people, holding conferences, ceremonies and exhibitions, publishing and releasing brochures, CDs, catalogues and posters, advertising, researching and supervising the projects.

6.3.3 Re-entanglement

In the final stage of transition, re-entanglement of the actor-network of transition is shaped. This step stabilises the incumbent sociotechnical regime through the creation of new social practices. The actor-network of transition towards high-tech agriculture has been shaped through the alignment of interests among various stakeholders, such as governmental organisations, the private sector, and knowledge institutes. The transition trajectory is defined by the interplay of the involved actants from various levels over time.

Technical control and monitoring of the transition process are conducted by the agricultural and natural resources engineering organisation, agricultural bank and Agricultural Jihad Organisation. While the process of getting permission from several offices and organisations (see

Figure 57) to establish the greenhouses is an obligatory step, it is not needed for small greenhouses.

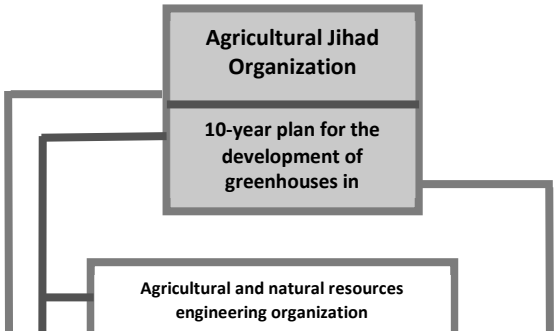


Figure 57. Re-entanglement steps

As indicated in Figure 58, science-based companies are considered as an intermediary to transfer knowledge from universities and science centres to the agricultural sector.

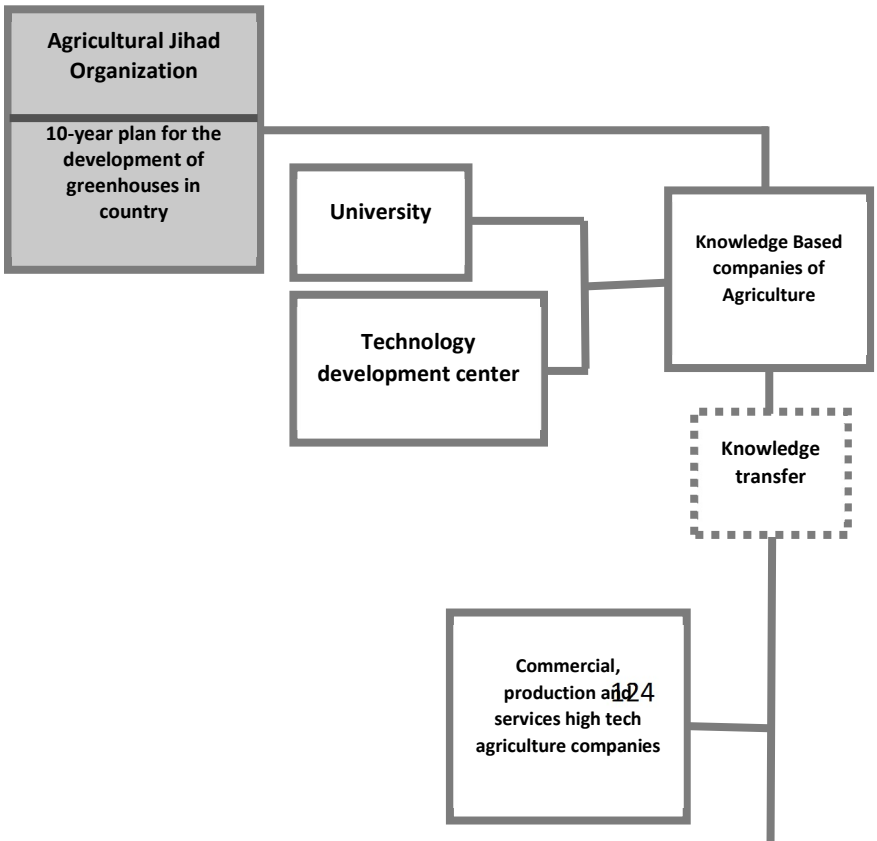


Figure 58. Re-entanglement steps

In Rafsanjan, pistachio fields would manage by major owners who have the ability to manage the pistachio cultivation process using new methods and technology. Therefore, by decreasing the number of owners, the Agricultural Jihad Organisation can monitor and supervise the pistachio cultivations process easier than before (

).

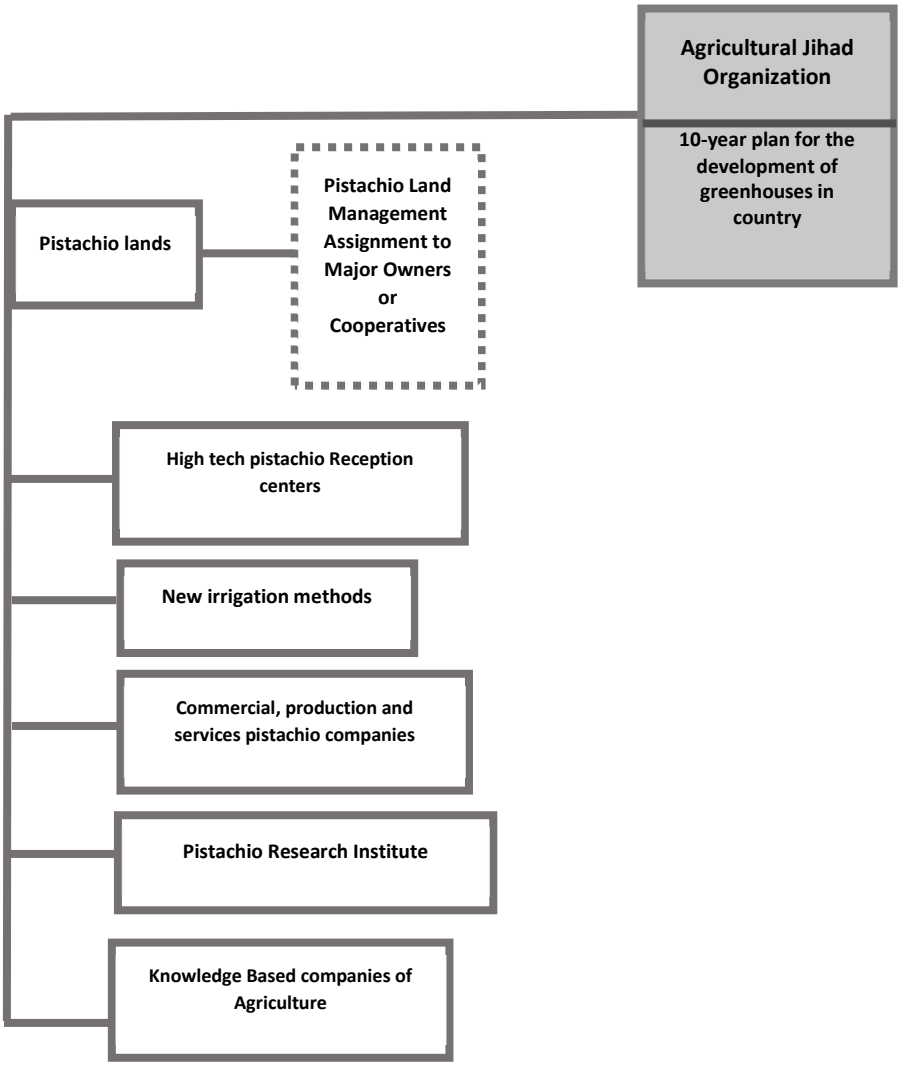


Figure 59. Re-entanglement steps

Actants achieve their initial goals though continued loyalty to their role in the actor-network of transition. The re-entanglement of new assemblages in sociotechnical regimes is a result of successful translation. Collective actions, development of infrastructures, and formulation of policies and regulations open windows of opportunity for new assemblages to replace themselves in the regime. Therefore, new material (technologies) will be adopted in agricultural section, new social competences and businesses will emerge, and new cultural meaning will be created over the time. In this stage of transition, high-tech development practices and new social practices will be formed. Re-

entanglement of high-tech agriculture results in transition of the agricultural sector. In the re-entanglement phase, the technological novelties will enter the regime level (Figure 60).

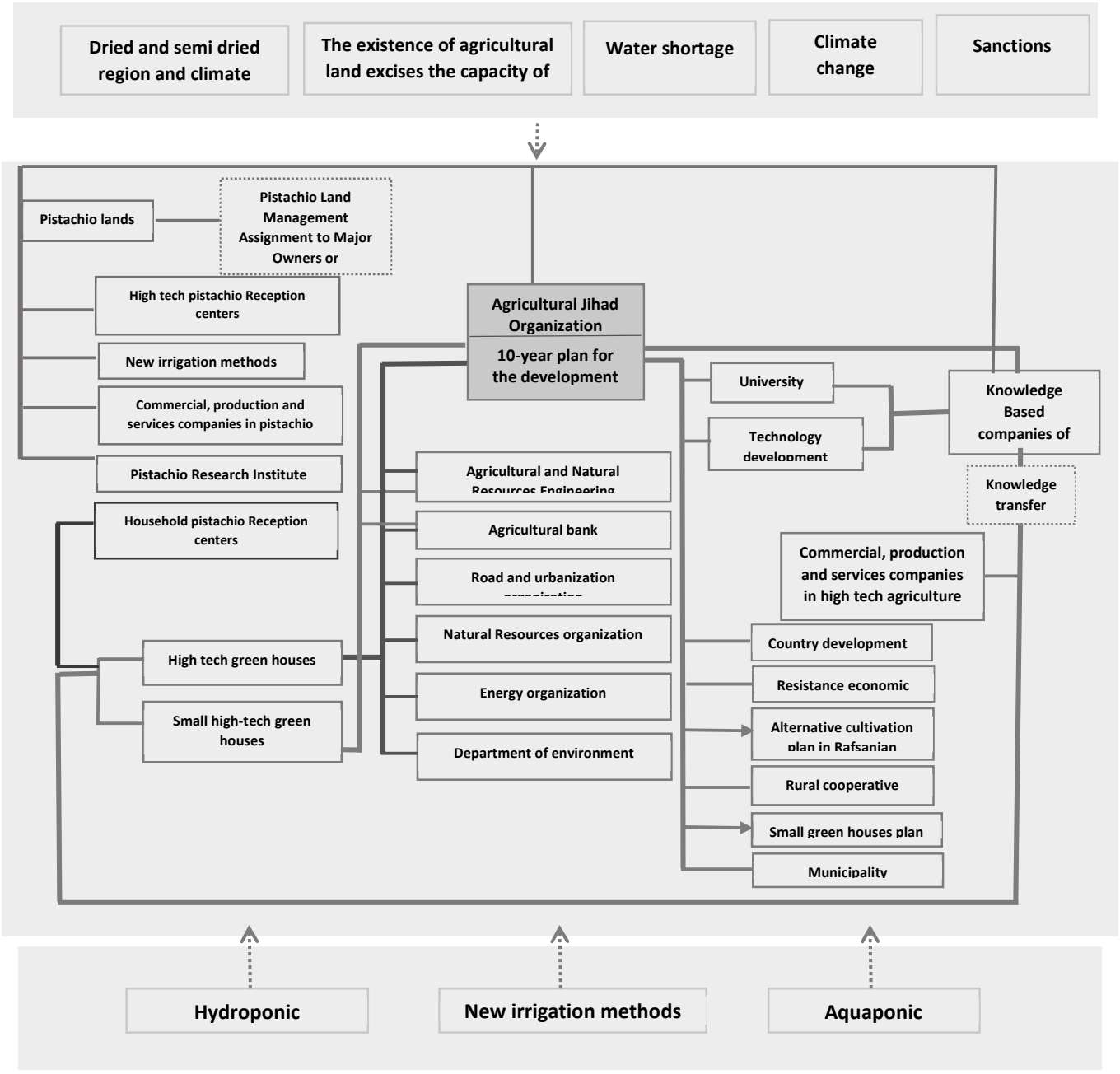
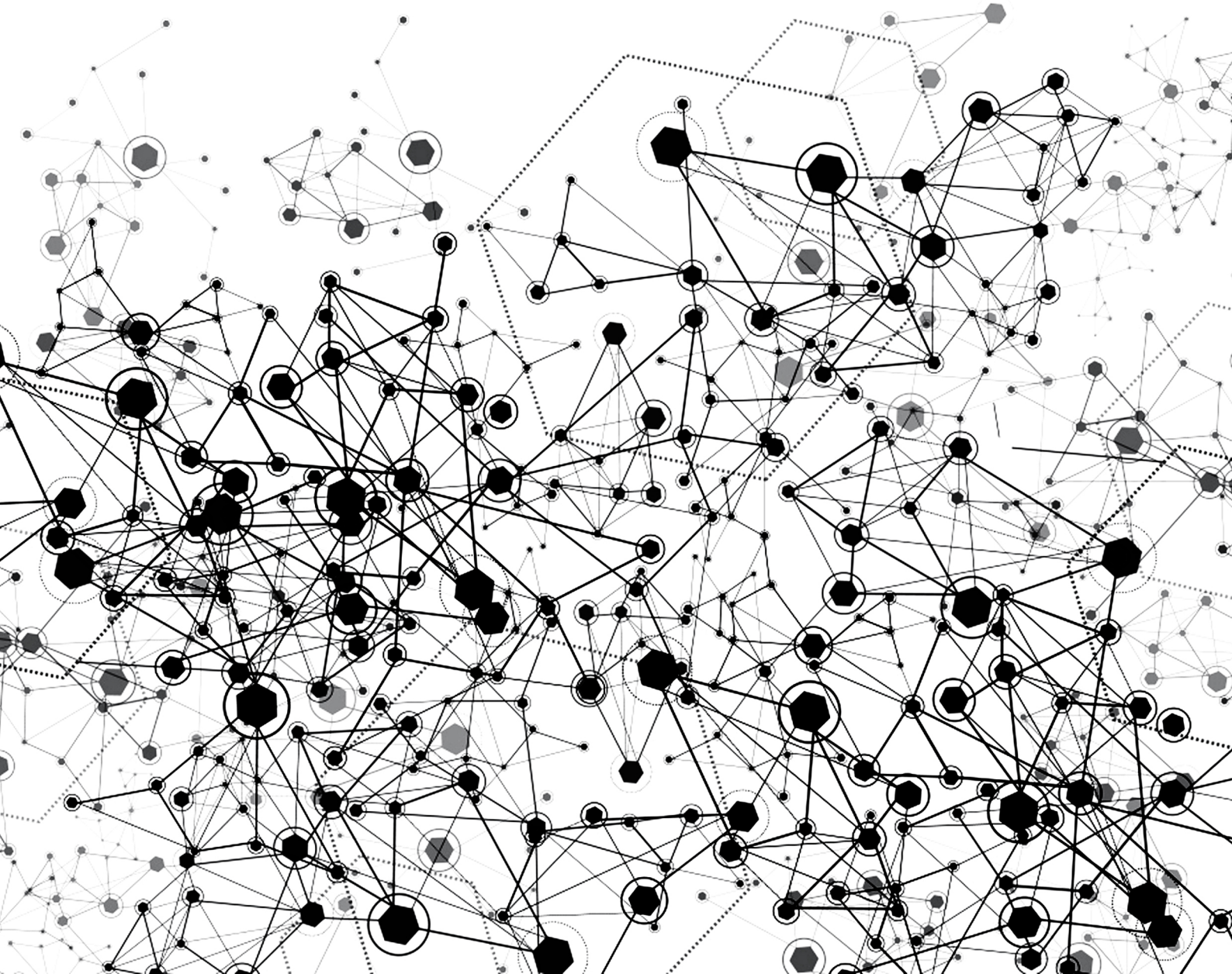


Figure 60. Illustration of the actor-network of transition to high tech agriculture

Chapter 7

Discussion and conclusion



Introduction

In the present study, as we mentioned in the first chapter, our main question was: " how development polices and development plans affect configuration and reconfiguration of social and material entities and determine the possibilities and constraints in the transition of conventional agriculture to high-tech horticulture in the County of Rafsanjan?". To answer the main question, first we defined two sub questions (see first chapter) and accordingly, we first studied the regional development plans and policies and then we detected the human and non-human actants and finally we analysed the effect of actanst and policies/plans on the transition process. To this aim, the availability of resources of knowledge and technology in the region has been collected by interviewing the experts, local people and authorities, observations, reviewing the documentaries and literature as well as conducting surveys. The collected information has been examined and analysed to answer our main question. In this study, we attempted to describe the current transmission of high-tech situation in Rafsanjan using a model named the "TT model" which itself is a combination of two well-known ANT and MLP models. Generally, the transmission process is described in the three steps of the TT framework which are disentanglement, punctualisation process and re-entanglement (see Section 2.4). The proposed TT model indicates how current environmental and social problem led to disentanglement of the social-technical regime of Rafsanjan, and then how a successful niche candidate can inter to socio-technical regime and try to fix the regime.

7.1 Theoretical implications

As we mentioned before, in this study, the current transmission of high-tech situation in Rafsanjan has been explained using the "TT model" which is a combination of ANT and MLP models. Latourian ANT insists that networks are not bigger, but they can be longer or more intensively connected. This is in contrast with top and bottom in social theory (top down and bottom up) (Latour, 1990). In line with latour's definition of networks, this study also concludes that it is rather how an individual actants become a collective or how individual actions result in collective actions and vice versa. Transition can be seen as the way poorly connected individual actants become well connected actants. Spatial dimensions (local and global) are not the focus of the study but what is studied is whether actants are connected. When there is connection, the network is expanded. Networks are important and the agency of actants in creation of them. These networks are influenced by context and in particular with cultural aspects. The context dependency of actor-networks is in conflict with Latourian. We argue that the relationship between human and non-humans and non-humans with each other creates sociotechnical systems that allow performance of everyday practices. But what makes humans and non-humans (especially technologies) different is that technologies (machines) can be multiplicated. Therefore, two or more nonhumans with identical characteristics can exist in two different places at the same time. However, the performance of these non-humans can be different, and they can establish different relationships with other humans and non-humans. That is due to the impacts of environmental, cultural, political or institutional contexts on the actor-networks.

This study attempts to improve the theory of TT. The TT theory that is used in this study conceptualises the trajectories of technology-driven transitions. It aims to explain how technological

novelties emerge and change the sociotechnical systems. It looks at both bottom up and top down transition pathways.

The TT adopts the flat ontology of ANT or the concept of general symmetry, the concept of translation, immutable mobiles and blackboxisation and combine it with the analytical levels of MLP. It does not only focus on bottom-up niche developments and without considering the MLP levels as a way to divide actors based on their agency or beingness which would be in contrast with the flat ontology of ANT. The levels are only categorising the actants for the simplification of analyses. One of the contributions of this study to the theoretical framework of TT is the theory that is developed in this study that actants are not context-dependent and there is no context to limit their agency. But the influence of context and culture on the technology-driven transition is considered as translation is studied within the creation of new regimes which are affected but every aspects of the context (cultural, political, institutional and economic). The trajectories can be summarised as follow: First, the landscape pressures force the regime to create new sociotechnical systems. Second, the new systems are affected by technological novelties. These novelties are emerging through landscape pressures on incumbent industries/firms and their efforts for creation of novelties or the regimes instability opens window of opportunity and niche developers use the chance (bottom-up) or governments organise R&D projects and plan for the change (top-down) or landscape pressure directly inspire niche developers to come up with solutions to avoid future problems (before regime become unstable). Third, after the development of novelties in niche level through incumbent firms, bottom-up niche developments or top-down strategies the technological novelties need to become part of regime and shape new sociotechnical systems. The creation of new sociotechnical system (the punctualisation process) happens in four moments of translation. Therefore, an actor network shapes which supports the adoption and adaptation of novelties in the sociotechnical system. The results (how technologies become translated) are dependent on the context as well. For example, cultural values can change the way in which immutable mobiles are adopted in new systems. Thus, the same novelties can be transferred in different places and keep their characteristics but the cultural context will change the ways they will be used by social entities and therefore the final results (products of novelties) will be different in each context. Finally, in the last stage, technologies become locally diffused and shape new practices.

Accordingly, our results indicate the disentanglement and instability of socio-technical regime of Rafsanjan occurred due to some pressures from landscape on the current agricultural system. The most important source of pressures is associated with the decline of quality and quantity of water which is the result of climate change and improper use of underground water. However, there are some niches resulting from available disentanglements, and are trying to fix the regime. The result of our survey showed that while some created niches were effective in the transmission process, others create extra pressure on the current regime. Hydroponic greenhouses are one the niches which could be introduced to the regime and are able to entanglement of the regime. In punctualisation of transition to high technology agriculture in Rafsanjan, a network of defined social and material entities including human actants (public, private company, individual) and non-human actants (technology, infrastructure, representative nature, regular, material) was shaped. The actants are influential or influenced in the transition to high-tech agriculture of aligned interests.

After analysing the actants and their relationships, power, effect and value of actants were determined. Since, the decision-making and implementation of policies and plans in Iran are based on the hierarchy of politics, the actants related to governments have higher power in the transition

process compared to other actants like universities and private sectors which are considered as effective actants in the network.

Furthermore, in this study, the Jihad Agriculture Organisation, which is managed by the Iranian Ministry of Jihad Agriculture is defined as a focal actor. A "10-year plan for the development of greenhouses" (6.1.2) has been detected as the OPP (see Section 2.3.1) for all involved actants in this study by Jihad Agriculture Organisation. The 10-year plan has been used to convince other actants to alliance for the transition to high technology agriculture. The main objectives of this plan is expanding greenhouses and developing high-tech agriculture via several intermediaries (Section2.3.2) such as supporting the private, science-based companies and small business, holding the exhibition, courses, meetings and workshops and decreasing the taxes for building the greenhouses. The involved actors can be enrolled in the network of transition to high technology agriculture by accepting their roles through negotiations with the executor of the 10-year greenhouse development plan after presenting their plan. In Rafsanjan, the public relation office of the Jihad Agriculture Organisation is known as the representative of actants and attempts to create interaction among involved actants.

7.2 Empirical findings

All evidence used in this study emphasises the importance of the transition from current agriculture to high-tech systems. However, the transition process is described and planned using the TT model which is explained in detail in previous sections and chapters. In Figure 61, the findings and results are summarised by illustrating the TT model in a hierarchical environment.

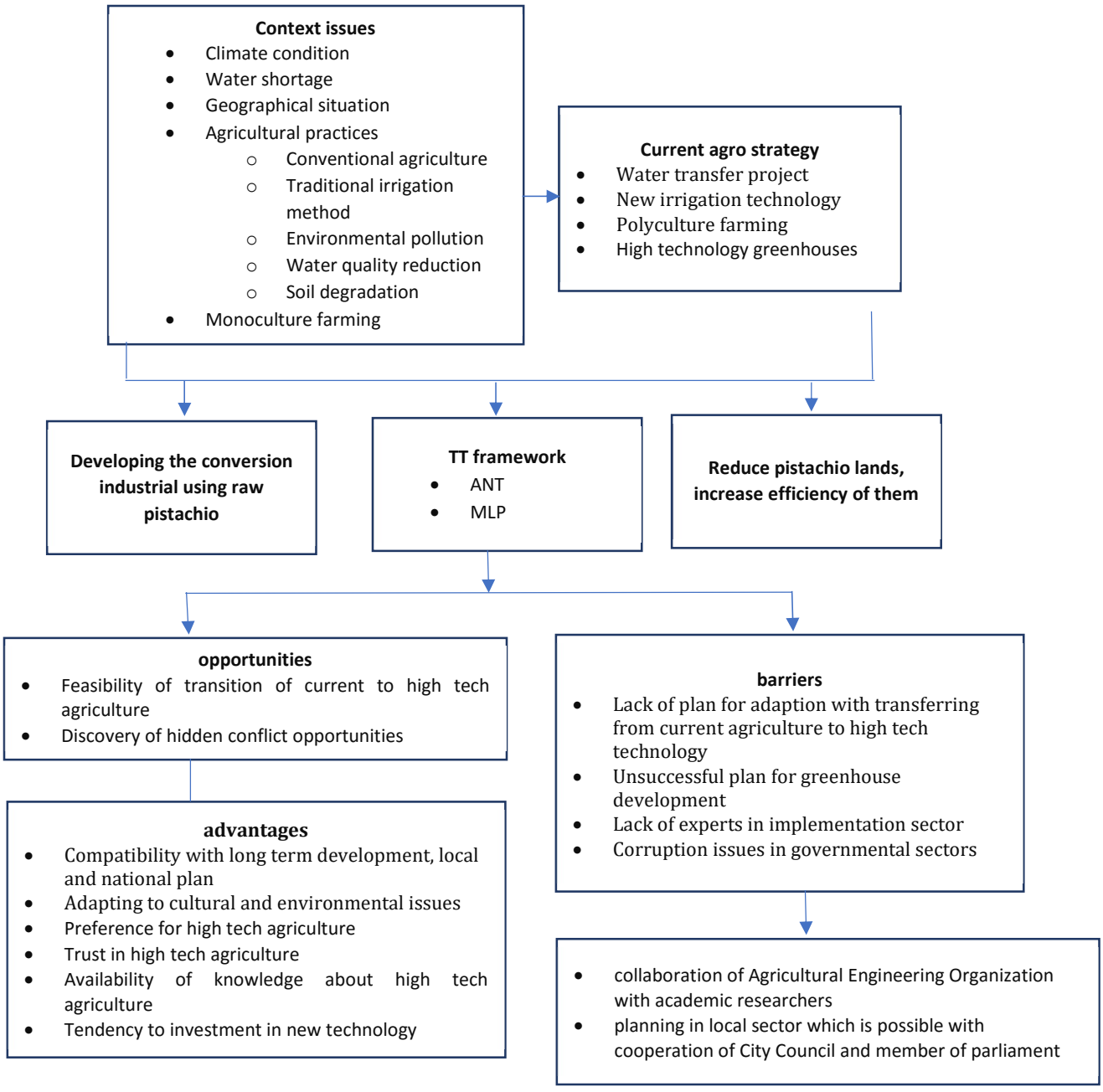


Figure 61 Translate model (TT) within a hierarchical environment

The County of Rafsanjan is an agricultural area located in the southeast of Iran, in a desert and semi-desert region with scarce rainfall. The economy of Rafsanjan is dependent on pistachio monoculture which is considered as one of the most important and valuable export products in Iran. As the documents show, cultivating pistachio in Rafsanjan became popular and has been replaced with other crops since 1956 because of the high price of pistachio, extracting the underground water using immobilisation instruments, government policy for dividing the lands (land reform law) pistachio.

The most important advantage of monoculture farming is related to increasing the efficiency, maximising the yields and higher incomes because of focusing on only one product which leads to developing existing knowledge, methods and experience about the cultivation and producing that particular products. Thus, these positive aspects of monocultures persuade the people to continue cultivating the pistachio as a single plant and the infrastructure of agriculture in the region has been constructed merely based on pistachio monoculture process for a long time.

After the revolution and until 2009, the pistachio cultivation area was increased dramatically (Abdollahi et al. 2011; Iranian Statistics Centre, 2017; Mehryar et al, 2016; Rezaei et al, 2003). While monoculture pistachio farming was considered a very attractive agricultural practices to earn more money, it creates several problems in the region. Generating the resistance cultivars against pesticides, environmental pollution due to extra usage of pesticides and fertilisers, water crisis, reducing the biodiversity and soil degradation are some important eventuality of monoculture farming. Among all mentioned disadvantages, according to the interview and the current surveys, water shortage is the most important factors which led to reduction of the pistachio cultivation area after 2009 (see Section 5.5). Based on previous studies, water shortage has several consequences such as increasing plant diseases, increasing salinity of soil and consequently, reducing soil fertilisation, reducing crops, livestock, and gardening (e.g. Abdollahi and Javanshah, 2006; Sedaghati and Mohammadi, 2009).

The literature and documents indicated that although people did not have any idea about water shortage issue in the county for a long time, the governmental organisations were aware of the critical water situation in the region for at least four decades. Apart from climate conditions, several activities such as the used traditional irrigation methods (e.g. traditional hurricane or stacky manner) and extracting a huge volume of water by drilling machines and watering pumps with low price especially after the Islamic Revolution (1978) when there was no sufficient control on the agricultural process for a long time, increased the water scarcity issue.

Although pistachio has been considered as a resistant plant against drought shocks, the studies show that increasing the irrigation period and decreasing the consumed water led to multiple stresses and sometimes caused serious damage to the plants. During the past years, all governmental efforts and projects to manage and control the water shortage issues in the region failed (e.g. transferring water Karoon River located in southwester of Iran to Rafsanjan and development of new irrigation methods) (eg. Abdolahi, 2007; Abdolahi et al., 2005; Mohammadi & Sedaghaty, 2011). However, water scarcity in Rafsanjan is the result of interaction among several actors and actions such as technological issue, assigning low budget to create facilities and structures, climate change as well as social and political variables (Abdolahi et al., 2005; Mohammadi & Sedaghaty, 2011). In the present study, we merely focus on political and sociological variables, which directly or indirectly affect water crisis.

Our research shows that the following social and political issues can be considered as the causes of water shortage in Rafsanjan, which is in agreement with the results of other surveys (Abdolahi et al., 2005; Mohammadi and Sedaghaty, 2011; Qureshi et al., 2001; Vatanperast, 2017):

1- The emphasis on self-sufficiency as a political issue has an effect on increasing the agricultural production. However, the increasing process of agricultural activity does not necessarily lead to the development of agricultural sector.

2- The low price of consumed energy including water in Iran and allocating the governmental subsidy led to extraordinary use of water resources. This can be considered as a reason why new irrigation methods have not been accepted by the majority of farmers.
3- The lack of appropriate infrastructure to create job vacancies in industry and other sectors rather than agriculture over the past decades led to tendency of people and investors to agricultural activity which worsened water shortage.
4- While farmers are aware of the problem of water scarcity in the region and water shortage has been introduced as the most important constraint for agricultural activity in Rafsanjan for several years, still extra and non-standard extraction of water for irrigation of the pistachio fields happens due to the lack of trust regarding the government and ignoring their warnings.
5- Because of the high cost of new irrigation methods and low price of water, only major landowners use them and new methods are not economical for the owners of small pieces of land. However, it is observed that even major owners, who are new irrigation system applicants, use the saved water for creating new pistachio fields or for over-irrigation of their land, thus practically the used new methods do not have an effect on water storage (Interviewees with expertise on actants: 61).

While statistical reports and the result of this study (Section 0)indicate the decreasing pattern of pistachio fields in Rafsanjan over time due to the negative aspects of monoculture farming like water shortage which were mentioned earlier in the previous paragraphs, pistachio industry is still the first economy activity of the region. As a result, to find the best solutions to control and manage the problems caused by monoculture pistachio systems, we collected data from the literature, documents and interview (Interviewees with expertise on actants: 10, 18, 35, 51 and 61) with experts and authorities. Accordingly, to reach sustainable agriculture and overcome present agricultural problems, switching from monoculture to polyculture farming has been suggested as an essential plan by experts. To this aim, it is needed to keep pistachio cultivation in some parts of the region because of the economic value of the pistachio and also find some alternative crops which can survive in Rafsanjan climate.

To find the best way for improving pistachio production systems and increasing the yields of pistachio we used available reports and statistics obtained by the University of Rafsanjan, pistachio institute and private Urban Laboratory of Rafsanjan. According to all references because of extra usage of fertilisers, farmers are facing with soil degradation in the majority of the City of Rafsanjan. The interviews and surveys indicated that the present fields inside cities need to be converted functionally due to social and environmental problems they caused.

As mentioned in Section 4.3, the pistachio fields cause several social problems such as insecurity which occurs particularly during the harvest season because of arrival of domestic and foreign workers or drug addicts. Additionally, the gardens are a shelter for stray dogs which are often vector of pathogens such as rabies because of their inadequate living conditions. Moreover, the effect of pistachio cultivation on environmental pollution (due to extra usage of pesticides and fertilisers) are undeniable. Based on water analysis reports, the percentage of Arsenic in drinking water is increasing dramatically due to extra usage of pesticides as well. Furthermore, Rafsanjan more than any other agricultural region in the country, has possibly been adversely affected by land subsidence due to the destruction of underground water resource. Thus, all of these factors are the reasons why the experts recommend limiting the pistachio cultivation outside the city where there are suitable

conditions for the cultivation of pistachio. According to the annual reports of the Urban Laboratory, two regions located in the north and western-south of Rafsanjan named “Ferdos and Noogh” and “Kabootarkhan” are the most suitable places for the cultivation of pistachio. The result of soil and water analysis revealed that these areas have water in high quality and quantity which increases the efficiency of irrigation systems. Moreover, the soil of these area is fertilised and have suitable structure for cultivating the pistachio. The location of the mentioned area is shown in

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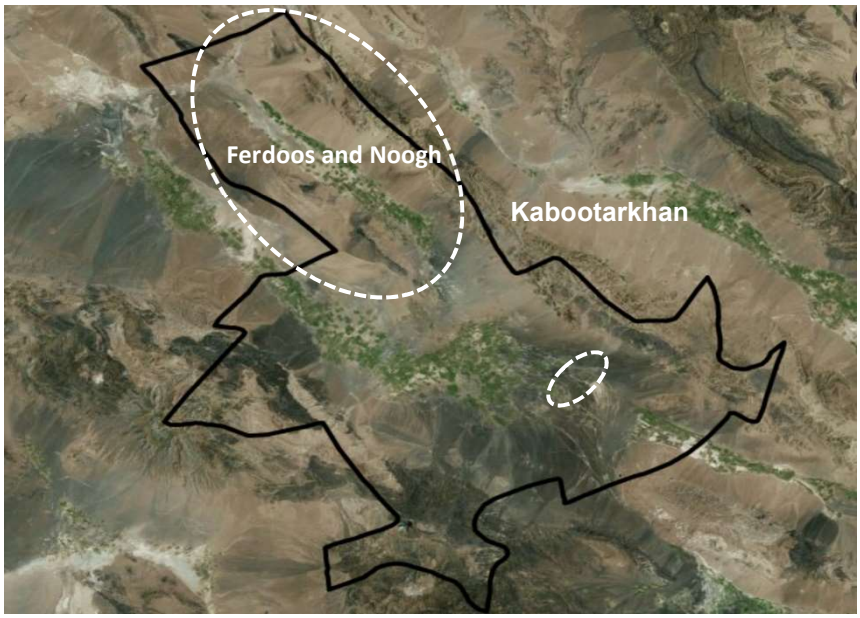

Figure 62. Location of the area suitable for pistachio production

According to the results of interviews, another solution to activate the pistachio industry is to focus on the conversion industry by converting raw pistachio to other products. The conversion and packaging industries of pistachio like other agricultural products can lead to high accounting profits. Pistachio crop can be used in the production of ice cream, pastries, chocolates, sausages, etc. Although the Pistachio Research Center in Rafsanjan has several projects to produce some pistachio-based products such as pistachio butter, pistachio milk, pistachio chocolate, pistachio "Halva", and a type of activated coal, pistachio is mostly exported as a raw crop. The main reasons why exporting converted pistachio to other countries failed can be due to lack of sufficient government funding for research activities in the conversion industry and lack of updated equipment in the conversion industry because of economic sanctions from the United States.

Furthermore, in order to maximise the yield of pistachio, it is necessary to increase the efficiency of agricultural practices. According to the reports and literature (Abdollahi et al. 2011; Iranian Statistics Centre, 2017), before 2012, Iran was the leading pistachio producer across the world. The commercial varieties, higher kernel to in-shell ratio and famous taste of Iranian pistachio made it more demanding than other pistachio types. After the year 2011, the United States dominated the pistachio production in the world by maximising the yield crop using modern and innovative methods during cultivation and decreasing the amount of consumed water per produced kg of dried

pistachio. Thus, the agricultural system of the USA can be used as a template in the pistachio field of Rafsanjan. The most important obstacle to high-tech agriculture is the high cost of the systems which are not desirable and affordable for small owners. A survey conducted by Ahmadi et al. (2016) revealed that the smallholders play an important role in the unsustainability of pistachio agriculture in Rafsanjan. Moreover, according to the interviews of the survey in this study, experts believe that one of the solutions to solve the problems of agricultural pistachio section is managing the pistachio fields by major owners, who use scientific methods in agriculture and adopt high-tech irrigation methods. However, managing the pistachio lands by major owners leads to an increase in the number of unemployed people with small pistachio fields. Hence, finding a job in Rafsanjan as an agricultural region can be considered a huge challenge.

As a solution to create new job vacancies, local experts and authorities have addressed to transition of current agriculture to high-tech agriculture (Interviewees with expertise on actants: 32, 51, 61). This result is in agreement with the results of a survey conducted by Jalilvand and Nori (2010) in the provinces of "Sistan and Bluchestan" in Iran where there is serious water shortage as well. The author of the paper concluded that hydroponic agriculture is the most appropriate solution to solve some social problems such as immigration. Vahedi et al (2017) also introduced hydroponic agriculture as a proper activity in investing and creating new job vacancies which can be resulted in the economic development of the country.

Furthermore, as mentioned earlier, converting the monoculture system in Rafsanjan to a polyculture one, it is needed to find an appropriate alternative crop which can tolerate the climate condition of Rafsanjan. Considering the water shortage problem, dry weather and low-quality soil, a few types of crops such as Saffron, medical herbs, barberry and Damask rose can be considered as alternative crops in some special parts of the region but not everywhere. Growing a broad range of plants without considering the environmental condition can be possible by creating the closed greenhouses. The disadvantages of soil greenhouses, such as the spread of fungal and bacterial diseases and lowering the quality and quantity of products due to contact with the soil as well as dis-absorption of the elements due to inappropriate pH, can be resolved by building the hydroponics greenhouses. The hydroponic planting systems produce healthier yields with low workload by using an optimal amount of water and fertilisers and maximising quality and quantity. The largest hydroponic greenhouse of the southeast of Iran, which is 13,000 square meters long, is under construction in the County of Rafsanjan. As a result, based on this study and previous surveys, the transition of current agricultural system to high-tech will keep agriculture alive and improve the quality of life in Rafsanjan. In the next step of this research, we attempted to study the feasibility of the plan. In order to do that, data has been collected to study the trust of people about hydroponics systems and the availability of relevant knowledge about these systems in the society. Therefore, we have gone thorough documents to find whether there is sufficient governmental support in terms of applying high-tech agriculture in the region.

According to the results of the survey (see Chapter 6), the residents of Rafsanjan believe that the current agriculture has a negative impact on the region. The negative aspects of current agricultural activities in Rafsanjan, such as increased air pollution because of over usage of chemical products and pesticides and destroying natural underground water, to increase pistachio products, have been confirmed in previous studies as well (Dehhagipur and Mirzai 2015; Rahimpur and Memarian 2016).

Based on the survey presented, more than 53 percent of people believe that high-tech agriculture is a solution for current agriculture problems in Rafsanjan. Water shortage, air and water pollution

(caused by fertilisers and pesticides), economic benefit and successful experiences of people who worked in this field are the reasons why people encourage the transition of current traditional agriculture to high-tech agriculture. The majority of people who agree with this selected hydroponic agriculture which is introduced by university and well-advertised as the best replacement for current agricultural activities. Furthermore, the results revealed that most people in Rafsanjan prefer using crops which are produced through hydroponics methods as they believe that hydroponics products are healthier than other products due to less consumption of chemical pesticides and fertilisers. The conducted surveys in other cities of Iran, where there is water shortage, found high technology agriculture, including hydroponic and aquaponics systems as the best replacement for conventional agriculture systems (Alizade and Sodaeizade 2018; Shaker and Hosseinnia 2016; Danieifar and maazed 2017; Jamshidi and Mansouri 2012).

Based on this study, the most important factor for accepting the hydroponics systems is the information and education level of the investors. These results are in agreement with Nejadrezaei et al. (2015) and Alibeygi et al. (2011) who showed the importance of the education level of farmers in terms of accepting new technology in agriculture.

In this study, the University of Rafsanjan has been recognised as a major actor in the transition process from current situation to high-tech agriculture by supporting knowledge-based companies which are under the supervision of the "centre of technology and development". These companies are, indeed, a centre for information and knowledge exchange between the university and the agricultural industry.

The data collected from interviews shows that the accessibility of experts and researcher to the new knowledge about the high agricultural technology is medium. Based on the interviews, the most important barrier for experts and researcher to acquire new knowledge is the difficulty of participation in international communities and conferences, and the majority of all participants believes that the level of collaboration between experts and local authorities is sufficient. Additionally, holding the meetings is considered as the most effective way for gathering and communication of experts and authorities.

Thus, according to the results obtained, it was concluded that the society of the County of Rafsanjan and public attitude towards applying high-tech agriculture, particularly hydroponics systems, are positive, and the level of knowledge is increased by the effort of university and communication among experts. But due to the top-down approach of policy decision, to have a successful plan for converting the agricultural system, governmental support is necessary. Available documents indicate that current governmental policies and laws, such as 5-year national development plan, resistance economic policy, agricultural ministry policy and 10-year development greenhouses plan, support the establishment of high technology greenhouses and small-scale greenhouses (less than 3,000 square meters) in residential areas. According to land use rules, the owner of agricultural fields inside a city cannot change the application of their pistachio fields from agriculture to other commercial types but can start up other agricultural activities including the construction of greenhouses without any legal permission. While the establishment of huge greenhouses (minimum of 3,874 square meters) is a rather lengthy process, building a small-scale greenhouse (less than 3,000 square meters) in rural and urban areas can be completed in a short period. Therefore, due to the mentioned law and policies as well as other issues like water shortage and special environmental conditions of Rafsanjan (see Section 6-1-2 and 6-1-3), constructing hydroponics greenhouses can be considered as a feasible economic activity for the owners who want to change their land use.

The information gathered through in-depth interviews indicates that although all mentioned factors are supporting the idea of transition to high tech, plans are facing several organisational barriers. These results are in agreement with other surveys (Saliami et. al 1393; Seifaldini and Penahandekhahthat 1389 and Motevaseli et. al 1397). In conclusion, although the hydroponic system was a well-known method for the participants of this survey and around 50 percent of them tended to invest in hydroponic, most of them were not satisfied with the governmental rules and laws associated to the establishment of hydroponic greenhouses. Jalilvand and Noori (2009), who performed a similar survey in the eastern part of Iran, concluded that replacing hydroponic cultivation requires proper planning and more government-provided facilities and investment.

Generally, according to the collected data, some of the known barriers for the transition process to high tech are:

1- Based on the data collected in this study, the best way for switching from monopoly cultivation to polyculture is applying high-tech agriculture in the region. However, all the infrastructure, structure and equipment of the region are only prepared for the cultivation of pistachio. Therefore, apart from the policies which support high- tech agriculture in the region, there are is vision or plan for the region to adapt current infrastructure, structure and equipment to high- tech agriculture.
2- Unsuccessful practical executing of a 10-year plan for greenhouse development is a second obstacle facing the transferring process. Decision making of agricultural and development policies and plans in Iran is top-down, with the best experts, planners and policy makers of Iran. Each plan has been approved regardless of the actual situation of every region especially at county level such as Rafsanjan. Moreover, there is no expert in the region to manage the transferring process and localise the plan by adopting the national plans with region conditions. Also, usually, there is not any appropriate cooperation between authorities of the plan, organisations and between private and governmental sectors. As a result, planning and policymaking do not take into account the environmental and social characteristics of the region and merely emphasise the details of the rules as opposed to the main objective set by plan implementers.
3- Authorities and those who are responsible for the management of the plan presented unrealistic goals, without having a realistic perspective on the agricultural transmission process in the region due to lack of enough knowledge. The most important scientific source for high-tech agriculture in the region is universities; however, the universities of Iran usually have very poor communication with implementation, technology and development centres. Recently, new established science-based companies are considered as a policy to transfer knowledge from universities and science centres to the agricultural/industrial sector. Although, the science-based companies of Rafsanjan were successful in connecting universities with the private sector, the communication between universities and authorities is still insufficient. Thus, despite holding annual meetings and seminars to improve current communication, the activity of decision makers in Rafsanjan is not according to regional research done by universities. In order to fill this gap, it is needed to establish a centre as an intermediary between universities and authorities to solve the problem associated with lack of experts in the implementation sector.
4- Besides the mentioned organisational barriers, there are some other informal, economic and social obstacles such as corruption issues in governmental sectors, irresponsibility of executive of the plan and lack of trust to the governmental sectors.

7.3 Comparing the agricultural transition process in Rafsanjan with other cities

The transition to high technology in Rafsanjan was compared with Shanghai and Amsterdam as being successful cites in the agricultural transition process, which is studied in a survey conducted by Hosseinifarhangi (2019).

The results of the study of Hosseinifarhangi (2019) show that the implementation of policies and plans which are related to high technology agriculture and their adoption into the practices in Shanghai such as Iranian cities occurs by top-down decision-making, as such the grassroots initiatives have an important role in the development of innovations and development of high-tech agriculture. However, innovations and the development of technologies in Amsterdam are dependent on grassroots initiatives, and "the involvement of bottom-up forces in Amsterdam is organised through top-down approaches to policy implementation".

Furthermore, in agreement with the results obtained by Hosseinifarhangi, which indicate that, unlike developed countries, the aim of application of technology in agriculture in developing countries is "producing knowledge and developing cutting-edge technologies for alternative food production methods that are more sustainable, circular, and climate change-resistant to improve social cohesion as well as developing and exporting knowledge and technology". In Rafsanjan, producing food and the resistance against current social and economic pressures have been considered as the main aim of adopting technology in agriculture

7.4 Conclusion

In the thesis presented, the Rafsanjan County has been selected as the case study to analyse the transition process from the current agricultural situation to high-tech agriculture. This county is located in the south-east part of Iran with a dry and semi-arid climate. Rafsanjan is the most important pistachio cultivation centre in Iran and has an important effect on the global pistachio market. Recently, the region has been facing several social, environmental and economic challenges due to cultivating the pistachio as a monoculture product inside and outside the county.

According to the data collected during this research, which were obtained from several surveys and communicating with experts and authorities, the best policy to overcome current social, environmental and economic issues (e.g. water shortage, air and soil pollutions, and unemployment) resulted from monoculture systems, is to adopt a polyculture system. In other words, it will be required to limit the pistachio cultivation in some parts of Rafsanjan and find alternative crops besides pistachio. As a result, it is suggested to eliminate the pistachio fields within the city which may lead to social and environmental problems. Furthermore, based on the presented survey, it is suggested to keep the pistachio fields available, which are located outside the cities where there are fertilized soil and appropriate conditions for producing high-quality pistachio. Based on all available reports, three regions named "Kabootar-Khan (South of Rafsanjan), Noogh and Ferdoos (North of Rafsanjan)" have been selected as the best regions for this aim. Also, in order to improve the pistachio cultivation process and increase the efficiency of the producing systems, it is necessary to use up-to-date and modern high-tech methods for the irrigation and cultivation process. Since the high-tech

agricultural systems are rather expensive, to have sustainable agriculture, the pistachio fields should be managed merely by main owners who exert effort to provide such systems. Ignoring the small owners from pistachio industry lead to increasing number of unemployment.

Furthermore, hydroponics systems have been selected by experts, authorities and the public as the most appropriate high-tech systems, based on the environmental and climate condition of Rafsanjan to plant a variety of crops which cannot naturally grow in Rafsanjan. These new technologies can also be considered as an opportunity to create new job vacancies for the locals. Thus, in order to do this and, at the same time, solve the problems related to growing alternative crops which cannot naturally grow in the climate of of Rafsanjan, building high-tech greenhouses, particularly hydroponic greenhouses, has been selected by experts, authorities and the public as the most appropriate high-tech system.

Applying high-tech agriculture and the transition process from current agriculture systems need special infrastructure, governmental and public support and knowledge. The feasibility of the transition process has been performed in our study by conducting surveys, interviews and collecting data from documents and the literature. The results reveal the trust, desire and existence of enough knowledge provided by the University and Institute of Rafsanjan. Additionally, there are sufficient laws and governmental support to implement such projects. The only problem, which is considered the barrier for the transferring process, is related to non-efficiency of the laws which creates a gap between the theoretical and practical aspect of the transition process.

In order to describe and plan the transition process from current agriculture to high-tech, a model named "TT model" has been used in this study. This model, which contains three steps (disentanglement, the punctualisation process and re-entanglement), is a combination of two well-known ANT and MLP models. According to this model, landscape creates pressures on conventional agriculture which all leads to the disentanglement and instability of the socio-technical regime of Rafsanjan County. On the other hand, some niches attempt to fix the instability of the regime while others create extra pressure. In this study, hydroponics greenhouses are considered as a niche that can result in the entanglement of the regime. In punctualisation of transition to high technology agriculture in Rafsanjan, a network of defined human and non-human actants has been shaped and their relationships have been analysed. The results show that the actants with higher power, i.e. the ones related to the government, are more successful than efficient actants, e.g. universities, due to the top-down policy of Iran. Based on our analysis, "Jihad agriculture organisation", "10-year plan for the development of greenhouses", "Public relation office of Jihad agriculture organisation" were defined as the focal actor, the OPP and representative of actants, respectively.

7.5 Limitation

During this research, there has been a number of limitations which are summarised in the following paragraphs:

1- The impossibility of random sampling for the implementation of questionnaires because of the unavailability of a list which shows the name of people who are registered in the county and are considered as the residents.
2- Inaccessibility to some governmental information due to confidentiality.
3- The unwillingness of some interviewees to have their voices recorded.

4- Successive economic and political changes during this project which occurred due to new sanctions implemented by the United States. This change affected the results, and thus some parts of the project had to be repeated several times.

A mix of quantitative and qualitative approach has been used in this research to reduce the impact of these limitations of the results of the research. Additionally, in order to gather the information required, we attempted to approach many experts with an in-depth knowledge about planning and involvements of various stakeholders in the transition process.

7.6 Recommendations

This research defines how the development polices and development plans affect the configuration and reconfiguration of social and material entities in transition of conventional agriculture to high-tech horticulture in the County of Rafsanjan as the presented case study. According to the results of this study, it is suggested to conduct research to help identify low-income villages in terms of the industry of pistachio, as well as define a model based on the characteristics of each region and the available policies and plans, so as to apply a transition process from current to high-tech agriculture in order to improve the lifestyle of the locals.

The following is recommended:

1- Harmonisation of scattered plans and policies in the form of a comprehensive plan for a successful transition into high-tech agriculture

The plans and policies of national government play an important role in the transformation of the agricultural sector in every region in Iran. However, the existing plans and policies are issued by different organisations and ministries. Some of these plans and policies are in conflict with one another. Collaboration among ministries and organisations attempting to solve common issues can be organised through committees that are shaped by these ministries and organisations. Although these organisations are working on the same issues, communication does not flow smoothly among them. Thus, these committees can then analyse the policies and plans and be used as a communication tool among related organisations.

2- Parallel top-down and bottom-up approaches

The actor-network analysis has shown that governmental organisations play an important role in the transition process. It has also revealed that private businesses unable to perform independently and be innovative. The bottom-up effort is limited to the guidelines of government. This may promote a highly focused transition trajectories, but it can limits innovation and finding creative solutions to existing problems. Therefore, it is suggested that top-down R&D projects are separated from bottom-up niche development efforts as this can result in a more dynamic and innovative agricultural sector. However, this requires the exemption of private business owners from following the development guidelines.

3- Local planning for implementation of national plans

The interviews have shown that the planners of local government have a better understanding of the context and problems in the city, but they are not effective actors in the planning processes. Their

involvement in the preparation of long-term plans for the development of the city can be beneficial for the city and its residents.

4- Establishment of an information network to inform authorities, universities, corporations, investors and other actors about the research studies, achievements and experimental results of one another

Communication tools and intermediaries among businesses, governmental organisations and knowledge institutes are needed for innovation in the agricultural sector. The creation of networks of professional, researchers and governmental planners and decision makers can play the role of an intermediary among the actors. These networks can be created in the shape of an online platform.

5- Clarifying and informing people about the plans and policies and involving them in the planning processes

The role of people in the planning processes and decision making is insignificant. The integration of their opinion in planning and decision making through participatory planning is recommended for better integration of the plans in the context. Moreover, the people's participation can be through the city council and neighbourhood's committees.

6- Legal control and government involvement in the exploitation of groundwater resources with the simultaneous engagement of government and operators.
7- Water shortages and resolving the problems regarding this issue require direct involvement of government and its resources. However, in order to avoid conflict among different groups in the society, it is suggested to involve city councils, experts, environmentalist and other stockholders in the planning processes. This requires revision of the planning processes and decision making for local issues.

7.7 Future research

The technology-driven transition approach for the transformation of agricultural sector of Rafsanjan can be highly beneficial to face the challenges posed by climate change and water scarcity in the region. This research project attempts to investigate the institutional barriers and driving forces in the transition of the agricultural sector of Rafsanjan into a more resilient and sustainable agricultural sector. However, the impact of high-tech agriculture on the ecosystem, landscape and lifestyle in the region requires further studies. A Life-cycle analysis of high-tech polyculture agriculture in drought-affected areas such as Rafsanjan can answer several questions regarding the negative and positive impact on the transition on the region. The questions that still require addressing are: What are the impacts of transition towards a high-tech polyculture agricultural sector on the ecosystem and landscape of Rafsanjan? Since both the lifestyle and economy of Rafsanjan are highly dependent on pistachio, how can a high-tech polyculture agricultural sector change the lifestyle and economy of the city?

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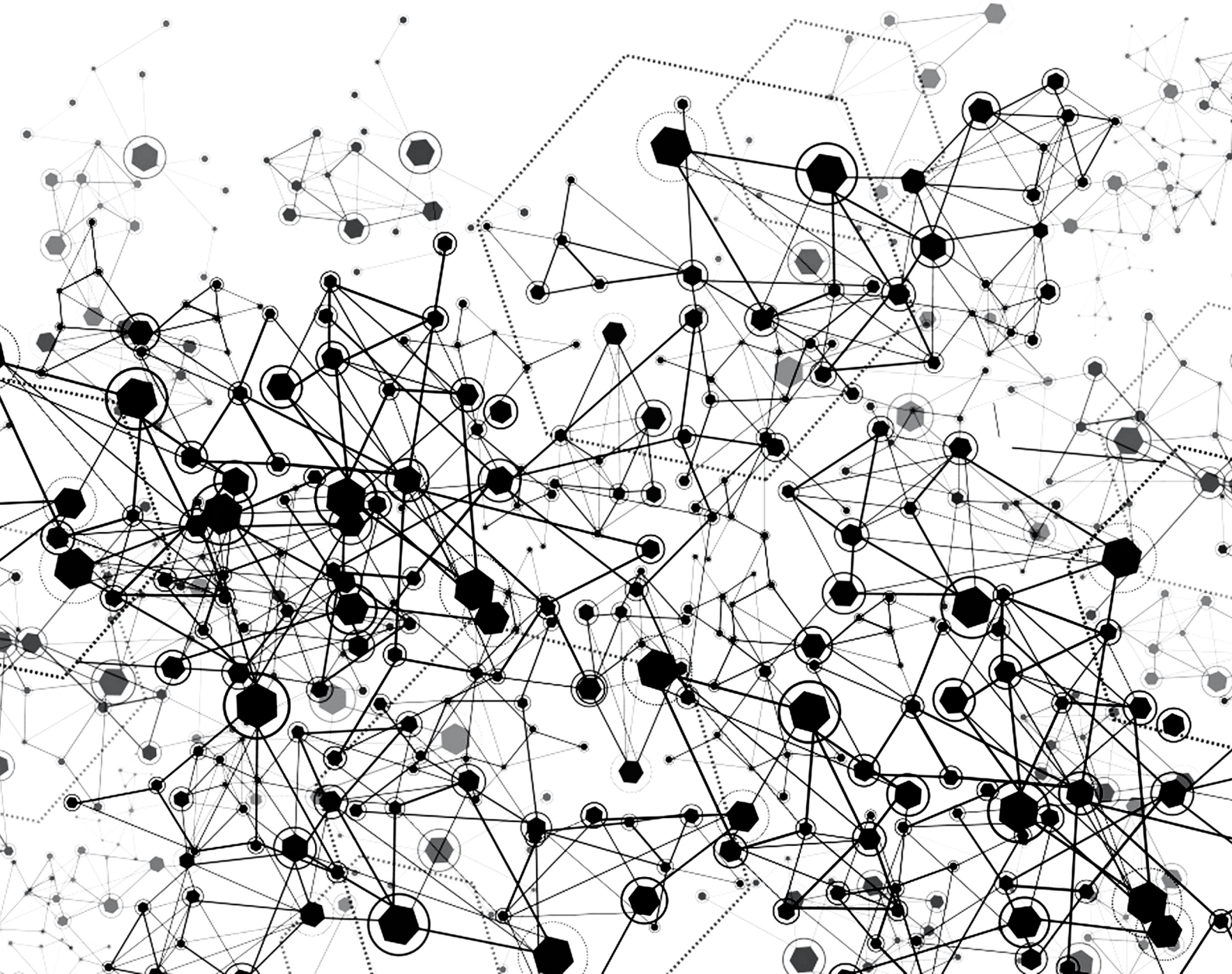
Appendix



Appendix A

People and vertical and hydroponics agriculture in Rafsanjan

The questionnaire

1 Location Village○, City

2 Gender Female, Male

3 Age

4 Are you active in the field of agriculture? Yes, No

5 Is your field of study related to agriculture or you have spent a period in agriculture? Yes, No

6 How far do you know about high-tech agriculture like hydroponic agriculture? Too much, A lot, Moderate, Little, Very little or not at all

7 Do you want to invest in high-tech agriculture such as hydroponics? Yes, No, No viewpoint

8 In your opinion, does Rafsanjan need to invest in this field? Yes, No, No viewpoint

9 Do you think kind of current agriculture in Rafsanjan has had a negative impact on the region? Yes, No, No viewpoint

10 Do you think that high-tech agriculture such as hydroponics can be a solution to the current agriculture problems? Yes, No, No viewpoint

Please list your reasons Yes, No, No viewpoint

11 Do you know about laws and incentives provided by the government about establish hydroponic greenhouses? Yes, No, No viewpoint

12 In your opinion, how much have these laws and incentives been effective? Yes, No, No viewpoint

13 Which one do you prefer to use between the product produced by the hydroponics method and the conventional method? Hydroponic, Other

Please list your reasons

Of the 384 subjects, the minimum and maximum age was 15 and 89 years, and the mean age was 40.39. Also, according to the Skewness and Kurtosis factors, the age distribution was not normal (Table A1).

Table A1. Distribution of the age

N	Valid	384
	Missing	0
Mean		40.39
Std. Error of Mean		.718
Median		40.00
Mode		43
Std. Deviation		14.066
Variance		197.841
Skewness		1.091
Std. Error of Skewness		.125
Kurtosis		1.739
Std. Error of Kurtosis		.248
Range		74
Minimum		15
Maximum		89

Among 384 subjects, 182 (47.4%) were female and 202 (52.6%) were male (Table A2).

Table A2. Distribution of the sex

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	182	47.4	47.4	47.4
	Male	202	52.6	52.6	100.0
	Total	384	100.0	100.0	

Of the 384 individuals, 71 (18.5%) had under the diploma, 72 (18.8%) had diploma, 95 (24.7%) had Associate, 89 (23.2%) had Bachelor, 48 (12.5%) had Master and 9 (2.3%) had PhD (Table 3A).

Table A3. Distribution of the education

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Under the diploma	71	18.5	18.5	18.5
	Diploma	72	18.8	18.8	37.2
	Associate	95	24.7	24.7	62.0
	Bachelor	89	23.2	23.2	85.2
	Master	48	12.5	12.5	97.7
	Phd	9	2.3	2.3	100.0
	Total	384	100.0	100.0	

Of the 384 individuals, 144 (37.5%) person have studied in agriculture-related fields or have participated in the agricultural training courses, and 240 (62.5%) were not trained in agriculture (Table 4A).

Table A4. Distribution of the education or training in agricultural fields

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	144	37.5	37.5	37.5
	No	240	62.5	62.5	100.0
	Total	384	100.0	100.0	

Of the 384 individuals, 274 (71.4%) are active in agriculture and 110 (28.6%) are not active in agriculture (Table A5). Of these, 230 (59.9%) are commercially engaged in agriculture and 60 (15.6%) are recreational (Table A6).

Table A5. Distribution of agricultural activities

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	274	71.4	71.4	71.4
	no	110	28.6	28.6	100.0
	Total	384	100.0	100.0	

Of 384 subjects, 40 (10.4%) were very familiar with vertical and hydroponic agriculture, 94 (24.5%) were familiar with vertical and hydroponics agriculture, knowledge of 99 (25.8%) Was moderate, 83 (21.6%) had little knowledge about this type of farming, and 68 (17.7%) had very little or no familiarity with agricultural and vertical hydroponics (Table A7).

Table A6. Distribution of the level of familiarity with vertical and hydroponics agriculture

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very little	68	17.7	17.7	17.7
	Little	83	21.6	21.6	39.3
	Moderate	99	25.8	25.8	65.1
	A lot	94	24.5	24.5	89.6
	Too much	40	10.4	10.4	100.0
	Total	384	100.0	100.0	

Of the 384 individuals, 188 (49.0%) tend to invest in hydroponic or vertical agriculture, 164 (42.7%) did not want to do this kind of investment, and 32 (8.3%) did not have a view of this type of investment (Table A8).

Table A7. Distribution of the desire to invest in vertical or hydroponic agriculture

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	188	49.0	49.0	49.0
	No	164	42.7	42.7	91.7
	No viewpoint	32	8.3	8.3	100.0
	Total	384	100.0	100.0	

Of the 384 individuals, 267 (69.5%) believed that Rafsanjan needs to change toward hydroponic or vertical agriculture, 77(20.1%) did not have this idea, and 40 (10.4%) did not have a view of this transition (Table A9).

Table A8. Needs to transition toward hydroponic agriculture

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	267	69.5	69.5	69.5
	No	77	20.1	20.1	89.6
	No viewpoint	40	10.4	10.4	100.0
	Total	384	100.0	100.0	

Of the 384 individuals, 244 (63.5%) believed that the current agriculture has negative impact on the region, 72(18.8%) did not have this idea, and 68 (17.7%) did not have a view of this idea (Table A10).

Table A9. Negative impact on the region due to current agriculture

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	244	63.5	63.5	63.5
	No	72	18.8	18.8	82.3
	No viewpoint	68	17.7	17.7	100.0
	Total	384	100.0	100.0	

Of the 384 individuals, 206 (53.6%) believed that the high-tech agriculture can be as a solution for current agriculture problems in Rafsanjan, 63(16.4%) did not have this idea, and 115 (29.9%) did not have a view of this idea (Table A11).

Table A10. High-tech agriculture as a solution for current agriculture problems

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	206	53.6	53.6	53.6
	No	63	16.4	16.4	70.1
	No viewpoint	115	29.9	29.9	100.0
	Total	384	100.0	100.0	

Of the 384 individuals, 172 (44.8%) are notice of laws and incentives provided by the government about establish hydroponic greenhouses, 106(27.6%) are not notice about that (Table A12).

Table A11. Notice of laws and incentives provided by the government

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	203	52.9	52.9	52.9
	No	181	47.1	47.1	100.0
	Total	384	100.0	100.0	

Of 384 subjects, 113 (29.4%) believed that the laws and incentives what provided by the government about establish hydroponic greenhouses are very bad, 126(32.8%) believed they are bad, 103 (26.8%) believed they are in Moderate level, 33 (8.6%) believed they are good, and 9 (2.3%) believed they are in very good (Table A15).

Table A12. The effectively of incentives and laws

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very bad	113	29.4	29.4	29.4
	Bad	126	32.8	32.8	62.2
	Moderate	103	26.8	26.8	89.1
	Good	33	8.6	8.6	97.7
	Very good	9	2.3	2.3	100.0
	Total	384	100.0	100.0	

Of the 384 individuals, 263 (68.5%) prefer to use products which produced by the hydroponics method, 46 (12.0%) prefer to use products which produced by the and, for 75 (19.5%) was not different between kind of production (Table A16).

Table A13. Tendency to use of hydroponic production

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	263	68.5	68.5	68.5
	No	46	12.0	12.0	80.5
	No different	75	19.5	19.5	100.0
	Total	384	100.0	100.0	

Appendix B

Present position of agricultural lands in Rafsanjan

Of the 384 selected people, 80 (20.8%) were satisfied from the existence of agricultural land in residential areas, and 240 (62.5%) were unsatisfied from the existence of agricultural land in residential areas and 64 (16.7%) %) did not comment on this question (table A17).

Table A14. Satisfaction from the existence of agricultural land in residential areas

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	80	20.8	20.8	20.8
	No	240	62.5	62.5	83.3
	No viewpoint	64	16.7	16.7	100.0
	Total	384	100.0	100.0	

Based on the calculations by Chi square test, the significance of the relationship between satisfactions from the existence of agricultural land in residential and person's residence is investigated (Table A18 and A19).

Table A15. The relationship between the satisfaction of agricultural land in residential areas and the place of residence

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	25.462[a]	2	.000
Likelihood Ratio	25.492	2	.000
Linear-by-Linear Association	23.432	1	.000
N of Valid Cases	384		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 26.00.

Table A16. Satisfaction of the agricultural land in residential areas according to the person's residence

Count

		Place of residence		Total
		City	Village	
Satisfaction	Yes	29	51	80
	No	151	89	240
	No viewpoint	48	16	64
Total		228	156	384

Of the 234 respondents who answered the question, 73 (31.2%) changed all or part of their agricultural land in the last 10 years, and 161 (68.8%) did not change their agricultural land use. Among the 73 people who changed their agricultural land, 49 (67.1%) of agricultural lands are in urban areas, 21 (28.8%) of them are in rural areas and 3 (1.4%) of agricultural lands are out of residential areas (Table A20 and A21).

Table A17. The rate of changes in agricultural land use

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	73	19.0	31.2	31.2
	No	161	41.9	68.8	100.0
	Total	234	60.9	100.0	
Missing	System	150	39.1		
Total		384	100.0		

Table A18. The location of agricultural land has been changed

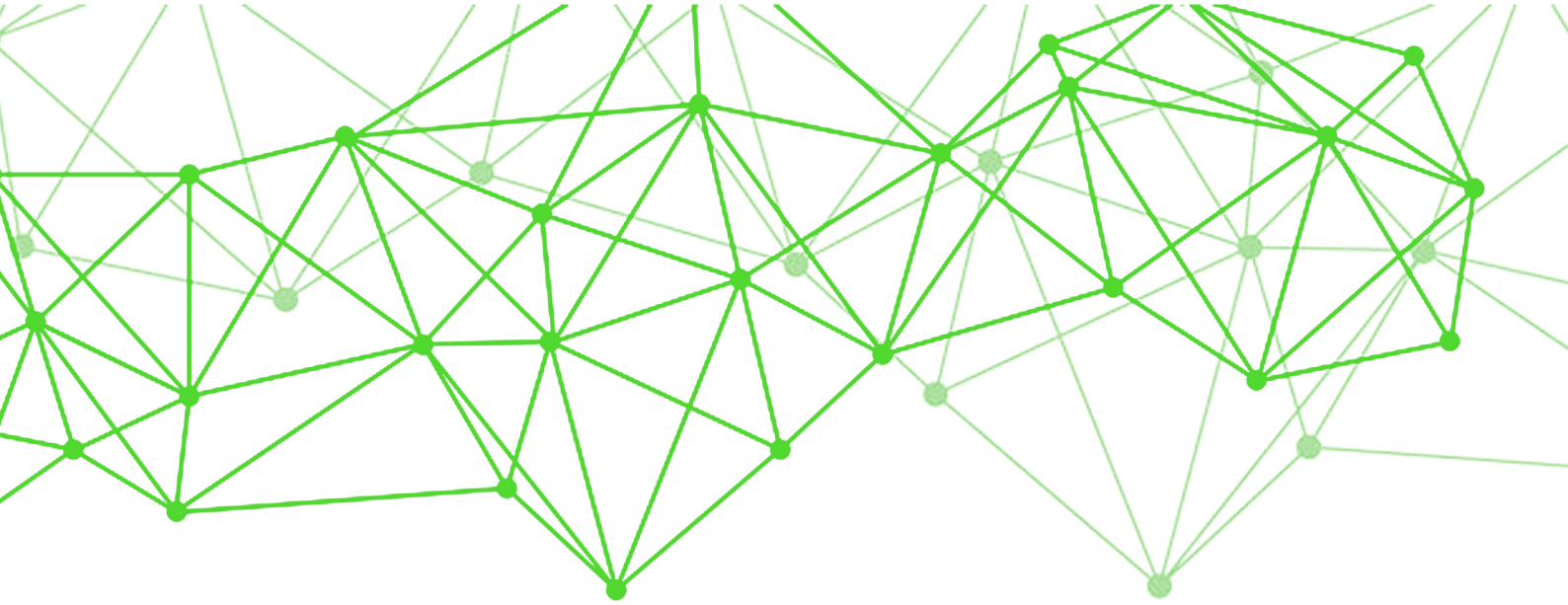
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	City	49	12.8	67.1	67.1
	Village	21	5.5	28.8	95.9
	Out of residential areas	3	.8	4.1	100.0
	Total	73	19.0	100.0	
Missing	System	311	81.0		
Total		384	100.0		

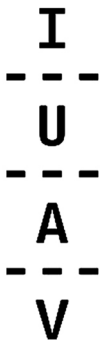
Appendix C

Subjects of interviews

In this research, to gather information about feasibility and answering our main questions, we interviewed with authorities, local people, project developers and experts. To this aim we designed a list of questins, the topic of which have been summarized as follow:

- The current situation of agriculture in Rafsanjan and ways to deal with agricultural problems with emphasis on high-tech agriculture.
- Possibility of transferring current agriculture to high-tech agriculture and search for actors.
- Review the actors and discussion about them more closly.





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Architecture, City and Design

Ph.D. Thesis