www.water-alternatives.org Volume 11 | Issue 3

Mirnezami, S.J.; Bagheri, A. and Maleki, A. 2018.
Inaction of society on the drawdown of groundwater resources:
A case study of Rafsanjan Plain in Iran.
Water Alternatives 11(3): 725-748

# Inaction of Society on the Drawdown of Groundwater Resources: A Case Study of Rafsanjan Plain in Iran

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ABSTRACT: In this paper we will present a case study in Iran which explains the reasons for inaction by a society that is highly dependent on rapidly depleting groundwater resources. To obtain a better understanding of social inaction when faced with groundwater depletion, we investigated the changing role of society in groundwater systems and the movement away from collective action. A qualitative inquiry was used in this study, based mainly on an analysis of multiple interviews conducted with groundwater users, complemented by documentary analysis. Results are presented in different sections. First, a brief description of groundwater management in Rafsanjan is presented as typical of groundwater management in Iran. Then we present the chronology of the emergence of chaos in groundwater management in Rafsanjan. Finally, we provide the water users' dominant frame of reference for the resolution of the critical water resource situation. Results indicate that the two main factors contributing to changes in groundwater drawdown are technological transitions and national policy reforms. However, findings suggest that the incorporation of factors related to political ecology – such as power relations, equity, and corruption – are important elements to consider in relation to the collective self-regulation of groundwater social-ecological systems. This paper does not provide a feasibility study for implementing a specific model of community-based management in Rafsanjan Plain, neither does it present an action plan towards self-regulation. It does, however, provide a more realistic viewpoint on the potential for pursuing a community-based management approach by helping to identify key challenges that would have to be considered.

KEYWORDS: Inaction, society, over-exploitation, groundwater, Rafsanjan, Iran

## INTRODUCTION

According to international databases, Iran is the fifth-highest user of groundwater (as measured by withdrawal rate), after India, the United States, Pakistan, and China (Giordano, 2009). Groundwater resources have been used for agricultural and domestic purposes for thousands of years in Iran, and the invention of qanats is attributed to its ancient residents (Fisher, 1928; Wulff, 1968; Beaumont, 1971). Although very few studies have been conducted on the causes of the high groundwater depletion rate in Iran, a list of explanatory factors can be derived from recent studies on the Iran water crisis (Madani, 2014). These include rapid population growth and inappropriate spatial population distribution; an inefficient agricultural sector; mismanagement; and a thirst for development. Some authors have focused on this last factor, exploring the development ambitions (Nabavi, 2017; Moghimi Benhangi et al., 2018), and modernisation (Yazdanpanah et al., 2013) of recent decades. To some degree, the arguments focusing on the chronology of development in Rafsanjan echo studies that show the role of groundwater in global agriculture and the economic significance of groundwater irrigation at national and international scales (Shah, 2014).[1]

Inspired by international studies and academic discussions, critics of the government's traditional command and control paradigm in Iran commonly argue for the suitability of a community-based management approach, seen as the key to combatting the pressure of over-exploitation on groundwater resources.[2] The government's response to such criticisms is evident in their recent efforts around the country to initiate "participatory management projects" in pilot cases where there are over-exploited groundwater resources.[3] However, for the government's efforts to be effective, a comprehensive understanding of the reasons for community inaction is necessary: why have communities themselves – given that they have a long history of using qanat systems – not already built coalitions to protect groundwater resources? Using qanats is currently considered to be an example of effective community-based management of groundwater-based systems (Jomehpour, 2009). In this article, we aim to explain why society has been inactive in the conservation of groundwater, despite their quite recent experience of successful community-based management.

The Rafsanjan Plain, named after the city located in this area, is a well-known case of groundwater over-exploitation in Iran (see Figure 1), and this area is also well known internationally for the relatively long periods of production of high quality pistachio crops, and for being the birthplace of the late president, Ayatollah Hashemi Rafsanjani, former head of the national parliament and of the national policymaking organisation, the Expediency Discernment Council of the System.[4] The monoculture of pistachios has been a feature of this area for the last seven decades, but the exclusive dependence on qanats for drinking water and irrigation (there are about 150) has decreased since the 1960s due to the spread of tube wells (Zera'at-kaar and Gol-kaar, 2016). There are now about 1400 drilled tube wells all over the plain, pumping up water that is used mainly for irrigation of pistachio orchards. Only a handful of low-flow qanats are still partly active, mainly at the upstream points of the plain which are fed by seasonal downhill runoff streams (MOE, 2012b: 33). Over-exploitation of groundwater resources (over 160 $Mm^3$/year more than the renewal rate) is considered to be the main reason for the drawdown of groundwater resources since the 1960s (Farzaneh et al., 2016). It is not only the qanats that are drying up, but also the deep tube wells which have reportedly been redrilled to deeper levels, or replaced, after drawdown of the groundwater level. Moreover, the geological properties of this area have caused most deep tube wells to reach into the salty zone of the aquifer, so there are many wells which have become unusable due to this hypersalinity, which is now too high for agricultural use. The orchard area in Rafsanjan Plain has followed the pattern of boom and bust, reaching its maximum area of 110,000 hectares in the early 2000s (Farzaneh et al., 2016). The Rafsanjan Plain is a typical Iranian case of groundwater over-exploitation, which offers itself as a good case study for the investigation of reasons

[1] This accounts for the rising number of studies on the political economy and political ecology of groundwater irrigation systems which reflect the social and political aspects of groundwater over-exploitation, and reveal the complexity of moving from intention to actual practice in the reduction of groundwater use (Prakash, 2005; Mukherji, 2006; Zeitoun et al., 2012; Birkenholtz, 2009, 2015).

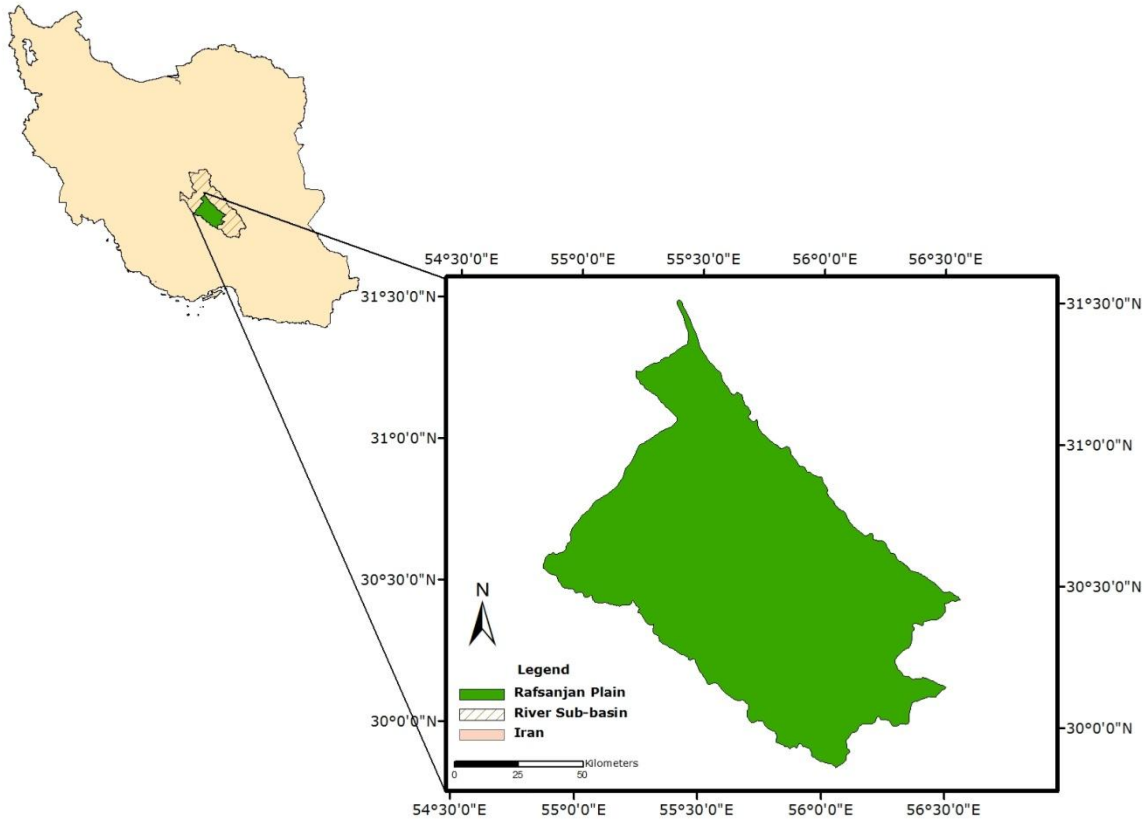
[2] Refer to https://goo.gl/FnPT7x (accessed 10 September 2018).

[3] These projects are considered to be part of a full package developed by the government (Groundwater Resources Stabilisation and Restoration Programme) to restore groundwater resources in Iran. The pilot projects are to be carried out with the aid of JICA (Japan International Cooperation Agency) (MOE, 2017).

[4] Refer to https://goo.gl/fu5nAr (accessed 23 April 2018).

for the inactivity of a highly groundwater dependent community, even though that community has the memory of a qanat operating system.

Figure 1. Rafsanjan Plain in Iran.




In the next section, we will provide the conceptual basis for studying society's inaction with regard to groundwater systems, preceded by a detailed explanation of the evolving role of society in groundwater management. After reviewing the methods used in this study, we will present the results in a chronological framework, explaining society's inaction and ways in which water users frame their solutions to this critical water resource situation. We will then present a discussion of the changing role of society with regard to groundwater management, and the main critical reflections and lessons drawn.

## CHANGING ROLE OF SOCIETY IN GROUNDWATER MANAGEMENT

Historical research on groundwater use and management is scarce. Springs were the first sources of groundwater, and dug wells and qanats became the first technologies for exploitation of groundwater, invented thousands of years ago by residents of arid areas (Garcia et al., 2017; Wulff, 1968; Foltz, 2002; Balali et al., 2009). Absence of sovereign powers in areas of long-term irrigation with groundwater proves the existence of socially regulated systems of groundwater management. In his inquiry of the irrigation systems of Persia, Fisher (1928) indicated the high monetary cost of establishing a qanat and the great degree of cooperative effort required. This helped to perpetuate the feudal system, as hundreds of tenants would live around the water supply when faced with dry deserts. In a rough estimate of the profitability of qanat-supported agricultural production in Iran, Wulff (1968) argued that there was an acceptable return rate on construction and maintenance costs. This technological innovation, and its locally administered management institutions, were resilient in turbulent times. At the core of this socio-technical innovation was the local land and water management regime of *Buneh,* which was supported by Zoroastrian and Islamic ethico-religious frameworks (Balali et al., 2009). Buneh was a multi-family collective land and water management system. It functioned as an institution which ensured the productive use of scarce water resources (ibid).

Global studies on the overuse of groundwater are abundant. The introduction of tube wells and pumping technology in the early decades of the 20th century, and their consequent popularity after 1950, are important factors (Shah et al., 2007). The adoption of such technologies in Spain, USA, China, India, Iran, Pakistan, and other countries made it possible to extract large volumes of groundwater reserves quickly (Giordano, 2009). This technological change and the resulting agrarian boom enabled windfall economic revenues, lifting millions of people out of poverty (Shah et al., 2003; Allan, 2007; Giordano and Villholth, 2007; Kemper, 2007). As scholars have stated, this change was rapid, and thus adaptation by societies through the crafting of new institutions or adjustment of existing ones, was difficult. Kemper (2007) argues that the agrarian boom was hampered by a "missed evolution" of "institutional arrangements and investments in management agencies". The 'groundwater revolution', as termed by Giordano and Villholth (2007), involved many vital aquifers in the boom and bust trajectory of development. Villholth and Giordano (2007), after a number of critical studies of agricultural groundwater trajectories, concluded that two fundamental human drivers are active in the undesirable development of groundwater resources: survival and profit. They illustrated this finding by comparing a small-scale farmer in central India – trying to survive by supplementing irrigation of his or her rain-fed plot with groundwater – with a large-scale farmer in the American Midwest who seeks more profit for his or her maize farm. Global studies reveal the dependence and self-interest of societies as a strong factor in the over-exploitation of groundwater resources. This is further enhanced by modern technology and the ease of access to technologies enabled by governmental policies and programs.

The increase in global groundwater over-exploitation triggered by modern technology could be analysed from an institutional perspective. From this point of view, groundwater resources could be considered a pure example of a common-pool resource (CPR), since in most cases the exclusion from access to aquifers results in extreme deprivation, and extraction of groundwater by a user can subtract from the aquifer's storage capacity (Feeny et al., 1990). When studying the general problems of CPRs, the classification by Ostrom (1992) can be very useful. She differentiated between appropriation and provision problems in CPRs. In a groundwater CPR, the appropriation problems are related to local issues of harvesting a resource – problems which could possibly be solved by community action, such as collaborating on the time of abstraction. But the provision problems of a groundwater CPR are related to the conservation and recovery of the resource. Schlager (2007) has further elaborated on the differences between these two types of problems in groundwater CPRs. She stated that "groundwater irrigators need the assistance of higher levels of government if they are to adequately address provision problems" (ibid: 144). Solving provision problems is costlier and much more difficult, therefore requiring close coordination of regional or national governments with local communities. This collaborative relationship could include provision of data and information; required or potentially useful expertise; encouragement of collaborative interactions between hydrologically related local communities; facilitation of community-level activities; and support of effective monitoring and sanctioning mechanisms (ibid).

Ostrom's studies of CPRs have contributed extensively to our understanding of such systems. Ostrom (2002) identified multiple attributes of both the resource and the appropriators which are crucial for self-regulating systems. Her Social-Ecological Systems (SES) framework for diagnostic analysis of such systems (Ostrom, 2007) identifies 10 critical attributes, among other variables, which are presented in Table 1 (Ostrom, 2009).

Table 1. Self-regulation in groundwater systems, based on Ostrom (2009).

| Ostrom's variables of self-regulation | Value for self-regulation |
|---|---|
| Size of resource system | Larger is worse |
| Productivity of system | More overexploited is worse |
| Predictability of system dynamics | Lower predictability is worse |
| Resource unit mobility | Lower controllability of units is worse |
| Collective-choice rules | Lower possibility for (local) collective rule crafting and enforcement is worse |
| Number of users | Larger is worse[5] |
| Leadership/entrepreneurship | Lack of it is worse |
| Norms/social capital | Lower trust and reciprocity is worse |
| Knowledge of SES/mental models | Lack of common knowledge and rapid population growth regarding the regeneration of the SES is worse |
| Importance of resource | Less dependent users are worse |

From a physical perspective, groundwater systems are intrinsically more difficult to self-regulate (see Theesfeld, 2010). Not surprisingly, regarding social-aspect variables (i.e. collective-choice rules, leadership, norms and importance of resources), we cannot make an easy judgement about self-regulation in groundwater systems. At least from López-Gunn and Cortina (2006) we can conclude that self-regulation in groundwater systems is not a myth. So one could expect that a society might initiate a movement, or get invoked by a governmental program, to take responsibility regarding groundwater drawdown, thereby overcoming the disadvantages of natural groundwater systems such that they are preferred despite even the 'free ride' that modern technology encourages.

As explained by Faysse and Petit (2012), Ostrom's approach is not the only one in groundwater governance. The idea of informal economies stems from the lack of capacity for implementation in most developing countries, and Shah et al. (2007) are the main developers of this approach, advocating more pragmatic policies with a range of different configurations. The political ecology of groundwater focuses on groundwater as a contested resource within social and political arenas, so the role of power relations and actors' interests and resources is at the core (see Prakash, 2005; Mukherji, 2006; Birkenholtz, 2009, 2015). While the critical points in Shah's 'informal economies' idea, and the power-related issues from political ecologists would be of interest in analysing groundwater conservation in Iran, in this paper we have mainly built on Ostrom's approach since it pays significant attention to collective action and the capacity for self-regulation.

## METHODS

A trade-off between multiple variables can presumably specify whether a groundwater system would self-regulate or not. Schlager and López-Gunn (2006: 50) stated that the various recognised factors "rarely apply uniformly across all common pool resource settings". When studying a single case this

[5] An exception is that in situations where monitoring is very costly, larger groups are better able to mobilise the required human and financial resources.

becomes a significant challenge, as it should be clear, for example, how much importance is attributed to the resource, or which knowledge base would best support self-regulation by a community. To overcome this complication and the trade-offs involved, and to understand the erosion of society's role in groundwater management, a chronological study of real cases is recommended. Breaking down the history of over-exploitation into multiple time periods can help to understand how changes in the main attributes of society have led to the disappearance of self-regulation.

To investigate the erosion of self-regulation and the reasons for social inaction, we selected the case study of Rafsanjan Plain as being fairly representative of Iran. The rationale for selection of a typical purposeful sample is to give greater depth of qualitative understanding of a statistical mean (Patton, 2002: 236). This area, like many others in Iran, has experienced drawdown of groundwater levels in spite of national regulations, and the number of users and tube wells has constantly increased. However, as in most cases of groundwater depletion in Iran, users have not initiated local activities to compensate for ineffective governmental regulations and provisions. To justify our selection of this area for study, we will first provide the national context for groundwater exploitation in Iran. We will briefly outline the historical changes in the state of groundwater resources and the relevant national regulations. The case history of the Rafsanjan Plain will then be presented as typical of historical over-exploitation in terms of variability in water use and total population. All data supporting this case study is based on secondary literature, i.e. national governmental reports, censuses, and related research articles.

To investigate the reasons for social inaction, we gathered primary data from unstructured interviews with local pistachio growers in Rafsanjan (Tracy, 2012: 140).[6] Access to initial interviewees was facilitated by the Iran Water Policy Research Institute, which had already had prior interaction with some Rafsanjani pistachio growers. A snowball approach was used to approach further interviewees. Thus, participants in the study were selected based on their historical involvement in the development of groundwater use, and they, in turn, referred other participants (Tracy, 2012: 136). In addition to interviews, this paper's first author participated in a few training sessions managed by a dealer, giving him an opportunity raise the subject of water drawdown and salinity with pistachio growers and witness their responses. This author also had the opportunity to participate in the yearly general assembly of the Iran Pistachio Association (IPA)[7] in Kerman city during the summer 2014, which also helped better understand the local debates.

Interviews were done through field visits by this paper's first author during the summer of 2014 and winter of 2016. Unstructured interviews were conducted with pistachio growers who had grown up in Rafsanjan and are now based there. A few interviewees had other professions – a researcher (economist), three international pistachio exporters, and two local pistachio dealers – adding to the depth and accuracy of information derived from the interviews. To have a comprehensive spatial perspective, interviewees were included from all sub-areas[8] of the Rafsanjan Plain. The number of interviews was determined based on the data saturation rule.

To prepare the interview protocol, we focused on the self-regulation variables identified by Ostrom (2009). Due to the professions of the interviewees, only the attributes which are related to the governance system and actors (see Ostrom, 2009) were emphasised (the last six attributes in Table 1). In general, questions asked of interviewees could be categorised into two main topics: 'formation of the water crisis', and 'solutions'. Since all participants had recognised the critical state of groundwater

[6] It should be noted that the results presented in this paper are part of a larger research project done on groundwater conservation in Iran which took place from 2011 to 2017 (Mirnezami, 2017). However, since the scope of this paper is the deterioration of society's activity, here we only present data gathered from non-governmental actors (pistachio growers).

[7] Refer to http://iranpistachio.org/en/ (accessed 10 April 2018).

[8] Including five areas: Noogh, Koshkouyeh, Rafsanjan, Anar, and Kaboutar-khan.

resources in their area, asking questions under these two main headings facilitated easy communication.

After coding all interview transcripts, we synthesised the coded data chronologically in order to explain the erosion of society through time in relation to inactivity. To better present the historical change derived from interviews, when it was potentially useful we added information from analysed documents presented in a recent larger research project on groundwater governance in Iran (Mirnezami, 2017). These documents included research articles related to the topic, national and regional reports, news articles, as well as legal texts. Also, some observations that were captured (in the form of photographs) during field visits were used to better present the current situation in the case area. Based on the synthesis, we developed a case study enabling us to track changes in the significant self-regulation attributes.

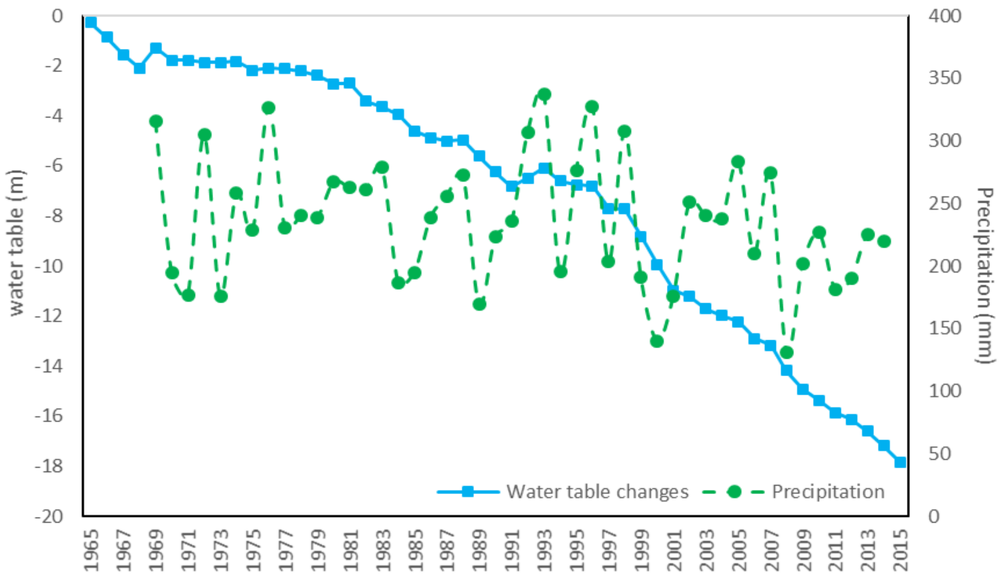
Finally, the solution-oriented part of the interviews was analysed. The coded transcripts revealed the framings of participants on what they thought could fix the problem. Frames work as simple stories which include problem definitions and solutions. Recognising the frames of solutions can clarify the base on which ideas are developed (Leach et al., 2010: 45-52). In addition to interviews, the observed activities in the area helped make a better presentation of current survival strategies.

## RAFSANJAN GROUNDWATER RESOURCES IN THE CONTEXT OF IRAN

### The national context

Iran has a dry climate with an average precipitation of about 250 mm per year,[9] which has a relatively undesirable temporal and spatial distribution over the country (Madani, 2014: 1). Thus, it is not surprising to see that more than half of the agricultural water use, and over 60% of drinking water and industrial water use comes from groundwater resources (MOE, 2014). A rough estimation in governmental reports suggests a negative balance of approximately 120 km$^3$ (ibid) in natural groundwater reservoirs (see Figure 2).

Figure 2. Trend in accumulated groundwater drawdown in Iran (Source: Moghimi Benhangi et al., 2018)




[9] This is less than one-third of average global annual rainfall.

This depletion of groundwater resources has taken place entirely since the nationalization of water resources act (Law of Water and the Way of Nationalizing It) was passed in 1968. This law recognised groundwater resources, as well as other natural resources, as public property under the control of the government (Nabavi, 2017). Coincidently, the technological facilities for drilling deep tube wells and electric pumping of groundwater were imported at this time. 1968 was a turning point in the governance of groundwater resources, and the Law of Water and the Way of Nationalizing It became the parent law for water-related affairs. According to this law, private property rights to groundwater resources were transformed into public property, and all previous and new users were obliged to obtain individual permission from the government in order to have access to, and abstract, groundwater resources (Article 9). Monitoring and punishment mechanisms were also granted to the government, making it responsible for determining the state of groundwater resources and announcing publicly if an aquifer was 'banned', or 'free' for further access and use (Article 24).

### Decline in groundwater and the impacts

Rafsanjan was among the first banned plains, as announced publicly in 1974 by the government (MOE, 2012b). However, the decline in groundwater levels and the increase in the number of tube wells did not stop, leading to the continued decline in groundwater levels. A decrease in the volume discharged from tube wells and qanats from the early 2000s, together with an increased – or at least steady – number of wells, indicates clearly the declining water yields due to the exhaustion of the aquifer (See Figure 3). Over-exploitation has also impacted water quality, with increased salinity observed in the plain (Figure 4). Gradual drawdown of groundwater levels has also resulted in land subsidence. Motagh et al. (2008) identified drastic land subsidence in the Rafsanjan Plain due to groundwater extraction.[10]

### Orchard trends

Data by the Statistical Centre of Iran shows an overall increase in the area of orchards over the years.[11] A rough estimation revealed that in the 1930s, when orchards were mostly irrigated by water supplied by qanats, the total area of pistachio orchards was approximately 30,000 hectares (Farzaneh et al., 2016). It increased slowly in the next decades, and then experienced a skyrocketing increase from the 1970s onwards, reaching its maximum level of 113,000 hectares in 2004. Since then the area decreased very rapidly, clearly correlating with a decline in the volume of groundwater discharged (see Figure 5). The drastic decrease in the orchard area is related not only to the amount of extracted water but to its increased salinity, as shown in the spatially scattered decrease in the yield of pistachio orchards.

### Population

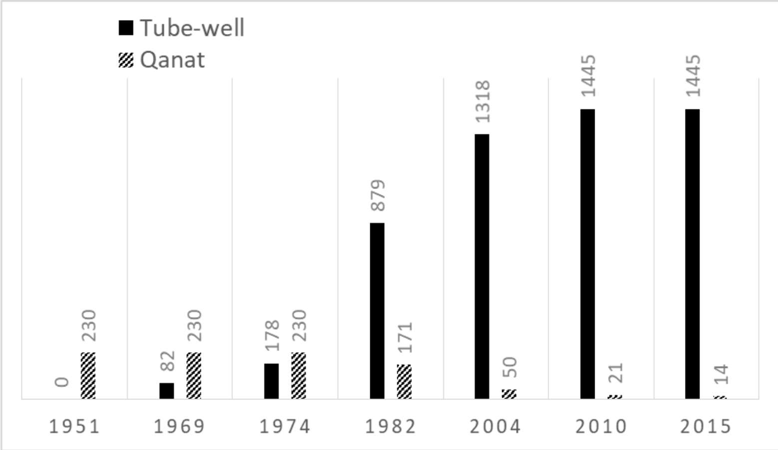
The population in Rafsanjan increased at a rate higher than that of the country as a whole.[12] According to data from an MOE report in 2012 (MOE, 2012a: 31) both the urban and rural populations increased during this interval. Considering the high dependence of the region on pistachio production (directly in the agricultural sector, and indirectly in industrial and service sectors), it is likely that pistachio production has been the main cause for this population increase.

[10] Motagh et al. (2008) calculated the level of subsidence during a 70-day period, and stated that there is a "plain-wide subsidence punctuated by local bowls exhibiting as much as 10 cm of subsidence" (~50 cm/year).

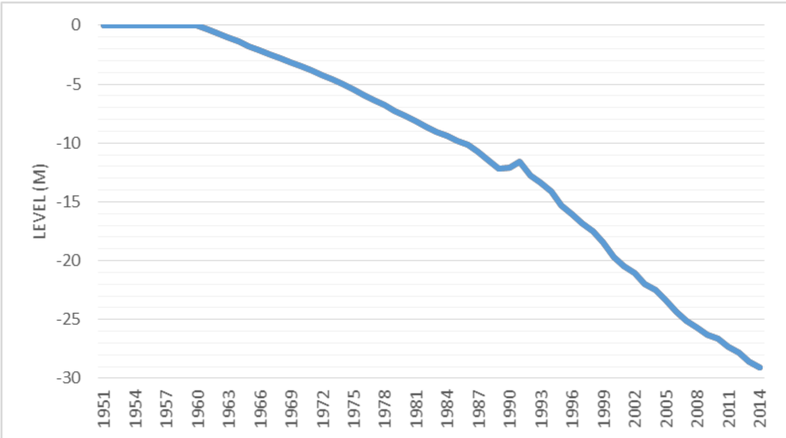
[11] According to the available census data, from 1988 to 2014 the total area of orchards has increased 1.7 times (see www.amar.org.ir; accessed 20 April 2018).

[12] Population between 1996 and 2006 in the Rafsanjan Plain increased from 235,611 to 304,934 (MOE, 2013: 103), a 2.6% increase. The average annual growth in rural areas of Iran has been negative, and in urban areas has remained steady at about 1.3%.

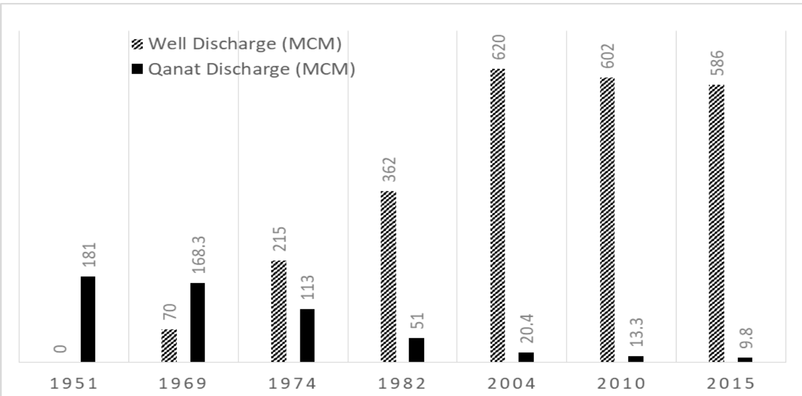
Figure 3. Groundwater abstraction in Rafsanjan Plain.




a. Number of tube wells and qanats in Rafsanjan Plain



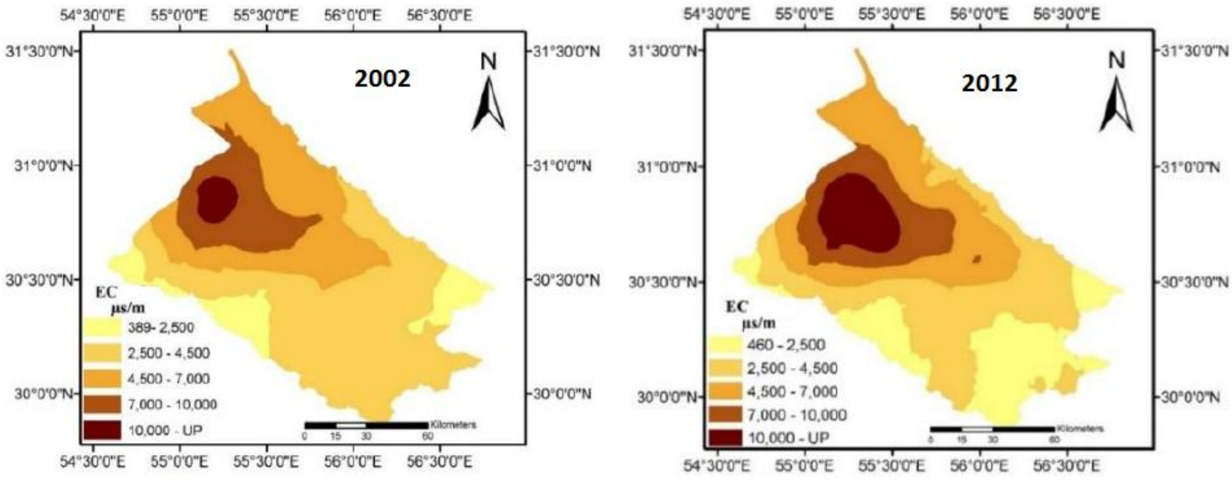

b. Trend of groundwater level drawdown in Rafsanjan Plain




c. Groundwater discharge volume

Source: Zera'at-kaar and Gol-kaar (2016).

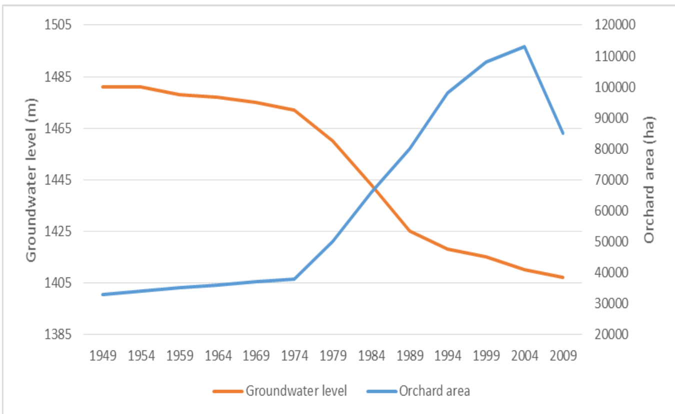
Figure 4. Groundwater salinity maps in Rafsanjan Plain, 2002 and 2012.




Source: Ghafouri-fard (2015: 134).

Figure 5. Changes in groundwater level and drying orchards in Rafsanjan Plain.

a): Drying orchard in Anar (photo by author).




b): Changes in groundwater level in an orchard area in Rafsanjan Plain (adapted from Farzaneh et al., 2016).

Comparing the increase in total population with the observed changes in the number of use points, we can identify the gradual effect of water scarcity. According to census data, the trend in the number of use points parallels the changes in orchard area. The census in 1988 showed that there were about 20,000 use points in Rafsanjan Plain; the number then increased to about 38,000 in 2003; and in 2014 it decreased to about 32,000. This trend reflects the rise and fall in pistachio production, despite the expected cumulative effect of land inheritance on the number of use points, which is a common issue around the country. The decrease in the number of use points after 2003 clearly shows that the negative effect of water scarcity could transcend the pressure from land-inheritance to increase use points. Thus, despite a lag in population decrease compared to the decrease in use points, population will start to decline because of the gradual decline in pistachio production.

## INACTION OF SOCIETY

### Emergence of chaos

#### *Phase 0: Before land reform policies in Iran (pre-1963)*

Historically, there would have been around 150 villages in Rafsanjan which were each formed around a single qanat (Abtahi, 1998). However, the qanats were not always all working at the same time: events such as wars or floods would lead to the destruction of a qanat system, resulting in evacuation by the villagers. Each village had one or two main landlords, with peasants living around them in a patron-client relationship which was the source of livelihood for the whole village. Landlords would supply money for initiating and sustaining activities and the peasants would supply the necessary human labour (English, 1998). Thus, local people could collaborate on the construction or restoration of a qanat (which could take more than 10 years), and then could earn their livelihoods from cultivating the irrigated land (Balali et al., 2009: 97). Whether or not there was justice in this arrangement, the peasants had no other choice, and any threat to their qanat would cause the whole community – both landlords and peasants – to react. Landlords could also use their direct (friendship or familial) or indirect relationships with local or even national powers to obtain better support against intruders.

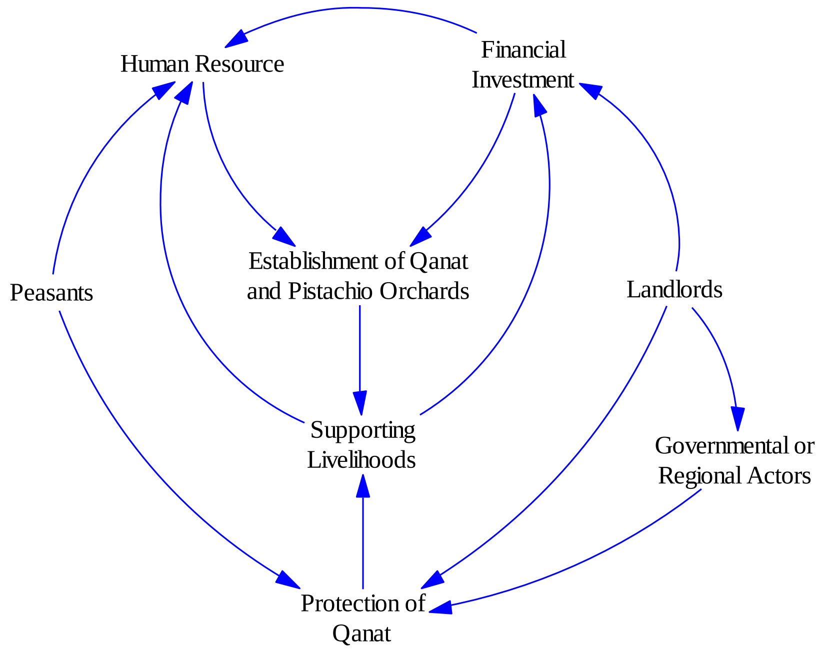
This way of life constituted a state of equilibrium in the system, although this equilibrium could be disrupted by such things as wars, floods, or drought (English, 1998). Although we should not ignore the limitations in the power of qanat technology to overdraft groundwater resources, in the final analysis this situation implies a self-governing social-ecological system that is resilient in the face of shocks (Folke et al., 2010). Considering the explanations above, Figure 6 shows how the overall social-ecological system would prevent easy intrusion by outsiders, and would thus preserve the community's interrelated livelihoods.

#### *Phase 1: The pre-Islamic Revolution period (1963-1974)*

In 1963, Mohammad-Reza Pahlavi, the former Shah of Iran, instituted the 'White Revolution', a package of economic and social policy reforms designed to improve the lives of Iran's 15 million landless peasants (see Shahbaz, 1963; Watson, 1976; Abrahamian, 2008; Katouzian, 2010). Anti-feudal land reform was thereby launched (Majd, 1987), and water resources became public property under the control of the government.

Since the land reform law was not applicable to orchards (Article 3 of the Law of Land Reform), it did not have a direct impact on Rafsanjan. However, the anti-feudal message of the Law of Land Reform, alongside the Law of Water and the Way of Nationalizing It (the first main water resources act), and the

Figure 6. The resilient social-ecological system of water use in the qanat system prior to 1963.




expansion of deep tube well technology in the country,[13] led to a major shift towards the entry of new water users in Rafsanjan. The new situation – mainly triggered by the White Revolution – decreased the power of landlords to restrict the entry of new owners, but it also motivated and empowered potential users. A group of civil servants, for example, could now obtain a well permit and establish a pistachio orchard (for a few years without production), and thereby have a fully legal and economically ideal opportunity to become pistachio growers. At the same time, landlords could change their water extraction system from qanats to deep tube wells, which required less time and money, were relatively effortless to operate, and were resilient to droughts and floods. They could also increase their orchard areas and add to their water resources by obtaining permits from the water authority, just as other people could. The relationships that had been previously cultivated between landlords or new users and the water authority made it easy for them to now increase the number of wells they could use.

During this period the government started to monitor water resources, and the first limited survey of wells probably occurred in 1969. According to Zera'at-kaar and Gol-kaar (2016), the first balance report of the Rafsanjan Plain, released in 1974, indicated a negative balance (-72 $Mm^3$) and it was concluded that the area should be designated a banned area (according to the Law of Water and the Way of Nationalizing It). At that time there were 178 deep tube wells, which was beyond the carrying capacity of the local aquifer (ibid).

In brief, the significant factors which exacerbated the situation during this period were: the new laws that triggered the entrance of new users and the drilling of tube wells; new drilling and pumping technology which facilitated this change; and corruption. Although the White Revolution had been initiated with the aim of bringing justice to the poor, most peasants were not its beneficiaries.

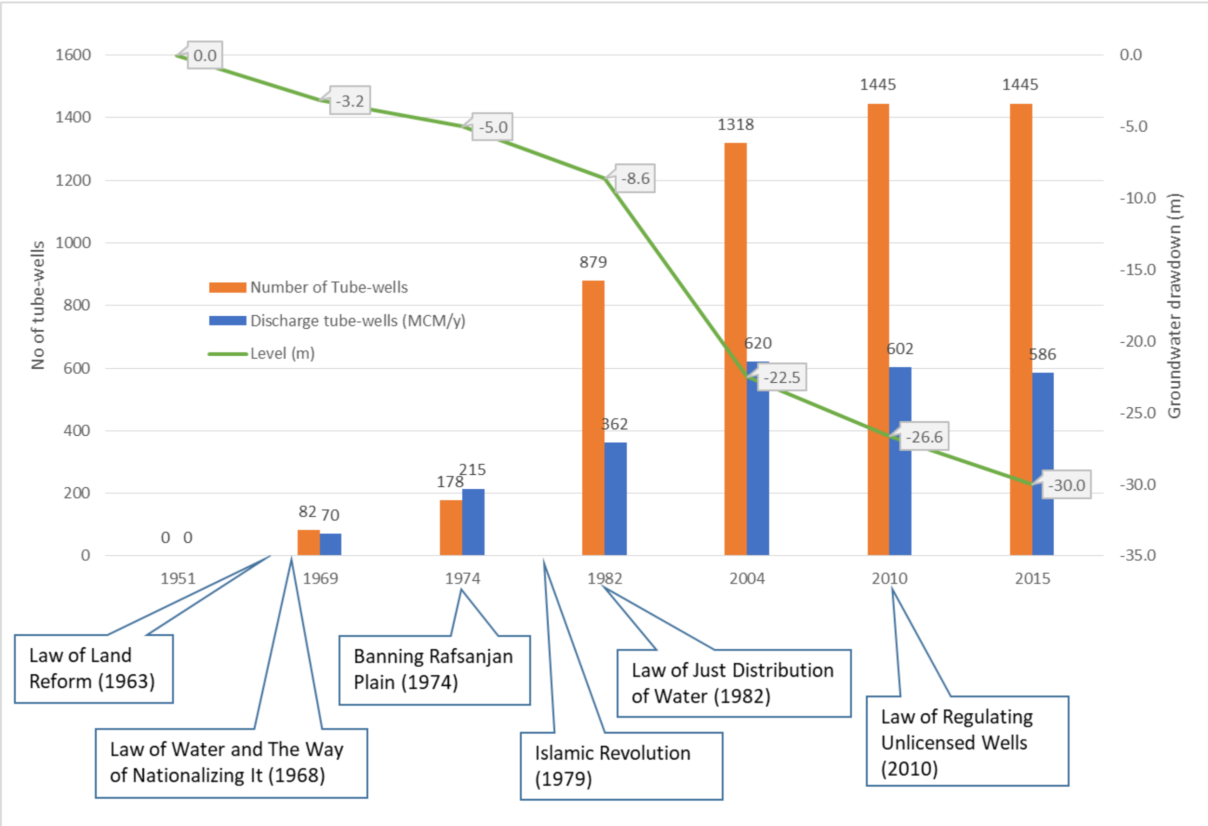
[13] Importation of this technology for agricultural use is attributed to Dr. Esfandiar B. Yeganegi in 1944 (https://goo.gl/tVKqTT; accessed 10 April 2018). But, as the interviewees explained, the use of deep tube wells spread during the 1970s. Shah et al. (2007: 398) also indicate that after the first wave of groundwater use (in Spain, Italy, Mexico, and the United States), the second wave started in the 1970s in many other places, including the Middle East.

*Phase 2: Development of the Islamic Revolution (1974-1982)*

Banning well drilling in the aquifer did not work, and in less than 10 years the number of deep tube wells increased by approximately five times (from 178 to 879), as shown in Figure 7. The incremental chaos after the revolution was accompanied by populism. One of the old growers who had been a peasant during his youth, stated:

> After Mohammad-Reza's *[the Shah's]* regime, the new regime preferred to be popular. He *[the Shah]* did not have such considerations *[to be popular among the ordinary people]*, so if anyone would do something wrong, they *[assignees of Shah]* would blow his head off. But this regime *[Islamic Republic]*, No! For example, if Mr. (…) would drill a tube well (…) immediately someone else would do the same. And *[when the users would get into trouble and conflict]* they *[assignees of Islamic Republic]* would mediate and made them come to peace; this is called a popular regime: These have one *[tube well]*, so let those to have one too! (…) Freedom was awarded *[by the new regime]*.

Figure 7. Timeline of main political/legal changes, and the deteriorating state of Rafsanjan groundwater.




Immediately after the Islamic Revolution (1979), and during the period of regime change when central control was at its lowest, a committee of local people (a 'Water Committee') was authorised by the new regime to make decisions about unlicensed wells. This committee had no experience or knowledge of water resource affairs, and their main goal was to bring justice to the poor and the oppressed. Peasants during this period were privileged in that the Water Committee insisted on sharing water resources only among them.

The informal procedure of right-giving by the Water Committee was not acceptable to the previous owners who had mostly applied for water rights through a formal legal process. Interviewees who were old water-right holders referred to the harsh behaviour of the Water Committee not only with them, but also with the water authority employees, who warned them of the disastrous future of the Rafsanjan Plain. The committee members' logic was that the occurrence of disaster was in the hands of Allah.[14] Old water-right holders also reported that during that time some of the landlords suggested sharing their water rights with new users instead of adding new water rights, but this drew a harsh reaction from the Water Committee, whose members said that these landlords were only looking out for their own interests and did not really care about the poor.

This chaotic situation encouraged peasants to drill as many tube wells as they could, and landowners whose requests to restrict well-drilling permits were met with anger, joined the rush for over-exploitation.

### *Phase 3: Post revolution (after 1982)*

After the settling in of the new regime, not only did the chaos not decrease, it intensified, in particular due to the national policies being advocated. In 1982, the central government ratified the Law of Just Distribution of Water, to replace the 1968 Law of Water and the Way of Nationalizing It. The new law was meant, as its title suggests, to have 'justice' as its ultimate goal. In 1981, the Minister of Energy defended the draft version of it in parliament with these words:

> That law *[the Law of Water and the Way Nationalizing It]*, considering the general view which was governing the tyrannical regime, had the main theme of perishing agriculture and destroying agriculture, and because of this reason and the legal issues never got implemented…

This statement supported the Water Committee. Similar to the previous version, the new water act banned further over-exploitation of the aquifers, and defined rules and punishments to halt unauthorised well-drilling activities. There was, however, a note in the act which stated that wells drilled before 1982 could be licensed if two hydrological experts agreed to do so after assessing the well (Article 3). Not only was the new law completely ignorant of the previous licensing process and water rights, but it also ignored the question of whether or not the wells had been drilled in an overexploited aquifer.

This new national law, in combination with other factors, encouraged people to pursue their own self-interest. Leaving the process of licensing to two experts who could be exposed to bribery or power-abuse, and providing poor judicial support to those who were in charge of prosecuting violators, signalled the freedom to freeride. Wells drilled before 1982, that had been licensed informally by the Water Committees, now were able to obtain a legal license (Agah and Hassani, 2015), and wells drilled after 1982 could also be authorised. Twenty-three years after the new water law was put in place, the cabinet added a statutory note instructing water authorities to stop implementation of the pre-mentioned note. But again, an astonishing new populist law was ratified in 2010 which repeated history. This law, entitled *Regulating Unlicensed Wells*, allowed a local commission to legalise unlicensed existing tube wells, placing them under the water authority. Unexpectedly, this time all the tube wells which had been drilled up to the end of 2006 could be included in the licensing procedure. Because of the low yield of the Rafsanjan aquifer, this law could not lead to an increase in the number of wells in that area, but it did demonstrate that the government rewarded violation of the rules.

Chaos was not limited to the licensing of tube wells, it was also visible in their operation and discharge rates. Although the well licenses issued by the local water authority determined the permitted amount of water abstraction in terms of monthly duration and maximum discharge rates, the users pumped as much as they could. Monitoring of wells by officials from the water authority was

[14] It was mentioned that the Water Committee claimed that there was a sea underground.

totally symbolic, and bribing officials was regarded as a natural phenomenon by pistachio growers. Many cases of violations have been reported by the water authorities to the jurisdictions, but the judges have mostly voted in favour of the violators.

Ownership and orchard-establishment patterns are issues which complicate this situation. The majority of pistachio growers in Rafsanjan are smallholders. The soil has degraded, and they do not have enough financial resources to improve the soil quality, which undermines production yields and financial returns. The situation of ownership has also become worse every year due to the subdividing of orchards among the heirs of owners (Abdollah-Zadeh et al., 2012), and this interferes with agricultural activity, increases the number of water users, and highly complicates the management of groundwater-based systems (Shah, 2014). In some localities the number of users from a single well with, for example, a 35 lit/s discharge, currently can exceed 200. This means that there are some users who have access to water for only a few hours every 50 days in a flood irrigation system.

### Responses from farmers

Desperation about the future of pistachio production and water availability is high among users (see also Abdolahi, 2012) – they believe that sooner or later the wells will run dry or become hypersalinised. Growers with financial capital have started alternative businesses, or have moved their pistachio production activities to a region where drying up or salinising of wells is not a threat. But the majority that remains faces growing expenditures and economic hardship.

A few other options have been implemented by relatively high-income growers in Rafsanjan. One such option is desalination, implemented by one of the main growers who can afford the cost of a desalination plant (Figure 8a). Another solution that appeared in Anar in the 2000s is underground irrigation using buried tubes (Figure 8b). This method is an expensive but highly efficient irrigation alternative which bypasses the basic problem of drip irrigation in saline regions (Goyal, 2013: 106). It is a method which is spreading due to its relatively good performance.

Figure 8. Measures taken by creative growers in Anar: desalination plant (left); underground irrigation (right) (photos by author).

Another proposed solution has been inter-basin water transfer from the upper Karoun River (in Chahar-Mahal-o-Bakhtiari Province) to Rafsanjan Plain. This plan, first initiated in the 2000s, was pushed by a few growers who are connected to national political actors in Rafsanjan. Through a public call by the Civilization Institute of Rafsanjan – an organisation that is claimed to have strong political connections – all growers were invited to invest in the project. According to interviewees, the large sum of IRR50 billion was raised in a short period of time (even many smallholders had invested in this project by selling their family assets), but due to the intervention of the president the project was completely stopped and the money returned to all the investors. Surprisingly, in late 2017 the project was again revived after news spread about confirmation of a plan by the Department of Environment to transfer 200 $Mm^3$. Clearly, after the previous halt, the political process continued and the project was still being debated.[15]

Whether these locally developed solutions (water transfer, underground irrigation, or desalination) will work out or not, it is important to note that their aim is not the overall conservation of water resources, they focus instead on supplying new sources of water or making more efficient use of the depleted water, without reducing the total water deficit (see Molden and Sakthivadivel, 1999).

The interviewees' literal responses are perhaps less important than understanding the way their responses were framed. In spite of blaming the government for the unsatisfactory conditions,[16] the solutions they suggested were totally government-oriented. Some suggested that the government should invest in desalination; others felt the government should buy salinated and drying wells and orchards from owners; and some thought the government should transfer water from nearby places such as Shemsh,[17] and should channel the waste-water of Kerman towards Rafsanjan. These are short-term solutions aimed at protecting their livelihoods and prosperous businesses not conserving groundwater resources. A few interviewees who had better understanding of economics (an economist and a few dealers) argued that the low price of energy was a critical parameter, one that was in the hands of the government. Some others (especially smallholders) referred to inequities in distribution of water rights and the need for government involvement in solutions.

Many others argued that they cannot do anything on their own. One of the interviewees from the southern part of the Rafsanjan Plain explained that a grower cannot start a new business even if the government buys his wells and orchards, and that the solution is that the government has to provide jobs:

> *[Imagine that]* the government buys my 10 hectare orchard. Let's imagine they pay IRR2000 million in exchange. What can I do with that money?! Establishing a factory?! No! Establishing a production unit?! No! Today, I cannot initiate a new job with 2 or 5 billion IRR. (…) I myself agree that not even 20 years later but 5 years later there would be no more water, or if it exists, it will not be suitable *[in terms of quality]* for use. All growers are aware of that. It is important for us that they *[government]* give us solutions to not lose our lives and existence. Taking my bread at noon *[metaphor for lunch]* with the hope of tomorrow's morning breakfast *[is not acceptable]*. If I am not going to be alive tomorrow *[from hunger, what is the use of that]*?! (…) Resources of the country are in the hands of government. Except for these four trees *[an exaggeration to indicate his lack of resources]*, I do not own anything else. (…) This is the solution: government has to establish factories here, and then buy our tube wells.

Proposing an extreme solution, one interviewee said that if one day of Iran's oil profits had been directed to Rafsanjan, the government could easily have fixed its problems by putting in place the solutions mentioned. This reflects the perception that power and financial resources are in the hands of

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[15] A parliamentary member from the Vanak-Soulekan River basin in Chahar-Mahal-o-Bakhtiari Province, from which water is to be transferred, has threatened to lobby against the Minister of Energy and the President if the project is not stopped (Farsnews, 2018). He questioned the competence of the head of the Department of Environment in making this decision, arguing that by depriving his region of water they are selling its unique apple orchards to the dying pistachio orchards. Considering his region's extreme dependence on agricultural activities and the lack of other employment, he stated: "We cannot tell a farmer that we are transferring your region's water to other places."

[16] From the participants' perspectives, government mismanagement is the main reason for the over-exploitation of groundwater resources. They complained, for example, about the government's poor performance in monitoring and provision of basic services. This included the poor quality of pesticides supplied in the early 2010s (as it is the responsibility of the government to control all such products in the market); poor agricultural extension services by the government during the establishment of pistachio orchards; the poor quality of drippers; and a corrupt administrative and judicial system.

[17] Shemsh is a region about 20 km from Rafsanjan Plain which has a better groundwater supply in terms of both quality and quantity.

the government. Historically, the behaviour of the government at critical moments has confirmed the conception of the "government as the father of the family". The revived project of water transfer to Rafsanjan is an example. It is interesting to note that many of the interviewees used the metaphor of 'the father of the family' to explain the importance of the government's role in solving problems. In their explanations, a child in the family has no backing other than his father, and if the child is in trouble, it is the father's duty to solve the problem; and if the father dies, someone else – an uncle, aunt, etc. – should take on this role, because the child is unable to take control of the situation and cannot afford the costs.

Thus a paradox is observable in the framing of solutions. Even though the people believe that the government is responsible for the ongoing crisis because of its poor performance, ineffectiveness, and high level of corruption, they do not advocate community-driven measures to reduce water use, but instead wait for government intervention. Generally, it sounds reasonable to expect the responsible actor to take up the burden but, as mentioned, there is a lack of trust in the government's commitment. This paradox has led to a stalemate. It is important to note that the way in which interviewees framed their responses is in line with the government's distribution of power and resources, which has not given the community any formal authority in water resource management. The life-long experience of community members, at least in groundwater management, has convinced them of the ineffectiveness of governmental interventions.

## DISCUSSION

Based on these results, we can now explain the deterioration, and lack of self-regulation, in the groundwater common-pool resource of Rafsanjan. The main reasons are summarised in Table 2.

Table 2. Deterioration of self-regulation in Rafsanjan Plain.

| Self-regulation variables | Historical state (qanat systems) | Current state | Main factors of change |
|---|---|---|---|
| Size of resource system | - | - | Not relevant (unchanged) |
| Productivity of system | Using less than the recharge rate; prevalence of ecologically harmless technology for water extraction | Excessive exploitation; entrance of, and easy access to, ecologically harmful technologies for water extraction | Technology transition |
| Predictability of system dynamics | - | - | Not relevant (unchanged) |
| Resource unit mobility | - | - | Not relevant (unchanged) |
| Collective-choice rules | Adequate use of socially crafted rules to regulate water use | Absence of socially crafted rules for regulating water use | National policy for centralisation and technology transition |
| Number of users | Low number of users due to the low potential water yield of the technology | Large number of users due to the enabling technology and the continuous centrally supported entrance of new users | Technology transition and national policy for just water distribution |
| Leadership/ entrepreneurship | Existence of landlords (owners of water-extraction facilities) as leaders | Nationally organised dysfunctional bureaucracy for controlling water use | National policy for centralisation and technology transition |
| Norms/social capital | Social cohesion for water conservation as a prerequisite for existence in the short and long term | Self-interested individuals, social segregation, and race to the bottom | Technology transition |
| Knowledge of SES/mental models | Unlimited groundwater reserves | Limited groundwater reserves | Personal experiences of the impacts of over-exploitation |
| Importance of resource | High sensitivity of peasants' livelihoods to groundwater access | Lower sensitivity of livelihoods to groundwater access | Technology transition |

The role of the socio-technological transition from qanats to pumping tube wells is dominant in the deterioration of self-regulation. Many national policies have also generated social inertia. While some of Ostrom's (2009) categories are helpful in comprehending groundwater over-exploitation, we have also identified other key reinforcing factors for the lack of collective action.

First, we believe that corruption is a critical reason for inaction. The spread and normalisation of corrupt behaviour as the product but also the cause of chaos, impedes change in society by ruining social capital and trust while strengthening the perception of inequity (Corral-Verdugo and Frias-Armenta, 2006). It is unreasonable to expect an active response by society in the face of such a corrupt situation (Smith and Walpole, 2005). Molle et al. (2017) has referred to similar cases in Middle Eastern and North African (MENA) countries, and argued that corruption and abuse of political power are limitations to the state's action (see Nassif, 2016; Wendle, 2016). As Huppert (2013) remarked, it seems that the intentionally neglected core dimension of rent-seeking in agricultural water management is common, since not only practitioners but also international professionals are "caught in multifaceted conflicts between formal objectives and hidden interests". As a response, transparency improvement is an essential component of laying the groundwork for societal involvement. This makes the action payoffs clear for all. In our case, which is typical of the wider situation in Iran, transparency is poor not only in terms of monitoring, sanction, and water-access and use rights, but also in terms of understanding the physical situation, as water balance studies are of poor quality. Recent research conducted by Torabi et al. (2014) shows how the lack of data has led to multiple readings and interpretations of the water balance in the Rafsanjan Plain by the state, which is a serious constraint on effective governance.[18]

Second, the evolving perception of inequity is a determining factor, leading to the inactivity of society in Rafsanjan where thousands of users are spread over a large landscape. One may claim that when qanats were in operation – usually considered to be a typical example of self-regulatory systems – people did not perceive themselves as equal and were like slaves of the landlords. But technological change has enabled users to make individual decisions and become independent of the group, and to live and earn money independently. This has accentuated the perception of inequity more than at the time of functioning qanats. Dessalegn and Merrey (2015), referring to the motor-pump revolution in Ethiopia, underline that people perceive pumps as liberation from "the social limitations of traditional communal irrigation" (ibid: 1).

The relationship between water rights and inequity is a heated debate (Hoogesteger and Wester, 2015), and the elusive nature of groundwater resources (Theesfeld, 2010) exacerbates this problem. Transforming informal access and extraction rights into legal-use rights through state-led bureaucratic procedures (Mukherji and Shah, 2005) has aggravated the perceptions of inequity. In Rafsanjan it led to social segregation between small and large landholders, which created a big obstacle to collective action. Ameur et al. (2017) have studied the impact of inequality on groundwater depletion. Their study depicts how inequality acts as a trigger for over-exploitation and how the over-exploitation by heterogeneous actors fuels socio-economic differentiations in North Africa. In our case, the problem has been compounded by the fact that the state – not only individuals – has violated right-holders at multiple points in time by encouraging the entrance of new users and legalising illegal wells in an overexploited aquifer. The failure of the state to fulfil its role as a guardian of rights has annihilated any possible collaboration in resource conservation.

Mukherji and Shah (2005) examine the reasons why governments in South Asia do not make tough regulations for groundwater. As they have stressed, not only the large number of groundwater-dependent populations but also the political power of farmers is significant. In the case of Rafsanjan,

[18] De Stefano et al. (2015) have pointed to transparency in relation to groundwater rights as one of the key issues which haves constantly prevented the resolution of groundwater management problems in Spain.

where some families have close political relations with the state, it is not surprising that a few use their power to force the government and the parliament to act unfairly, or against the interests of the wider public, as shown by the case of water transfer to Rafsanjan. As noted by Allan (2007: 63), farming lobbies are "even stronger in societies that have been coping with periodic 'lean years' for four or more millennia" like MENA countries. Nevertheless, even in countries which are more likely to have stronger regulations, such as Spain, other political reasons are also weakening the political will to implement regulations. De Stefano et al. (2015) underscored that ensuring sustainable groundwater management requires politicians to take unpopular measures and initiatives, which they are reluctant to do.

Third, access to resources, and distribution of power between the state and people, also impacts the potential for self-regulation. In our case, an oil-rentier state with financial resources is tempted to solve problems by investing in capital-intensive but illusory and superficial projects. According to the law, the public has no specific authority to intervene in management and investment decisions, and the government is responsible for all management affairs. Strong signals are sent out by the government that it can and will act unilaterally to address challenges. Such unilateral decisions include the transfer of water to water-scarce regions such as the water transfer from Karoun Basin to Gavkhuni Basin in central Iran (Gohari et al., 2013) and transfer of desalinated water from the Caspian Sea to Semnan in central Iran.[19] Cloud-seeding and extraction of deep water to meet increasing demand (Khabar-online, 2018; IRNA, 2018), and unprecedented investments for the restoration programme of Lake Urmia[20] are some typical examples of such unilateral decisions. This type of paternalistic behaviour which is bent on financing expensive solutions, actually foregoes, or at best delays, the social learning needed for societies to deal with these problems on their own. This is akin to the concept of unconstructive learning proposed by Vinke-de Kruijf et al. (2014: 8): a type of learning style that "produces or confirms negative perceptions of other actors, deepens differences in views, or worsens relationships". In the case of Rafsanjan Plain, the unconstructive learning is taking place because, at the critical moments that lead to transformations (Pahl-Wostl, 2017), the attention of the society is always diverted away from critical thinking and questioning, to simplistic but costly solutions which deal with the effects instead of the causes.

## CONCLUSION

Like many other groundwater-dependent countries, Iran is experiencing over-exploitation and unprecedented groundwater-level drawdown. Rafsanjan Plain is one of hundreds of plains in Iran which are suffering groundwater over-exploitation. The first question which occurs to anyone when first visiting this plain is how and why the public is not addressing the rapid exhaustion of a resource on which people are totally dependent. Speaking to locals whose main activity is growing pistachios, one finds that, around fifty years ago, locals had a well-organised groundwater-based system using the harmless technology of qanats. In contrast, at present people are engaged in a race to the bottom for a resource which is essential to their existence. The ineffectiveness of government controls and of the central management of water resources usually prompts critics of top-down approaches to reiterate the standard prescription that the solution is to shift to a community-based management approach.

[19] Refer to https://goo.gl/AdydCu (accessed 24 September 2018)

[20] Another recent related case is the government restoration programme for the drying Lake Urmia (Refer to http://ulrp.sharif.ir/en accessed 11 April 2018). To restore the lake, President Rouhani initiated the Urmia Lake Restoration Programme, promising a considerable budget of approximately US$575 million per year, which is comparable to the annual budgets of most ministries. The First Vice-President of Iran, after a visit to Lake Urmia on 1 April 2018, stated that, "Restoration of Lake Urmia will definitely take place and this subject cannot be omitted or put aside from agendas of governments. If it is required, we will allocate billions of dollars by external foreign direct investments to transfer water from overseas *[Lake Van in Turkey]* … Iran can under no condition be irresponsible about the Lake Urmia, and I strongly tell to the residents of this region not to have even a bit of worries about it…" (ULRP, 2018).

With the common-pool resource literature in mind, this recommendation may appear to be rational. But before any solution can be provided, we need to analyse the public inertia in the face of continuous groundwater drawdown.

This paper aimed to provide an explanation of social inaction by using the case of Rafsanjan Plain. We investigated the current inaction through a chronological retrospective, and guided our qualitative inquiry based on Ostrom's findings about the determinants of successful self-regulation (Ostrom, 2009).

We first documented the deterioration of self-regulation from the time of the qanats to the current state of inaction. The results showed the destructive impact of technological change on society, and how national policy reforms for centralisation and fair distribution have contributed to social inertia. We also identified some important interrelated factors that reinforce inaction. First, corruption appears to be both a cause and an effect of the chaotic state of water management. Increasing transparency should help make clear the payoffs of collective action and inaction. Second, inequity fragments society into multiple opposing divisions, and hence hinders collective action. Water rights have a significant impact on perceptions of inequity, and poor regulation by the government intensifies this situation. Third, we argued that the paternalistic and illusory solutions proposed by the government are destructive to collective action, since they reinforce the perception of the state as the source of solutions, and destroy any expectation that the public could also be part of finding solutions and making decisions.

The findings of this study indicate that factors related to political ecology are determinant in shaping collective action. Similar to the findings of Rica et al. (2017: 66-68), our study suggests the need to incorporate power relations and the issues of corruption or inequity in the study of decision-making. Thus, to those proposing a transformation from the current situation to self-regulation (with the hope of overcoming over-exploitation), this study suggests that there are a few key issues like inequity, corruption, and paternalistic state-citizen relationships that first need to be dealt with (see Molle et al., 2017: 540). This paper does not provide a feasibility study for implementing a specific model of community-based management in Rafsanjan Plain, nor does it present an action plan to establish a mode of self-regulation, however desirable such an option may be. Instead it urges experts and practitioners to adopt a more realistic view of our capacity to pursue such a tempting community-based management approach, and to be aware of the challenges ahead in order to avoid early disappointment.

## ACKNOWLEDGEMENTS

We would like to gratefully acknowledge the helpful collaboration of the Iran Water Policy Research Institute (IWPRI) in conducting our field visits to Rafsanjan. We also owe a great debt to the Rafsanjani farmers who gave us their time. And, finally, we greatly appreciate the intellectual insights of the three anonymous reviewers of this paper, and the thoughtful comments of the guest editors of this special issue. All shortcomings in this manuscript are ours.

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