Chapter 2
Making Meaning of Traditional Agricultural Knowledge: Ground Water Management in Arid Areas of Turkey

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Abstract This chapter introduces a case study focused on the problem of groundwater depletion resulting from the use of modern irrigated agriculture in an arid region that relies on groundwater, along with initiatives that have been made to address the problem. It became apparent, as a result of interaction with a diverse range of stakeholders, that local environmental knowledge possessed by pickling melon farmers and rain fed wheat farmers – groups of people that could be described as the socially vulnerable in the region studied in this chapter – has the potential to open up new markets as well as reduce the pressures on consumption of groundwater resources. The authors discovered that this local environmental knowledge connected with agriculture that is founded on the traditions and cultures of the socially vulnerable could help solve a series of regional issues caused by large scale modern irrigated agriculture which is run by farmers described as the socially privileged. As described in this chapter, the authors utilized a transdisciplinary approach in cooperation with a diverse range of stakeholders to visualize the problems at hand and to uncover and catalog local environmental knowledge, the content of which forms a story for solving local issues and creating a new history.

2.1 The Depletion of Groundwater

2.1.1 Global Situation Surrounding Groundwater

Fresh water makes up only around 2.5% of the world's water, with the remaining 97.5% consisting of salt water (Shiklomanov and Rodda 2003). It is said that of this fresh water, approximately 30% is groundwater, equivalent to somewhere in the

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T. Sato et al. (eds.), *Transformations of Social-Ecological Systems*, Ecological Research Monographs, https://doi.org/10.1007/978-981-13-2327-0_2

region of 0.75% of the total amount of water globally. Around 70% of fresh water resources are used for agricultural purposes.

The world's irrigated agricultural land covers about 300 million ha, of which an estimated 38% is irrigated using groundwater, and that an annually 545 km^3 of groundwater is used for this purpose (Siebert et al. 2010).

Globally speaking, Japan experiences comparatively large volumes of rainfall and has a humid climate, which is why it also has comparatively large volumes of groundwater recharge, in the region of 350–400 mm per year (statistics taken from Editing Committee for the Revised Groundwater Handbook 1980). However, in arid regions, which have very low rainfall volumes of only 300 mm per year, the volumes of groundwater recharge are almost zero.

2.1.2 Irrigated Agriculture and the Problem of Groundwater Depletion

From this perspective, irrigated agriculture, which utilizes groundwater, needs to be conducted in a way which pays extra care to storage volumes and recharge volumes, something which is particularly vital in arid regions. In arid regions, which have plentiful solar radiation and vast land areas, production volumes can easily be increased and farmers are able to enjoy a good livelihood through the introduction of irrigation, heavy machinery and chemical fertilizers. As a result, groundwater supplies are continually under use, pushing these regions ever closer to the threat of groundwater depletion. Arid regions that rely on groundwater can be found around the world. Groundwater depletion is an environmental problem that causes social issues in the form of the transformation and collapse, not only of sustainable agriculture in the area, but also local communities themselves. Also, if groundwater becomes depleted, the vast tracts of land that had once been covered in crops become exposed to the elements; if this situation continues in the long run, it can lead to increased damage from wind erosion (Akça et al. 2015). The end result of this is desertification and the supply of dust particles into the atmosphere like yellow sand, and the various environmental issues which exist in different areas come to symbolize global environmental problems with a reach extending throughout the planet.

This chapter examines the problems associated with groundwater depletion faced by arid regions with large scale irrigated agriculture that rely 100% on groundwater, along with the content of initiatives that have been made to address the problems through dialog with a diverse range of local stakeholders. It describes how two different minor forms of agriculture, the practitioners of which could be described as the socially vulnerable, encountered during this research have the potential to solve these problems. Based on this, it goes on to discuss the knowledge base gained from such forms of agriculture and the utilization of this in an attempt to shift to types of agriculture in arid regions that do not rely on groundwater alone.

2.2 Karapinar's Natural Environment and Agriculture

2.2.1 *An Arid Region that Has Successfully Kept Desertification in Check*

The area of study in this chapter is Karapinar City, located in Konya Province, the Republic of Turkey. Karapinar has an annual rainfall level of 300 mm, a high temperature of 38 °C in the summer, and a low temperature of −10 °C in the winter, making it a typical cold arid region. It occupies an almost central position in the Anatolian Plateau, is situated at an altitude of somewhere in the region of 1000 m, and has a flat topography.

Karapinar, an arid region, has a history of curbing the effects of desertification since the 1960s, something it has managed to achieve through the planting of trees. The initiatives taken to prevent desertification are known throughout Turkey as a notable success story of what can be achieved through such action. The organization behind these initiatives is the Soil and Water Research Institute of Ministry of Food, Agriculture and Livestock. This research institute is a residential research institute that, in addition to projects seeking to prevent desertification, provides the results of its research endeavors regarding regional irrigated agriculture to farmers in the form of information (Sato 2009).

The environmental problems that this area is currently experiencing include groundwater depletion and the formation of giant sinkholes (Fig. 2.1) thought to

Fig. 2.1 A sinkhole measuring 20 m in diameter with a depth of 40 m that opened up as a result of declining groundwater levels

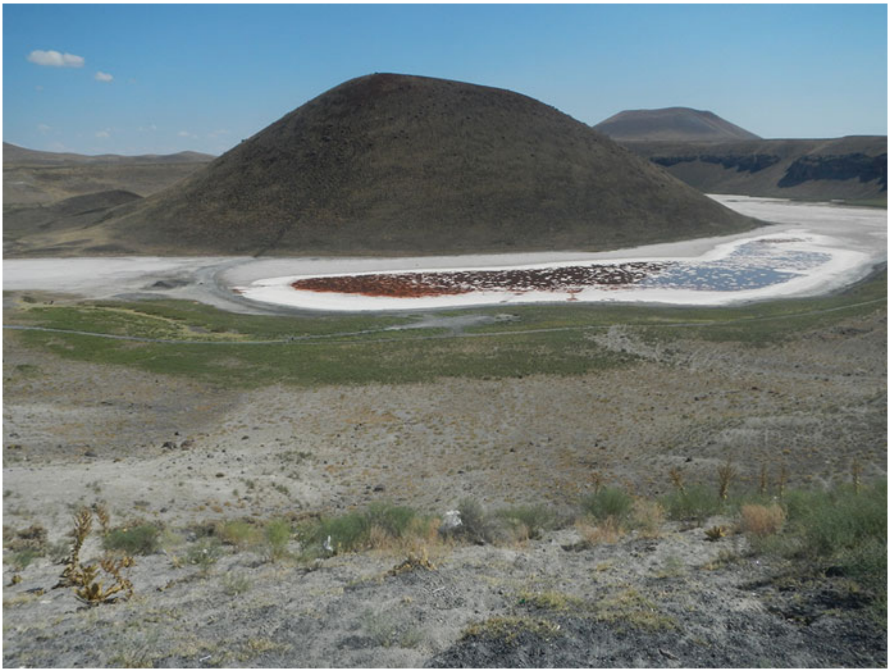

Fig. 2.2 Meke Crater Lake, a local symbol of ongoing exsiccation

be caused by this. The main factor behind groundwater depletion is shifting to irrigated agriculture. It is said that the sinkholes found in neighboring areas are caused by the same mechanisms as ground subsistence, which arises through the pumping-up of waste water (Çelik and Afşin 1998). A total of 33 sinkholes opened-up in the period from 1979 to 2009 (Yılmaz 2010) and three more developed only in 2016. Furthermore, decreasing levels of groundwater in this region have caused the lake water Meke Crater Lake (Fig. 2.2), a local symbol, to recede year by year. At the time of writing, the lake bed is almost completely exposed.

2.2.2 Agriculture in Karapinar

Large scale modern irrigated agriculture which uses groundwater, the main factor behind today's groundwater depletion, began in this area in the year 2000 and has continued (Fig. 2.3). There are many farmers in Karapinar, both large and small. Their operations range in scale from major farmers with center pivot irrigation systems in agricultural land in excess of 100 ha to farmers with only a few hectares of land. All depend 100% on groundwater for irrigating their land.

Karapinar City has a population of roughly 40,000 people, among whom approximately 20,000 people are farmers. Among these agricultural workers, about 18,000

Fig. 2.3 Large scale modern irrigated agriculture which relies on groundwater

people are members of Karapinar Agriculture Chamber, which provides support for all activities relating to agriculture. It is this chamber that has acted as the flagbearer for modern irrigated agriculture in Karapinar. The chamber's main work consists of registering loans related to agriculture, providing information on agricultural technologies, and mediation services for seeds, fertilizers and agricultural chemicals, but it is also a residential research institute equipped with a soil inspection laboratory.

The history of irrigated agriculture in Karapinar is relatively recent, dating back to around 1950, and it was in 1968 that the first well for irrigation was dug. At that time, marshy areas could be found here and groundwater existed at a depth of just a few meters, meaning that there was a high soil moisture content throughout the year and irrigation using wells was small-scale in nature. A series of large drainage canals that were once used to drain excess water in marshy regions still exist.

2.2.3 Where Does Groundwater in This Area Come From?

Looking at data on transitions in groundwater levels in Karapinar in recent years, we see that there are some locations in which groundwater levels have dropped by as much as 20 m over the past decade, with an average level of reduction of 1–3 m per year (Doğdu and Sağnak 2008). Our measurements show an annual level of reduction of 3 m in some locations. According to analysis of radioactive dating using the radioactive isotopes of carbon etc., today's groundwater in Karapinar recharged from the Taurus Mountains, 35 km away, around 10,000 years ago (Bayari et al. 2009).

Interviews conducted with multiple farmers in this area suggest that while there is a slight difference in water levels in some places, the current water level is at a depth of around 60–80 m from the ground surface, at its deepest reaching 100–150 m. Water levels are decreasing year by year, and pipes are frequently added to enable water to be pumped up.

Karapinar has a base rock layer at a depth of around 150–200 m; as such, if water decreases to this level, it will result in the destruction of the base rock layer and groundwater will need to be pumped up from underneath. It has been suggested that groundwater in deeper layers may contain dissolved sulfur and heavy metals.

2.3 Shock at Water Intake Restrictions

2.3.1 Sudden Notification from the General Directorate of State Hydraulic Works

During the first year that the authors commenced this research project, some major news broke out. This was the legalization in February 2013 of water intake restrictions for groundwater covering the whole of Turkey, including Karapinar. In accordance with a letter issued by the General Directorate of State Hydraulic Works (DSI), an order was given to reduce water intake volumes of groundwater to 200 mm per year.

In Turkey, Section 167 of the Groundwater Act was drawn up in 1960, which requires the issuance of a certificate of usage upon filing of notification when digging and using wells. While the number of wells in Karapinar alone is unclear, there are in the region of 200,000 wells in the Konya river basin area, which includes Karapinar, of which around 90,000 are illegal – i.e., uncertificated wells for which notification has not been given (Yilmaz 2010). The annual water extraction exceeded 4.5 Billion m^3 which is almost double of the allowed annual level of 2.4 Billion m^3 for Great Konya Basin (Pınarkaya et al. 2013).

As a result of this large number of unlicensed wells having been dug, groundwater levels were confirmed to be dramatically decreasing throughout Turkey. Therefore, the following item was appended to Section 126 Clause 167 of Article 10 of the Law relating to Groundwater, dated December 16, 1960 (Part of this law has been omitted. (The following text was translated from the original Turkish into Japanese by Shizue Miura, a member of the Japan-Turkey Society, Turkish interpreter and archaeologist.).

> Certificates of usage will not be issued in the event that a detection system for groundwater volumes drawn from wells, underground passages, tunnels or their equivalent has not been installed. This detection system is prescribed by law.

In addition, the following provisional clause was appended to Section 127 Clause 167 (partially omitted).

> Provisional Clause 3 – Those individuals who had already established wells, underground passages, tunnels or their equivalent prior to the date of the issuance of this clause and who are already in possession of a certificate of usage are to install the detection system prescribed in Article 10-2 within a period of 2 years. Those who fail to install a detection system within this period will have their certificate of usage revoked by the General Directorate of State Hydraulic Works, and the costs associated with the closing off of (wells etc.) will be borne by the owner.

The detection system mentioned in the above text is a kind of device that stops water intake for that year once the set level has been reached. As the letter states, though, even after this law was revised, there are still many illegal wells etc. for which a detection system has not been installed. As the law implies, if the owners of these wells do not install the system by February 25, 2013, they will have their certificate of usage revoked and even their electricity will be cut off.

2.3.2 Farmers Filing Petitions

Naturally, the changes to this law were met with a backlash from farmers. In Karapinar, where people rely 100% on groundwater to irrigate their crops, these restrictions on water intake represent a matter of life and death. For example, if a farmer who grows crops on a field that requires 600 mm of irrigation water is restricted to 200 mm in water intake, it means that the total area of cultivation will be reduced to 1/3 and his income likewise by 1/3.

Karapinar Agriculture Chamber filed a petition in response to this to the Grand National Assembly of Turkey in October 2012. The content of this stated that a water intake volume of 200 mm was insufficient for agriculture and that, as a result, the area of irrigated land would decrease and the farmers would experience a dramatic drop in their income. Next, it also stated that if the land was no longer covered by cultivated crops, soil run-off due to erosion would occur, leading to the risk of desertification occurring once more in Karapinar, a model area in Turkey for preventing desertification.

Moreover, Karapinar Agriculture Chamber requested that the General Directorate of State Hydraulic Works (DSİ, Devlet Su İşleri) disclose information providing clear scientific evidence of the reasoning behind its decision to set water intake at 200 mm. However, at present no clear answer has been received from the General Directorate of State Hydraulic Works detailing how it arrived at this figure. Perhaps this petition and request for disclosure of information had the desired effect, as the restrictions on water intake have been postponed on two occasions, and have yet to come into effect.

Fig. 2.4 A stakeholder workshop in progress (October 22, 2014)

2.4 Issues and New Light that Have Become Apparent Through Collaboration with Stakeholders

2.4.1 Aims of the Stakeholder Workshops

During the course of the surveys being carried out in Karapinar, which had been plunged into turmoil at the prospect of these restrictions on water intake, the authors held a series of three local workshops (Fig. 2.4) from April 2012 to March 2016 (Tables 2.1 and 2.2). In addition, during a local visit, we were introduced to some farmers and given consent to conduct a series of interviews with them through the mediation of Karapinar Agriculture Chamber. The aim behind these initiatives was to understand how the farmers themselves felt about the restrictions on water intake and the problem of groundwater depletion, and to gain a clearer picture as to what steps should be taken in the future to address the issues at hand.

The workshops proved extremely fruitful for our research. As a result, we could bring the issues facing the region back into focus and gleaned hints that would help shed new light on the content. For the remainder of this section, all quotation marks signify remarks that were made at meetings or during interviews.

Table 2.1 Overview of workshops and main participating organizations (with the exception of farmers)

Workshop	Date	No. of participants	Main participating organizations	Overview (aims)
1st workshop	February 7, 2013	Around 60 people	1	Clarify local issues through free discussion relating to agriculture and water problems
2nd workshop	October 22, 2014	Around 50 people	1, 2, 3, 4, 6, 7, 8	Exchange information on the future of the region with a diverse range of stakeholders, including students and female laborers, with a focus on the issue of groundwater
3rd workshop	January 9, 2016	Around 60 people	1, 4, 5, 7	Discuss what stakeholders can do to contribute to the future of Karapinar

Numbers of main participating organizations correspond to numbers of name of stakeholder in Table 2.2

Table 2.2 Participating individuals and organizations in this research adopting a transdisciplinary approach

Name of stakeholder	Content of work
1. Karapinar Agriculture Chamber	A private organization made up of around 18,000 farmers. It is the biggest stakeholder, contributing to the region's agriculture through the provision of information and technologies, including the provision of technologies to farmers, soil diagnostics, and mediation services for bank loans etc.
2. Mayor of Karapinar City	City mayor
3. District Governor of Karapinar City	Head of Karapinar's municipal government (public sector worker)
4. Soil and Water Research Institute	A governmental research institute that conducts research relating to crops, water, economics, and desertification
5. Konya Central Irrigation Union	An organization which manages and runs irrigation facilities in Konya Province
6. Bahri Dagdas International Agricultural Research Institute	A private agricultural research institute set up by a former Minister for Agriculture
7. Karapinar Trade Association	Karapinar's trade association, providing sales, processing and distribution of crops
8. Media representatives	Karapinar newspaper and journalists from surrounding areas

2.4.2 *Farmers and Groundwater*

The region faces serious problems when it comes to groundwater. "Everyone has known for a while now that the water will disappear if things continue like this." "We need to think carefully about how much water will be left for our children, on whose shoulders the future rests."

Movements among farmers to conserve groundwater had been limited to the bottom up stance of, “We do not waste water.” It would seem, though, that people have moved to a passive stance of waiting for the government to unfurl top down policies. “If we had sufficient assistance from the government, we would move away from crops that require large amounts of water.” “We would not need assistance for irrigation if we received assistance for rainfed agriculture.”

In addition, as Karapinar does not have any rivers or river basins, many were of the opinion that, when it comes to securing alternative sources of water, “If the water disappears, then all we have to do is draw it up from another location.”

Nobody appeared to voice remarks that were contrary to opinions such as those above. In other words, at the very least, those who took part in the workshops were almost unanimously of the view that they had already done everything they could, which is why they felt that the government should step in to handle the rest. We can also interpret this as a state of dependence on the government. In addition to the aforementioned kinds of remarks, there were more than a few people who also voiced the following sentiments concerning subsidies from the government: “We will undergo soil inspections for the simple reason that we can receive subsidies from the government. If these subsidies were to be cut off, we would not be inclined to undergo soil inspections.”

2.4.3 How Is Irrigation Water Being Used?

“We do not use irrigation water in ways that are wasteful.” This was a remark that came up time and time again, which is why the authors decided to ask farmers individually during interviews to clarify how they use irrigation water. This section presents the results of the survey using interviews from 5 randomly selected farmers and remarks made by participants during the workshops.

As Table 2.3 shows, it became apparent that the volumes of irrigation water being used by the farmers in Karapinar who took part in this study were somewhat excessive for corn and sugar beet when compared with the crop water requirements of FAO (Brouwer and Heibloem 1986). The crop water requirements of FAO serve as only guidelines and it is of course the case that they differ according to the soil,

Table 2.3 Irrigation water volumes in Karapinar and the crop water requirements of FAO (1986)

Crop	Water volumes in Karapinar (mm)	Crop water requirements of FAO (mm)
Wheat (irrigated)	450–600	450–650
Corn	950–1400	500–800
Clover	800	800–1600
Sugar beet	900–1400	550–750
Melons (for pickling)	150–200	400–600

farm's location and other conditions. Regarding corn, the state of germination of the crops was not good during the sowing period and that there were some farmers who conducted seeding once more, which is why there was an increase in volumes of irrigation water at present.

Concerning the volumes of irrigation water being used by the farmers, judging from the conditions under which the farms are being operated, while they tended to use too much irrigation water for sugar beet, overall it would be fair to say that, by and large, groundwater in this area is being using appropriately.

On the other hand, the timing and frequency of irrigation along with the volume of irrigation water used each time are decided by watching others and copying what they do. To begin with, a section of farmers learn the irrigation techniques of agricultural technicians at such organizations as the General Directorate of State Hydraulic Works, the Soil and Water Research Institute and Karapinar Agriculture Chamber. Then, other farmers who learn these techniques by watching and copying the farmers who originally learned them make their own improvements and pass them on to others. While this is perhaps not very scientific, one could say that appropriate irrigation management is being carried out based on experience.

2.4.4 Farmers Who Are Being Led Along and Increasingly Unquestioning Stance Toward Modern Irrigated Agriculture

Karapinar is a famous area in Turkey, despite being just one of many provincial cities. The main reasons for this relative fame is its success in tree planting activities as a means of preventing desertification, as well as its success in dramatically improving productivity through modern irrigated agriculture using groundwater, despite being the area with the smallest rainfall amounts in the country.

Success stories such as these have led to a range of projects being initiated in Karapinar. Beginning with the introduction of modern irrigated agriculture at the initiative of the government, several other projects soon followed in its wake, including a tree planting project, the construction of a new industrial park, a solar power generation station project, and an agricultural greenhouse project. Projects were able to get off the ground as long as they contained the name Karapinar, and all kinds of actors made their way to Karapinar to set up projects and then subsequently left, including governmental bodies, researchers, NGOs, and private businesses connected with agriculture.

Every time a new project was launched, local farmers obtained new information and technologies and had no choice by to abandon their old technologies. These farmers, who were being pulled in various directions, repeatedly invested in new facilities for irrigation. As a result, some farmers who fell into debt started abandoning sections of their agricultural land, and other farmers are now barely able to keep their businesses running.

These farmers, who have been led along by all the information they are being fed, related as follows: "The technologies are becoming more and more advanced every year, which is why it is probably best to keep buying new machinery." Meanwhile, the former head of Karapinar Agriculture Chamber stated that, "Another problem is that income which has been gained through farming has not been invested effectively." For example, there are more than a few farmers who have used the income they have obtained through farming to replace their family cars on an almost annual basis.

Modern agriculture in Karapinar initially blossomed as a result of bountiful groundwater and modern irrigation facilities. However, during the workshops, several issues surrounding fertilizers and agricultural chemicals were highlighted. The soil has lost its fertility and the ecosystems upon which microorganisms thrived have been destroyed; thus, there is the never-ending issue of agricultural land which is becoming increasingly unsuited to growing crops. This has made it customary for farmers to use without question the fertilizers and agricultural chemicals that were recommended by manufacturers: "We use the agricultural chemicals we are recommended without question." As a result, it has served to worsen the problem of farmers blindly accepting what they are given and taking an unquestioning stance toward agriculture.

2.4.5 *The Beginnings of Cooperation Brought About by Groundwater Depletion and Restrictions on Water Intake*

It is said that Karapinar has "reached a golden age" due to modern agriculture. And yet, it is facing the problem of how to deal with groundwater depletion. In fact, by sharing the issues at hand, the region is currently striving to inject stimulus into cooperative activities aimed at social and economic growth to effectuate sustainable agriculture.

With each workshop that was held, it became apparent that those involved were endeavoring to build stances along the following lines: "The problem of restrictions on water intake has enabled a range of different stakeholders, including farmers, to come together under one roof and meet like this." "Farmers, Karapinar Agriculture Chamber, researchers, KOP (Konya Plain Project), Konya Sugar Factory and the Soil and Water Research Institute will unite to tackle a range issues together." Concerning individual issues, such as the problem of artificial chemicals and fertilizers, some technicians from the Bahri Dagdas International Agricultural Research Institute made a specific appeal to the farmers for cooperation. "The thing which is lacking most is dialog. We (Bahri Dagdas International Agricultural Research Institute) are ready to listen to what you have to say."

In addition, the District Governor along with the Director of the Soil and Water Research Institute made the following remarks: "We also need to start holding gatherings such as these which include individuals from a wide range of professions and organizations." "We need gatherings like these in which a range of people and farmers can participate." This suggests that those involved are gradually coming to realize the importance of cooperation and that moves towards facilitation are starting to emerge.

2.4.6 Visualizing the Story in Which Issues Provide a Chance for Change

The biggest problem surrounding the issues discussed in this chapter is that while moves are being made to affect real cooperation between the diverse stakeholders, the fact remains that, at present, water intake volumes have not decreased in the least. Rather, new wells are being dug and registered, and irrigated agriculture continues to spread unchecked. Even though everyone understands the situation, in reality they are moving in the opposite direction to what which is needed.

In Karapinar, large scale and efficient crop cultivation has been made possible through the implementation of modern irrigated agriculture. In fact, methods of irrigated agriculture that have been learned through watching and copying have generated sufficient profits. Given these circumstances, it is not easy to persuade farmers to reduce their water intake volumes. In order to make this happen, it is necessary to visualize and put into practice a new story.

Karapinar is a region with an illustrious history of having halted desertification through the planting of trees. People there continue to take pride in and talk about the achievements they have made through these activities. And the effects of the steps they have taken continue to this day, with the land coverage provided by afforestation and irrigated agriculture giving rise to a synergistic effect that has facilitated astonishing economic growth. The story of how this region overcame desertification and allowed irrigated agriculture to flourish lies here.

And if Karapinar does not need new state of the art irrigation facilities, it equally does not need restrictions on water intake or agricultural subsidies from the government. It is also not enough for groundwater levels simply to recover to their original levels. What is needed is for the visualization and realization of a new story in which the knowledge and technologies which exist in the region are mobilized on a large scale, and for farmers to cooperate in creating technological and social solutions to groundwater management (Maruyama 2009). By taking these steps, Karapinar would be the first in the world to create sustainable forms of agriculture specifically for arid regions.

Therefore, at the same time as surveys on large scale modern irrigated agriculture, the practitioners of which in this case could be called the socially privileged, we also commenced surveys on comparatively small scale farmers who could be called the socially vulnerable, with the aim of mobilizing the region's knowledge. During our surveys, we encountered pickling melon farmers and rain fed wheat farmers. These farmers, the socially vulnerable in this case, hold the potential to bringing new light to the region.

2.5 The Production of Knowledge in Karapinar and Its Distribution

2.5.1 Pickling Melon Cultivation Which Makes Low Volume Irrigation Possible

In Karapinar, pickled melons are served at meal times as a free side dish. These melons are harvested and pickled just before they ripen, when they are around 15 cm in length. They are cultivated about a half an hour's drive from the city center, on arenaceous agricultural land that differs from other areas of Karapinar.

From interviews conducted among farmers, it became apparent that while the cultivation of regular melons necessitates irrigation to be conducted on 6 occasions (400–600 mm), the cultivation of these pickling melons only requires irrigation to be conducted on 2–3 occasions, with irrigation water volumes in the region of only 150–200 mm (see Table 2.3). By a curious coincidence, these water levels are the same as the 200 mm water restriction set by the General Directorate of State Hydraulic Works. Here, there is very little decrease in groundwater levels, just a fluctuation of around 50 cm during the irrigation season.

Melon cultivation in this area began in the 1980s. To begin with, the General Directorate of State Hydraulic Works dug wells for farmers who did not have wells on their agricultural land, and these wells are being used to conduct irrigated agriculture while being managed in cooperation with the Water Management Union.

Surprisingly these melons are extremely lucrative for the farmers. In usual cases, maize (corn) cultivation yields 3030 USD per 1 ha, but in the case of these pickling melons, it soars to 20,300 USD per 1 ha. However, the problem is that, even excluding irrigation, from cultivation to harvesting, growing melons involves many manual procedures, making mass production difficult (Fig. 2.5). While growing melons involves many manual procedures and hard work compared with modern large scale irrigated agriculture, the agricultural labor is concentrated over short periods and farmers are able to leisurely engage in other lines of work during off seasons. The farmers themselves state that they have no intention to give up this way of life.

Each farmer has his or her own original recipe for pickled melons, and producers and consumers who prefer certain tastes often deal with the same farmer over many years. In addition, during the harvesting season, many farmers set up open air stalls along roads to sell their produce directly (Fig. 2.6). In recent years, export traders who have heard about these melons have been visiting the area to purchase melons

Fig. 2.5 Pickling melons that make it possible to limit irrigation volumes through early harvesting

Fig. 2.6 Harvesting pickling melons

for export to the European countriese for use in salads, showing just how booming the melon cultivation industry is in this region.

2.5.2 Rainfed Wheat, a Practice Which Has Continued Since Before the Common Era

Rainfed wheat came to the attention of the authors during the second workshop, when the District Governor asserted the need to put in place rainfed agriculture as a means of conserving groundwater. Considering this comment, we promptly set about searching for rainfed wheat farmers. However, the farmers that we were introduced to by Karapinar Agriculture Chamber stated that they were no longer involved in rainfed agriculture. Furthermore, we were even told that there were no longer any farmers in Karapinar who practice rainfed agriculture. In addition, in an interview, staff involved in research on irrigation management at the Soil and Water Research Institute stated as follows: “Rainfed agriculture is beyond our capabilities.”

According to materials from Karapinar Agriculture Chamber, as of 2012 in Karapinar, the area of land under irrigation stood at 65,000 ha, while rainfed agriculture stood at 37,000 ha. Who exactly was using 37,000 ha for rainfed agriculture and where? We drove outside the city center for around 1 h where, before long, we happened upon a farmer who was cultivating rainfed wheat. We interviewed this farmer and found out the reason why we were having so much trouble finding rainfed wheat farmers. This is because rainfed wheat farmers do not belong to Karapinar Agriculture Chamber for various reasons. The rainfed wheat farmers that Karapinar Agriculture Chamber introduced us to had already given up rainfed agriculture and turned to modern irrigated agriculture.

Rainfed wheat cultivation in this area employs a farming method known as the Nadas System, in which fields are left fallow once every 2 years (Fig. 2.7). However, in years with high rainfall amounts, farmers using this system skip the fallow period and continue cultivating the land. The amount of yield of wheat using this method varies dramatically depending on the moisture content of the soil and rainfall volumes, ranging from 1500 kg/ha to 4000 kg/ha, lower than the amount of yield of irrigated wheat (4000–6000 kg/ha).

We asked about when, where and how the Nadas System was developed, but were unable to get to the bottom of it. There is also no mention of this system in a history of Karapinar published by Karapinar City.

It is said that the Central Anatolia region, which includes Karapinar, has one of the longest histories of wheat cultivation (Esin 2002). The evidence of agriculture in Konya Plain may be seen at the Çatalhöyük excavation site dates to Neolithic (9500 CE) where is about 70 km to the southwest of Karapınar (Fairbairnn 2005). While there is no documentary evidence relating to agricultural technologies in the ancient world, as with irrigated agriculture, it would be safe to say that the Nadas

Fig. 2.7 Cultivating rainfed wheat

System, which developed as a form of agriculture suited to arid regions, has been passed down since before the Common Era by watching and learning and through oral tradition.

2.5.3 Oral Tradition in Turkey and the Transmission of Knowledge of Irrigated Agriculture

The Mediterranean and Aegean Sea region have been home to a rich oral tradition, the most famous example being Homer in Ancient Greece. In Turkey, there were wandering minstrels called Âşik (Ashik)or Orak. These individuals compiled the histories of various countries and spread culture via oral tradition. In Turkey, information was not disseminated through writing until 1928, which Mustafa Kemal Atatürk, the founder of the Republic of Turkey, introduced the modern Turkish alphabet (Gencer and Ozel 2000), and the country's oral traditions continue to be passed down to this day. Prior to 1928, with the exception of a select few persons of learning and court scribes, the vast majority of the population could not read or write.

Karapinar is no exception, where this oral culture and historical background continues to flourish. Therefore, although a vast body of agricultural knowledge has been produced in this region, there is an extremely limited range of written documents and records on this subject. In other words, farmers simply learn about agricultural production by watching with their own eyes and listening to what others tell them. They do not keep records on irrigation by themselves. The farmers who were interviewed practice agriculture based on information they have been party to – for example, once the buds appear, the bulbs will open for around 24 h 10 or so days later.

We learned something surprising during an unscheduled interview with a farmer. Apparently, he was a new part-time farmer who was engaging in agriculture as a side business; his main occupation was running a tea shop serving chai, a popular drink in Turkey. He is increasing his income through irrigated agriculture by watching and learning from others as a means of increasing his income through a side business. He states as follows: "When it comes to practicing irrigated agriculture, I have simply rearranged the method of irrigation that I remember from helping out my father as a child." "If I am unsure of anything, I just ask another farmer nearby." In this way, in Karapinar, anyone can easily become involved in agriculture and increase their revenue if they have groundwater and modern irrigation facilities at their disposal.

As is apparent from this example, oral traditions that are rooted in the region have enabled knowledge of irrigation to been passed down correctly, and that this in turn has allowed farmers to learn the techniques and technologies needed for engaging in irrigation, despite slight variations and a lack of a scientific grounding. On the other hand, the fact that little care has been given to systematically obtaining and cataloging this knowledge in written form and disseminating it has not enabled individual farmers put it into application and develop it, thus making them susceptible to blindly accepting what they are told and taking an unquestioning stance toward agriculture. This is where to problem lies for knowledge production and dissemination in Karapinar.

2.6 Moving Towards Sustainable Agriculture Through the Utilization of Local Environmental Knowledge

2.6.1 Problems Inherent in the Various Agricultural Systems

As we have seen so far, irrigation that relies on groundwater in Karapinar has been developed on the initiative of the government, but this continues to cause the problem of groundwater depletion and the continuance of irrigated agriculture is under threat due to restrictions on water intake. Farmers who engage in irrigated agriculture have constructed agricultural systems through effective irrigated agricultural techniques that have accepted without question, but they are bringing ruin upon themselves through these very systems.

Meanwhile, pickling melon farmers and farmers who practice rainfed agriculture are producing new forms of knowledge that inject scientific knowledge into their own preexisting knowledge. The utilization of this fusion of knowledge shows signs of resulting in highly sustainable forms of agriculture that are suited to the region, avoiding the trap of blindly accepting things without question. However, agricultural operations of this kind are facing issues in terms of productivity and scale.

In this section we seek to visualize the issues surrounding modern groundwater irrigated agriculture, farmers who practice rainfed agriculture and pickling melon farmers, and to explore possible methods for promoting moves to sustainable forms of agriculture that will help solve the issues facing the region.

2.6.2 Issues that Have Become Apparent with Modern Irrigated Agriculture

First, farmers engaging in modern groundwater irrigated agriculture face the issue of dealing with groundwater depletion and unenforced water intake restrictions. Research relating to water resource management consists of Integrated Water Resources Management (Hassing et al. 2009) and Participatory Irrigation Management (Groenfeldt et al. 1999), but under these participatory approaches, farmers participate later in systems that have been set by researchers and governmental bodies. In this respect, a gap emerges between policy and those on the ground (Miyauchi 2013) and it becomes difficult for accommodative water resource management to function properly.

Bearing this in mind, prior to developing irrigation, it is perhaps important to take on board the remarks made by participants in the workshops: “What we really want to grow is wheat from which we can make bread.” “If we could gain sufficient support for growing wheat, we would not have to cultivate other crops that use large amounts of irrigation water.” It is likely that the current situation surrounding groundwater could have been avoided if the government had reflected opinions such as these in their policies, set the purchase price and subsidies for rainfed wheat at a high amount at the first stages of planning, and been able to reduce assistance for investment in irrigation.

In addition, if it is the case that “the proceeds gained from irrigated agriculture have not been properly reinvested,” by collecting part of the revenue gained through the use of groundwater, which is a regional shared asset, and investing it for the future as a fund for such things as groundwater conservation and measures to prevent soil erosion, then this revenue would create values which go beyond mere economic value and would contribute to sustainable agriculture, something which is more desirable than purchasing a new car every year.

2.6.3 New Forms of Local Environmental Knowledge in Karapinar

By harvesting crops that are rooted in the region early, irrigation water volumes can be reduced and the crops can be sold with added value. The production of knowledge and action behind this notion is best embodied by pickling melons. In this case, we can say that this knowledge set has created new forms of local environmental knowledge comprising of a range of factors including local culinary culture, the cultivation of crops that are rooted in the region, modern irrigation facilities and cultivation management that is performed through manual labor (Sato 2015).

In the same way, the cultivation of rainfed wheat through the Nadas System, something which has been passed down since before the Common Era, is a form of sustainable agriculture that has been realized through a unique form of local environmental knowledge that blends a diverse range of knowledge spanning centuries and which is rooted in the region. Rainfed wheat farmers have been making gradual improvements to the Nadas System by obtaining information from sources not related to rainfed agriculture, such as agricultural exhibitions and agriculture channels on television.

Farmers who adopt such cultivation methods are in the minority in Karapinar. The problem, then, is how to spread awareness of these methods throughout the region and make them take rood. One effective method would be to turn pickling melons and rainfed wheat into a local brand and begin by raising their profile at the regional level. This needs to start with those farmers who believe that there are no farmers left who practice rainfed agriculture or researchers who believe that rainfed agriculture is not possible. Karapinar's pickling melons and rainfed wheat would make the perfect items for branding; their association with the illustrious area of Karapinar alone would make this possible. But local farmers have yet to realize this.

2.6.4 Shifting Over to a Sustainable Society Through the Creation of a New Story

In Karapinar, the issue of groundwater depletion has created an awareness of the need for the region to cooperate in taking steps to conserve its groundwater resources. And through workshops consisting of a diverse range of stakeholders, issues that the region faces came to the fore and were shared with more force than usual.

If the District Governor had not make the remarks he did during one of these workshops, rainfed agriculture farmers may not have come to our attention. In addition, if we had not eaten pickled melons at a restaurant, we may not have had contact with pickling melon farmers. Interaction between various stakeholders and fortunate encounters served to strengthen the ties between us as scientists and the region.

Here, the most distinctive feature of our research processes, based on the transdisciplinary approach (Hadorn et al. 2008), is that they facilitated cooperation between various stakeholders through workshops, not only those involved in modern large scale irrigated agriculture (the socially privileged) but also traditional rainfed agriculture farmers who do not belong to Karapinar Agriculture Chamber along with comparatively small scale pickling melon farmers (the socially vulnerable).

And what became newly apparent to us through this process is the fact that the environmental knowledge possessed by the socially vulnerable has the potential to serve as a beacon of hope for the region in helping solve the problems and challenges caused by the socially privileged. No doubt, in addition to pickling melon farmers and rainfed agriculture farmers, other groups of socially vulnerable people who possess unique forms of local environmental knowledge exist in Karapinar. There is a need for action to be taken in uncovering these new forms of knowledge and documenting information that has been passed down through oral traditions, and to disseminate and develop this throughout the region.

An effective way for this to happen is for all the actors to cooperate in creating and sharing a story that can resonate across the region. The most acceptable way to achieve this in the region would be to imitate the way in which Karapinar created a history of success in stopping desertification through the planting of trees.

In other words, this new history of Karapinar necessitates the creation of a story in which local environmental knowledge is organized and developed and used by the entire region to act in conserving groundwater, becoming the first in the world to develop sustainable forms of agriculture for arid regions. By doing so, we could expect the production of knowledge and action by pickling melon farmers and rain fed agriculture farmers to be applied as viable methods not only in Karapinar but in other arid regions in the world experiencing similar problems.

The next challenge facing our research group is to continue this transdisciplinary approach to organize and reconstruct local environmental knowledge that has been passed down orally, and to then document it. This would be followed by the construction of a model for groundwater conservation using the local environmental knowledge of the socially vulnerable, which we would use to contribute to the improvement of sustainability in agriculture in other arid regions experiencing similar problems. This is the least that we as researchers can do in return for all we have learned through cooperation with the local stakeholders.

References

Akça E, Kume T, Sato T (2015) Development and success, for whom and where: the central Anatolian case. In: Chabay I, Frick M, Helgeson J (eds) Land restoration: reclaiming landscapes for a sustainable future. Academic Press, London, pp 533–541

Bayari S, Ozyurt N, Kilani S (2009) Radiocarbon age distribution of groundwater in the Konya closed basin, Central Anatolia, Turkey. Hydrogeol J 17:347–365

Brouwer C, Heibloem M (1986) Irrigation water management: irrigation water needs. FAO, Paris

Celik M, Afsin M (1998) The role of hydrogeology in solution-subsidence development and its environmental impacts; a case-study for Sazlıca (Niğde, Turkey). Environ Geol 36(3):335–342

Dogdu MS, Sagnak C (2008) Climate change, drought and over pumping impacts on groundwaters: two examples from Turkey. In: Conference on water observation and information system for decision support. BALWOIS 2008, Ohrid, Republic of Macedonia

Editing Committee for the Revised Groundwater Handbook (ed) (1980) Revised groundwater handbook (改訂地下水ハンドブック). Tokyo, Research Institute of Construction and Economy, Tokyo (in Japanese)

Esin U (2002) ASIKLI HOYUK. ARKEOATLAS-Yasayan Gecmisim Drgisi. D.B.R Istanbul, Istanbul

Fairbairn A (2005) A history of agricultural production at Neolithic Çatalhöyük East, Turkey. World Archaeol 37(2):197–210

Gencer AL, Ozel S (2000) Turk Inkilap Tarihi. DER YAYINLARI, Istanbul

Groenfeldt D, Subramanian A, Salman S, Raby N, Svendsen M, Schaak J (1999) Participatory Irrigation Management (PIM) handbook. World Bank 1(ii):54–91

Hadorn GH, Hoffmann-Riem H, Biber-Klemm S, Grossenbacher-Mansuy W, Joye D, Pohl C, Wiesmann U, Zemp E (2008) Handbook of transdisciplinary research. Springer, Netherland

Hassing J, Ipsen N, Jønch T, Larsen CH, Lindgaard-Jørgensen P (2009) Integrated water resources management in action. United Nations Educational, Scientific and Cultural Organization, Paris

Maruyama Y (2009) Questioning "earth-friendliness" – the narrow path of natural energies and nature conservation (「地球に優しい」を問う-自然エネルギーと自然「保護」の隘路). In: Kito S, Fukunaga M (eds) Environmental ethics. University of Tokyo Press, Tokyo, pp 171–183 (in Japanese)

Miyauchi T (ed) (2013) Why does environmental conservation fail??-(なぜ環境保全はうまくいかないのか). Tokyo, Shinsensha, 348pp (in Japanese)

Pınarkaya M, İnan GA, Şahin M, Bosyancı İ, Vanoğlu M (2013) External water allocation suggestions to KOP region. National KOP regional development symposium, 14–16 November 2013, Konya Turkey

Sato T (2009) From knowledge to wisdom – residential research institutions bringing together indigenous and scientific knowledge (知識から智慧へ-土着的知識と科学的知識をつなぐレジデント型研究機関). In: Kito S, Fukunaga M (eds) Environmental ethics. University of Tokyo Press, Tokyo, pp 211–226 (in Japanese)

Sato T (2015) Theory of sustainability science: solution-oriented production of integrated knowledge (サステイナビリティ学の科学論-課題解決に向けた統合知の生産). Environmental Research Quarterly 177:52–59 (in Japanese)

Shiklomanov IA, Rodda JC (eds) (2003) World water resources at the beginning of the twenty-first century. Cambridge University Press, Cambridge

Siebert S, Burke J, Faures JM, Frenken K, Hoogeveen J, Döll P, Portmann FT (2010) Groundwater use for irrigation – a global inventory. Hydrol Earth Syst Sci 14:1863–1880

Yılmaz M (2010) Karapınar Çevresinde Yeraltı Suyu Seviye Değisimlerinin Yaratmıs Olduğu Çevre Sorunları. Ankara Üniversitesi Çevrebilimleri Dergisi 2(2):145–163