Chapter 7
Turkey

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Abstract This chapter reviews irrigation development and policy with specific references to the main water- and land-based regional socioeconomic development projects in Turkey. It analyzes the expansion of irrigation investment as well as institutional and technological changes in irrigation policy and development in parallel with policies of liberalization and decentralization in the late 1980s. The chapter also discusses institutional changes in the management of the irrigation systems as a result of (partial) transfer of management of large-scale irrigation systems to a variety of water user organizations. Finally, it describes current technological and institutional problems and the further challenges to the irrigation sector, such as infrastructure deterioration, risks of drought, environmental and ecological system degradation, and insufficient investment. It also notes the efforts to equip new irrigation schemes with modern technology, such as closed pipes for conveying water instead of open channels, and water-saving micro-irrigation methods rather than surface irrigation techniques.

Keywords Turkey · Irrigation technology · Irrigation policy · Irrigation management

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F. Molle et al. (eds.), *Irrigation in the Mediterranean*, Global Issues in Water Policy 22, https://doi.org/10.1007/978-3-030-03698-0_7

7.1 Introduction

Turkey, a middle-income country with a population of over 79.8 million (TUIK 2017), is one of the world's 20 largest economies as well as the world's 9th largest agricultural producer (Çakmak and Kasnakoğlu 2016). Although the pace of population increase has slowed in past decades, its net growth rate is still positive: 1.31% per year. The rural-to-urban population ratio decreased from 80% in 1927 to 8.3% in 2016 due to steadily increasing internal migration, mainly to the big cities. As a result of population growth, alterations in water consumption habits driven by increasing socioeconomic development and growing urbanization, water-demanding, and water-dependent sectors have increased and diversified in recent decades, such as energy production, industry, tourism, and environment, along with the traditional consumers like agriculture and domestic use.

While Turkey's agricultural output in the past century has managed to outpace population growth and keep up with growing demand from rising incomes, labor and capital were scarce, while land was relatively plentiful until the mid-twentieth century (Pamuk 2006). A concerted drive to expand agricultural land brought spectacular results after WWII. In keeping with the global Green Revolution, the 1950s, 1960s, and 1970s saw the rapid introduction of machinery, fertilizers, high-yielding varieties, and new inputs, while irrigation in particular increased rapidly (Zurcher 2004). Although Turkey's agriculture was self-sufficient in the past, there has been a sharp decline in agricultural production as a share of GDP in recent years. In 1923, agriculture made up about 43% of total value added. Although gross domestic production value of the agricultural sector increased from about 9 billion TRY (Turkish Lira) in 1998 to 161 billion TRY in 2016,[1] its share of GDP declined from 12.5% to 6.2% during the same time period (TUIK 2017). However, agriculture is still vital to the national economy as a large contributor to export revenues not only generated from agricultural products directly but also as a producer of raw materials for industrial export commodities.

In this chapter, we analyze irrigation policy and development in Turkey. We first present Turkey's geographic and climatic attributes with specific references to water and land resources. We then describe the role played by irrigation and water policy in the creation of the modern state in Turkey with special reference to the major water- and land-based regional socioeconomic development project, namely, the Southeastern Anatolia Project (Turkish acronym: GAP). Subsequently, we analyze the expansion of regional irrigation investments as well as institutional and technological changes in irrigation policy and development which started in the late 1980s in parallel with a policy of liberalization and decentralization. We find that irrigation investment is likely to continue in Turkey. There is a concerted effort to equip new irrigation schemes with modern technology, such as closed pipes for conveying the water instead of open channels and water-saving micro-irrigation methods

[1] Nine billion TRY in 1998 was worth 18.5 billion USD (28 billion in 2016 values), and 161 billion TRY in 2016 was worth 53 billion USD.

rather than surface irrigation techniques. We argue that stakeholders in the irrigation sector, namely, the state and farmers, should sustain institutional progress and reform programs for the sustainable and equitable management and use of water and land resources in the country.

7.2 Physical Setting and the Importance of Water in Turkey

In Turkey, water bodies such as rivers and lakes total around 10,000 km^2 out of a total area of 783,577 km^2. With an average altitude of about 1131 m above sea level, the country is predominantly mountainous, and lowlands are confined to coastal areas. There are three primary climate types (following the Köppen-Geiger climate classification) in Turkey. The Mediterranean and Aegean coastal areas of the country experience a temperate Mediterranean climate characterized by hot and dry summers and mild and wet winters. The Taurus Mountains' abrupt rise on the Mediterranean coast contributes to the irregular distribution of precipitation both in space and time. The Black Sea coastal region has a temperate maritime climate with warm and wet summers and cool and wet winters. This region receives on average 2250 mm of annual precipitation, evenly distributed throughout the year. The interior of Turkey, including central, eastern, and southeast Anatolia, is subject to a continental climate, which has hot summers and cold winters. In central and southeast Anatolia, rainfall is low throughout: less than 300 mm per year. Eastern Anatolia, which consists of several high mountain ridges and high plateaus, receives heavy snow (Türkeş 2010).

The long-term averages for mean temperature, annual precipitation, and evaporation in Turkey are 13.5 °C, 574 mm, and 1173 mm, respectively (see Fig. 7.1). In

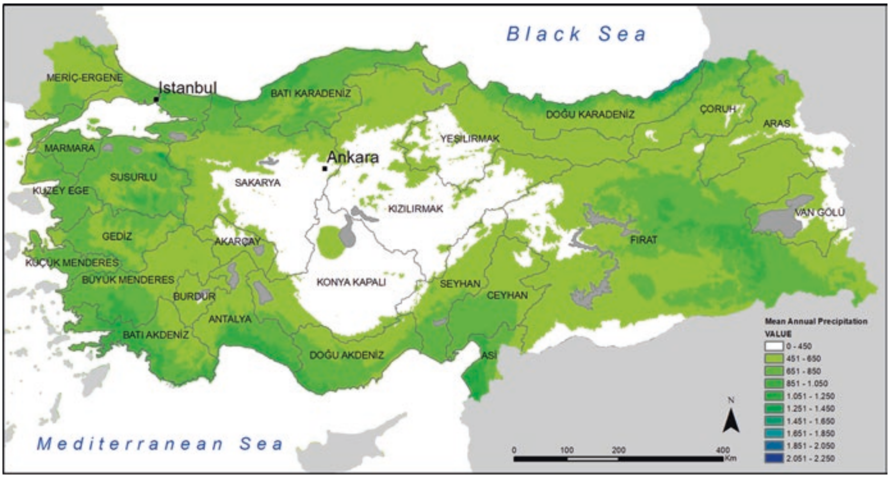

Fig. 7.1 Mean annual precipitation distribution over Turkey

all regions, except the eastern Black Sea region, approximately 70% of total precipitation falls between October and March. Besides the limited rainfall, evapotranspiration rates are high due to prevailing high temperatures during the summer months (Coşkun et al. 2017). Therefore, agricultural production, particularly in fertile regions, such as western, southern, and southeastern Turkey, can only be achieved through irrigation (Topcu 2011).

Comprehensive surveys of Turkey's land and water resources began around the 1930s and were carried out after the establishment of the General Directorate of State Hydraulic Works (Turkish acronym DSI) in the 1950s. Turkey's total annual precipitation amounts to 450 Bm^3, and, considering the water lost to evaporation from the surface, transpiration through plants, and seepage to aquifers, and gained from surface runoff coming from neighboring countries, the total surface runoff is about 172 Bm^3. Since not all the renewable water resources can be utilized, for topographical, geological, economic, and technical reasons, the exploitable surface runoff, which includes inflow from neighboring countries, only amounts to 94 Bm^3. The renewable groundwater potential is 18 Bm^3, hence the total exploitable surface and groundwater resource amounts to 112 Bm^3. In total, 54 Bm^3 per year (50%) of the usable water potential was diverted in 2016 (DSI 2016). The largest share (40 Bm^3) of freshwater resources (74%) was utilized by the agricultural sector, while the remaining 26% was shared equally between industry (7 Bm^3) and domestic use (7 Bm^3).

Turkey has 25 river basins with a wide range of catchment sizes, and large variations in the average annual precipitation, evaporation, and surface runoff parameters. Consequently, river discharges are irregular (see Fig. 7.2). Sixteen rivers rise in-land and reach the Marmara and surrounding seas within Turkey's territorial boundaries. Four of the 25 are closed basins, i.e. they have no outflow to the sea: the Konya, Akarçay, Burdur Lakes, and Lake Van basins. The other five are

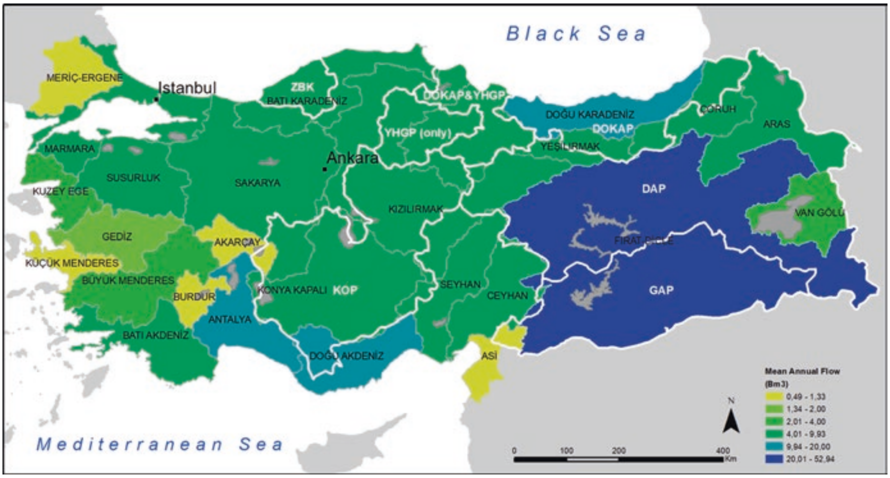

Fig. 7.2 Turkey's 25 river basins and their mean annual flows, Bm^3. (DSI 2016)

the main transboundary basins. Turkey is upstream of Syria/Iraq in the Fırat-Dicle/Euphrates-Tigris, of Georgia in the Coruh, and of Georgia and Iran in the Kura-Araks. Conversely, it lies downstream from Lebanon and Syria in the Asi/Orontes basin and downstream from Bulgaria in the Meriç/Maritza basin. These five transboundary rivers constitute about 35% of Turkey's water potential (DSI 2016). Some regions, such as Thrace, the Aegean Sea coastline, and central Anatolia, include about 20% of Turkey's cultivable area but only 10% of the country's surface water resources. Per-capita water availability is below 1000 m^3 in the Marmara, Kücük Menderes, and Asi basins. Together with the Sakarya basin, these three basins are threatened by severe water stress in terms of both quantity and quality.

Turkey's landscape is mainly composed of natural land cover (54%), dominated by transitional woodland and shrubs, and agricultural areas (42%), including nonirrigated and irrigated arable land, agriculture with natural vegetation, and complex cultivation patterns. The total cultivable land area is about 28 million hectares, 25.85 million of which is suitable for irrigation. Considering the water resource potential given by DSI, 12.5 million hectares can be irrigated, but, for technical and economic reasons, only 8.5 million hectares (7.9 and 0.6 million hectares from surface and groundwater resources, respectively) are planned to be equipped for irrigation by DSI by the year 2023 (DSI 2016).

Out of a total irrigated area of 6.09 million ha, an estimated 3 million ha of arable land is affected by waterlogging (i.e. poor drainage and topography) and a further 1.5 million ha, a quarter of the irrigated area, has yield limitations due to salinity and sodicity problems. In particular, irrigated lands of the Harran plain in the Euphrates river basin, the Amik plain in the Asi basin, Konya in central Anatolia, and the Lower Seyhan plain in the Seyhan river basin are threatened by salinity and sodicity (Küsek 2010). As much as 83.21% of agricultural land is currently under risk of severe water erosion. The hilly topography, soil conditions that facilitate water erosion (fine texture, low organic matter, poor plant coverage due to semiarid climate), inappropriate agricultural practices (e.g. excessive soil tillage and cultivation of steep lands, not using land in accordance with its capabilities), and forest fires are the main causes for intensified erosion in Turkey.

The most common crops in terms of percentage of irrigated area are maize, cotton, and cereals with a share of 25%, 14%, and 13%, respectively. These are followed by fruit trees (7%), fodder crops (6%), sugar beet (5%), vegetables (5%), sunflower (5%), legumes (3%), vineyard (2%), and other crops (12%). However, cropping patterns show regional variance depending on land-soil-climate conditions, as well as economic and social factors, such as input and output market prices and farmer habits. The benefit of irrigation in terms of yield increase as reported by the DSI (2017) was 273% for cotton, 147% for fruit trees, and 155% for citrus, whereas the largest increase (a sixfold increase in yield) was achieved for maize since irrigation was introduced.

Water is at once the most critical and limiting factor in agricultural production in many parts of the country including central and south Anatolia, the Aegean, and the Mediterranean regions. Intensive drought periods caused the loss of crops and animals and the migration of farmers to other areas over recent decades. The cost to the Turkish agricultural sector in a year of significant drought, 2007, was estimated at around €2.3–2.5 billion (see Oral 2008; MoFAL 2013).

The productivity in many agricultural areas equipped for irrigation is much lower than originally planned due to (i) a low *irrigation ratio* and (ii) inefficient *water use*. The irrigation ratio refers to the net area that is actually used for irrigated crop production within the irrigation scheme at least once a year. The low *irrigation ratio* means that a considerable amount of land within an irrigation scheme is not irrigated although it is served by irrigation networks. The average irrigation ratio is about 65% in the country (DSI 2016), varying between 45% and 90% in Water User Association-managed areas (Yavuz et al. 2006). Another important performance indicator for irrigation projects is *water-use efficiency* (Alizadeh and Keshavarz 2005). According to the latest records, the irrigation efficiency was around 45% in irrigated areas managed by Water User Associations (DSI 2016), meaning 55% of diverted water returned to the river/aquifer system.

7.3 State Consolidation and Irrigation Policy

Turkey's hydraulic history is characterized by urban waterworks rather than irrigation schemes, though potable water supply and irrigation often went together. Dam and channel building in Turkey has a millennial history, several dam types were premiered on its territory, and several of these structures are still in place. The Greeks, Romans, and Byzantines constructed a host of well-preserved waterworks: water conveyance systems, aqueducts, stone pipes and lead-pipe inverted siphons, tunnels, spring water collection chambers, reservoirs, cisterns, but also dams, such as the Faruk dam near Van, which collapsed as recently as 1988 (Ozis et al. 2005). The first of three dams constructed in Dara near Mardin during the reign of Justinian (527–565) is known as the oldest arch-type dam in the world (Cakmak et al. 2004). The Ottomans built many dam structures, several of which are still operational, and countless urban water structures. The first modern irrigation and drainage project was implemented in response to a severe drought devastating the Konya region: the Cumra Irrigation and Drainage Project in Central Anatolia (1907–1914) conveyed water to the Konya plain, mainly from Beyşehir Lake.

From the 1920s to the 1950s, Turkey was engaged in state consolidation efforts, which included the investigation and exploitation of water and land resources. New government institutions, namely the Ministry of Public Works (established in 1920) and the Electrical Power Resources Survey and Development Administration (established in 1935) were mandated to conduct hydrological surveys of the country's water resources and hydropower potential and to carry out related civil works (Tigrek and Kibaroglu 2011). Framework laws, such as the Village Law (1924), the Water Law (1926), and the Law on Municipalities (1930), were enacted, and various water projects were implemented. The earliest studies of the Euphrates-Tigris basin date back to the 1930s and eventually led (in the 1980s) to the Southeastern Anatolia Project (GAP). Poor water quality across the country was one of the urgent problems which the state had to address to improve public health. Responsibility for implementing the Water Law was therefore entrusted to the Ministry of Health and Social Aid. Similarly, the draining of swamps was seen as essential if certain waterborne diseases, such as malaria, were to be eradicated. Throughout this period, public investment in infrastructure was decided centrally on an ad hoc basis and thus in response to pressing needs.

Turkey had long followed a Keynesian development model, which assigns the state an active interventionist role in the economy, including the provision of public services (Kibaroglu et al. 2009). After World War II, state-led water resources development was fostered by the establishment of a central water bureaucracy, the DSI, which assumed a role similar to that of the US Bureau of Reclamation. One of the DSI's main objectives was to stimulate economic development through water-related infrastructure. It was believed that only the state was able to overcome underinvestment and realize economies of scale (Scheumann et al. 2011).

From the 1950s onward, Turkey adopted a river basin planning approach based on exploratory hydrological studies. Law No 6200 of 1953 ruled that the DSI should focus on major river basins and have regional directorates. Two laws enacted in this phase reinforced the status of the DSI as the main public water agency: the first was the Groundwater Law (1960), which mandated the DSI to grant licenses for the utilization of the country's groundwater resources (however, individuals and groundwater cooperatives would be entrusted with management issues); and the second was Act No 1053 (1968), which made the DSI responsible for water supply to cities with a population greater than 100,000.

Following the adoption of an import-substitution industrialization program, public investment in the water sector was arranged through the national 5-year development plans: major water infrastructure, such as irrigation systems including storage facilities and dams for hydroelectricity generation, was state-financed and state-managed. In recognition of the economic and political importance of the agricultural sector to the country, particular attention was also paid to rural development (Scheumann et al. 2011). Hence, Law no. 7457 of 1960 established the early General Directorate for Soil and Water (Toprak-Su), which was later reconstituted as the General Directorate for Rural Services (GDRS), under the Ministry of Agriculture and Rural Affairs, in 1985. While the DSI, under the Ministry of Energy and Natural Resources, was responsible for the construction and management of the large-scale public irrigation schemes, the services for on-farm irrigation, including the construction and management of irrigation facilities up to the 500 l/s, and supplying water to municipalities in rural areas below 3000 inhabitants, were the responsibility of the GDRS. Other on-farm services related to irrigated agriculture (e.g. surface and subsurface tile drainage, land leveling, land consolidation, soil and water conservation measures, research on soil-plant-water relationships) were also within the remit of the GDRS. As part of an economic program in 2005, the GDRS was abolished, and its duties and facilities (as well as the personnel) at all provincial levels were transferred to the Special Provincial Administrations (SPA) except for two metropolitan municipalities in Istanbul and Kocaeli. The former Bank of Provinces (renamed İlbank in 2011), under the Ministry of Environment and Urban

Planning, is another actor in the financing and providing of technical support to local authorities for the construction of water supply (also surface and groundwater for irrigation purposes) and waste water treatment units.

Under the guidance of the State Planning Organization, Turkey made considerable progress in augmenting water supply. This phase also witnessed the birth of GAP, one of the most significant projects in Turkey's history. With the stated aim of overcoming the relative backwardness of the southeastern Anatolia region, the development of water and land resources through public investment was regarded as an effective strategy (Kibaroglu et al. 2009). GAP is Turkey's largest integrated development project and is considered vital to the economy. It has the potential to meet the rising demand for hydropower caused by population growth, along with urbanization and the country's industrialization impetus. Upon the completion of the GAP project, 1.7 million ha of land will be brought under irrigation, equivalent to nearly one fifth of Turkey's irrigable land; energy production in the region will reach 27 billion kWh; per capita income is expected to rise by 209%; and employment opportunities will be created for around 3.8 million people. This will be accomplished through the construction of 22 dams, 19 hydropower stations, and extensive irrigation and drainage networks. By the end of 2016, 504 million ha of agricultural land were under irrigation in the GAP region. GAP's basic development objectives are defined as follows: to raise the income levels in the GAP region by improving the economic structure in order to narrow the regional income disparities; to increase productivity and employment opportunities in rural areas; to enhance the assimilative capacity of larger cities in the region; and to contribute to the national objective of sustained economic growth, export promotion, and social stability through the efficient utilization of the region's resources.

To these ends, the GAP was transformed from a pure infrastructure development project into a project in support of sustainable development with additional investment in urban and rural infrastructure, agriculture, transport, industry, education, health, housing, and tourism. The sporadic political and economic crises during the 1970s, 1980s, and 1990s prevented this investment from being completed in a timely fashion. From the very beginning, the GAP project and, in particular, its dam component has come in for some harsh criticism. The objections specifically concern resettlement issues, environmental and cultural aspects, and impacts on the rivers' riparian countries, Syria and Iraq (Scheumann et al. 2011).

The economy ran into a serious crisis with high inflation, a growing trade deficit, and high unemployment rates at the end of the 1970s (Kibaroglu et al. 2009). A balance-of-payments crisis emerged in late 1979, arising from insufficient exports and external debt service obligations (Scheumann et al. 2011). This meant that the state-led import-substitution model had to be restructured. This also had repercussions on irrigation planning, development, and management, as the next section outlines.

To summarize, until the 1980s, Turkey's water policy, including the irrigation development among the other water-related sectors, can be characterized as follows: (i) policy initiatives were basically shaped by national considerations, and governments decided on their agendas without the interference of foreign actors. This certainly does not mean that it was an entirely closed scene: professional relations existed with the US Bureau of Reclamation, and leading bureaucrats and politicians had been educated abroad. (ii) Managing a river's water resources was largely the mandate of the DSI: planning and investigation were focused on the 25 river basins, and decisions were taken by bureaucracies at the national level and dictated by national priorities. (iii) Public spending was the only instrument used to finance irrigation infrastructure projects.

7.4 Irrigation Development and Management[2]

In addition to the GAP project, which marks the post-1980 era, there are other important irrigation development projects (Fig. 7.2), such as the Zonguldak-Bartın-Karabük (ZBK) Regional Development Project (1995–1996), the Yeşilırmak Basin Development Project (YHGP) (1997), the Eastern Anatolia Project (DAP) (1999–2000), the Eastern Black Sea Regional Development Plan (DOKAP) (1999–2000), and the Konya Plain Project (KOP) (2011) (DSI 2016).

The UN Environment Program (UNEP) identifies Turkey as one of the first places where desertification will start in Europe, and, within Turkey, the Konya closed basin (central Anatolia) will face desertification by 2030 if nothing is done. While 17% of Turkey's irrigated area is located in the KOP region, that region has only 4% (4.36 Bm^3) of the available water resources, three fifths (2.44 Bm^3) of which come from groundwater resources. The KOP region covers about 3 million ha of cultivable land; however, with the existing water resources and even using water-saving irrigation techniques, only 1.1 million ha of this area can be irrigated. Hence, the KOP also envisages water transfer from the river Göksu through the Blue Tunnel into Konya, to be stored in reservoirs and used for irrigation. Agriculture is the major water-using sector (94%) in the Konya closed basin, and, as a consequence of groundwater overexploitation over recent decades, the groundwater level has fallen by 3 m a year on average. The KOP does not so much aim to expand irrigation in the area as to make it more efficient (DSI 2016).

The Eastern Anatolia Project (DAP) is to irrigate about 1.37 million ha. It covers 23% of Turkey's geographical area, involving 15 provinces and affecting 8% of Turkey's population. The DAP includes irrigation, drainage, and reclamation projects, as well as hydropower and domestic supply projects, and one third of the agricultural lands in the region are already under irrigation (DSI 2016).

The Eastern Black Sea Project (DOKAP) aims to restore degraded soils for agricultural production by means of irrigation and drainage projects and flood control, but also involves fishery, forestry, industry, tourism, and cultural heritage conservation. The planned area to be irrigated within the DOKAP region is around 287,000 ha, and irrigation projects were completed for almost two thirds of the planned total by the end of 2016 (DSI 2016).

[2] Some parts of this section are drawn from Kibaroglu et al. (2012:27–34).

Besides controlling the irregular flow regime which causes floods every year, the Yeşilırmak River Basin Development Project (YHGP), initiated in 1997, aims to prevent erosion and pollution as well as to promote irrigation and drainage in the project region (DSI 2016).

Following the above-mentioned regional priority projects, in 2012, Turkey began a project called “1000 reservoirs in 1000 days” to bring irrigated farming to rural areas that were outside planned large-scale irrigation schemes. Flood and erosion control were also among its goals. The project was completed in 2015, and the reservoirs, with a total storage capacity of 600 million m^3, are for irrigation and flood control in an area of about 1.7 million ha (DSI 2016).

7.4.1 Technological Change

During the 1950–1965 period, water was mostly conveyed using open channel distribution networks from the reservoirs to the fields. Since the 1970s, canalets (concrete raised parabolic flumes) were constructed, whereas from the 1980s onward, pipeline distribution networks were utilized in areas with irregular topography, high slopes, and limited water resources. Pipelines conveying and distributing water to the fields have become the rule, reaching 94% of irrigation schemes under construction by the end of 2016. However, in many old schemes, surface irrigation continues to be dominated by gravity-fed systems such as furrow, border, and even wild (uncontrolled) flooding; pumping systems only account for 22% due to their higher cost (DSI 2017); electricity can account for 80% of operation expenses.

The main canal, tertiary canals, and discharge canals are of trapezoidal cross section with concrete lining. The smaller backup, tertiary, and distribution canals, on the other hand, are generally prefabricated canals placed on supports above ground level at heights varying according to the topography. Water delivery systems (see Fig. 7.3) in irrigation schemes as a country average comprise:

- Classic trapezoidal open canals (37%)
- Canalets: precast concrete half ellipsoidal open canals (41%)
- Piped systems (22%)

Fig. 7.3 Typical open canal, canalet, and piped systems used in Turkey’s irrigation schemes (DSI 2017)

As of 2016, an area of about 6.09 million ha was equipped with irrigation infrastructure, 63% of which was developed by the DSI and 37% by the now-abolished General Directorate of Rural Services (GDRS) and its successors. Although the DSI has continued to build irrigation systems, most irrigation schemes have now been transferred for operation and management to either:

- Irrigation cooperatives, e.g. groundwater irrigation cooperatives and water user associations
- Local authorities, e.g. village authority and municipality
- The public sector, e.g. universities, research institutions, and public agricultural enterprises: TIGEM

About 75–80% of Turkey's irrigated area is irrigated using surface water, and the remaining 20–25% using groundwater (see Box 7.1) (DSI 2017). To enhance flexibility and reliability in irrigation schemes, the conjunctive use of surface water (canal water) and groundwater is required, particularly in areas where surface water is insufficient.

Box 7.1 Resources used for abstracting irrigation water (DSI 2014)

- *Surface water resources, 80%*
  - Pumping: 18%
  - Gravity: 82%
- *Groundwater resources, 20%*
  - Supplementary to gravity: 16%
  - Abstraction by pumping*: 84%

**Groundwater irrigation cooperatives and individual (private) irrigation*

For this purpose, the DSI installs wells and manages groundwater abstraction from those wells into the irrigation schemes they operate. Nevertheless, the operation of these groundwater irrigation networks has been occasionally transferred to organizations such as water user associations and groundwater irrigation cooperatives. The use of groundwater resources more than 10 m deep requires a license issued by the DSİ, which solely covers the right to use it; it can neither be transferred nor sold.

About 14 Bm^3 of the total groundwater potential (18 Bm^3) has already been assigned to different water users including mainly the groundwater irrigation cooperatives, individuals (private), and public entities for different purposes, such as drinking and domestic use, industry, and irrigation. Agriculture (69%) is the main user of groundwater. About 4.4 Bm^3 is allocated to organizations such as groundwater irrigation cooperatives, the DSI (then on to the irrigation associations), and public entities for irrigation of about 684,000 ha. The Groundwater Irrigation Cooperatives founded from 1966 onward are a major user, and 72% of the total area irrigated with groundwater is under their control. Although 273,962 licenses for the use of around 5.1 Bm^3 of groundwater had been granted for individual (private) irrigations as of

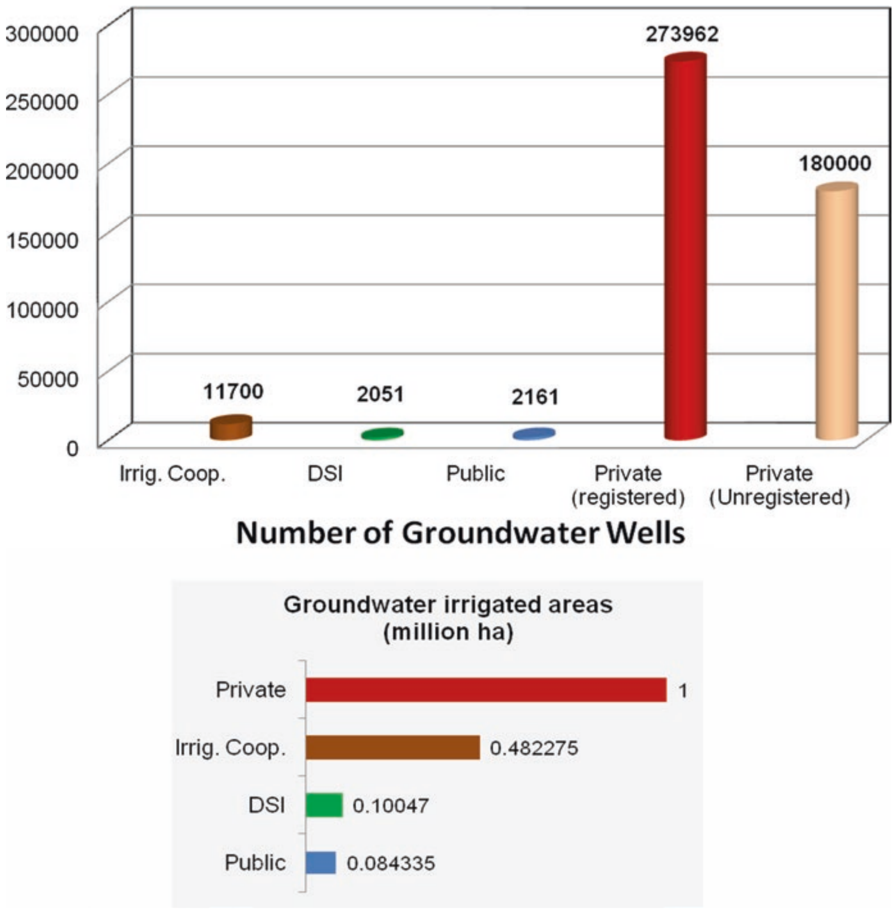

Fig. 7.4 Number of groundwater wells and irrigated areas (DSI 2014)

2014, there is no reliable data about the irrigated areas using these resources except for a rough estimate of around 1 million ha (Fig. 7.4).

DSI and the Ministry of Food, Agriculture, and Livestock (MoFAL, formerly the Ministry of Agriculture and Rural Affairs: MARA) have taken steps to encourage farmers to use sprinkler and drip irrigation methods, particularly in areas with high climatic vulnerability, such as the Aegean and Mediterranean regions as well as in central Anatolia (Konya closed basin), where resources are scarce due to overexploited surface and groundwater. Turkey has experienced prolonged droughts every 30 years, and the frequency appears to be increasing (Sen et al. 2012). The latest run of dry years was 2007–2009–2013. After the 2007 drought, the government prioritized short-term compensation measures to offset losses but also introduced economic instruments to tackle droughts. Farmers' debt repayments to state banks were postponed for 1 year, and interest-free loans and subsidies for implementing water-saving irrigation technology were provided, along with direct payments to farmers for mitigating drought effects.

These incentives successfully convinced farmers to switch from flooding to pressurized systems, such as drip and sprinkler, and even more so after the subsequent drought in 2009. Within the first 3 months following this initiative, more than 8000 farmers had changed their irrigation practices to pressurized systems (Topcu 2011). By the end of the year 2012, 205,919 farmers had benefitted from the incentives, and a total of 402,726 ha land was equipped with drip irrigation (Türker 2013). According to Turkey's fifth national communication under the UNFCCC report, a grant was provided for irrigation cooperatives and village authorities to transform on-farm irrigation systems to closed and pressurized systems through the Supporting Rural Development Investments Program implemented by MoFAL. The grants support 75% of costs for collective pressurized irrigation applications and 50% of within-parcel modern pressurized irrigation investments. The rest of the investment is provided as low-rate, long-term loans (Republic of Turkey Ministry of Environment and Urbanization 2013). Until 2017, the subsidy granted to individual farmers and collective entities could amount to a maximum of 200,000 TRY and 500,000 TRY, respectively. Although these ceilings were reduced to 50,000 TRY and 2000,000 TRY in 2017, the Ministry of Forestry and Water Affairs announced the preparation of a new law to enforce the compulsory use of water-saving irrigation methods, particularly in water-scarce areas in 2018. State loans (50% of the cost) and interest-free credit were provided to farmers (Akşam 2018).

As at 2017, approximately 67% of the total area in Turkey was irrigated by surface irrigation methods (furrow, border, etc.). The remainder was irrigated with pressurized irrigation methods such as sprinkler (19%) and drip (14%) (DSI 2017).

The shift from surface to micro-irrigation has generally taken place in fruit and vegetable growing areas in addition to those under protected cultivation. The use of sprinkler irrigation is also becoming common for field crops, such as sugar beet, potato and groundnut, particularly in drought-prone and water-scarce areas. The citrus, apple, grape, cherry, peach, fig, olive, and walnut orchards are the main fruit tree varieties to be irrigated with drip systems in the northwestern, western, and Mediterranean regions of the country, whereas apricot and pistachio orchards are irrigated mostly with drip systems in the eastern Mediterranean and eastern Anatolian regions. For vegetables, furrow irrigation methods have also been replaced with sprinkler and drip irrigation.

Water user associations calculate irrigation water charges per hectare according to balanced budget principles, generally dividing the cost of O&M and investment expenses by the total irrigated area. However, the fees may not be less than the operating and maintenance tariffs announced by the ministerial cabinet each year. In most of the country's irrigation schemes, irrigation water charges are based on the "area-crop" system in which the charge per hectare is determined by the type of crop. Farmers may pay less per hectare when using water-efficient irrigation technologies and increasing the production per area in many irrigation schemes. The charges showed a significant increase compared to those collected by the DSI before the irrigation management transfers to WUAs. Irrigation water charges vary significantly between schemes using gravity and pumping systems; however, there are also different cost categories within each system depending on the infrastructure and combined use of both systems. In general, farmers under pumping schemes pay around 2.5–5 times more than those under gravity schemes. Depending on the cultivated crop, the fees per hectare vary as well, e.g. farmers growing cereals, vegetables, and rice in a gravity-irrigated scheme with basic infrastructure pay 10.5 TRY, 20.5 TRY, and 40 TRY, respectively. The sample figures are selected from the tariff table published in the Official Gazette of 9/26/2017 (no 30192) for 2018.

Over the last 15 years, attempts at land reform could not prevent the Turkish agricultural sector from being beset by fragmentation, so that the size of farm holdings remains small. According to reports by the General Directorate of Land Reform and DSI, the average size of a farm holding is around 6 ha; however, these farms are generally fragmented into six or more parcels, each of approximately 1 ha or less. Despite incentives and increased farmer awareness, the use of water-saving technology is far behind the ultimate target due to increased costs from fragmentation. Consolidation is now part and parcel of regional development schemes, several of which are now in progress. During the 41 years between 1961 and 2002, only 450,000 ha was consolidated, whereas the consolidated area reached 6 million ha in 2016 (MoFAL 2016; DSI 2016).

7.4.2 Irrigation Management Transfer

In 1993, under an accelerated program of Irrigation Management Transfer (IMT) which was guided and partially financed by the World Bank, Water User Associations (WUA) were established to operate and maintain the secondary and tertiary levels of almost all large-scale public irrigation systems (Kibaroglu et al. 2009). Until 1993, the DSI and the General Directorate of Rural Affairs (KHGM) planned, built, operated, and maintained irrigation infrastructure, even though the small-scale decentralization of irrigation operation and maintenance (O&M) had taken place prior to this date. The DSI operated the irrigation schemes with a top-down approach that had low levels of farmer participation and very low cost-recovery rates, at around 10% (Akuzum et al. 1997: 552). In fact, Law 6200 of 1954 granted the DSI the right to transfer the management of state-owned infrastructure. However, the rate of transfer of irrigation O&M was insignificant prior to 1993. The transfer of irrigation O&M was caused by “(a) rapidly escalating labor costs, (b) a hiring freeze on government agencies, and (c) consequent concern over the agency’s ability to operate and maintain systems serving the expanding irrigated area for which it was responsible” (Svendsen and Nott 1999a). This model of irrigation management transfer was inspired by the Mexican example (Palerm-Viqueira 2004).

Following the transfer of O&M, the DSI maintains only the ownership of the resource infrastructure. The responsibility for the secondary and tertiary canals is transferred

Table 7.1 Organizations governing transferred irrigation schemes

	Number	%	Area (ha)	%
Villages	201	21	33,671	1.5
Municipality	124	13.0	89,551	3.9
Water user association	383	39	2,036,836	88.6
Irrigation cooperative	246	25	130,105	5.7
Other	17	2	9727	0.4
Total	755	100.0	2,299,890	100.0

Source: DSI (2016)

to the WUAs or irrigation cooperatives.[3] WUAs and cooperatives took over O&M in cases where the irrigation scheme covered more than one village (Svendsen 2001). In other cases, it was the village administration or municipality which took over the O&M responsibility. As can be seen from Table 7.1, in recent decades, the management of over 2 million ha of irrigation schemes has been transferred.

The legal standing of the WUA should in principle be guaranteed by an enabling law which authorizes its establishment and the transfer agreement between the state agency and the WUA (Salman 2002). However, in Turkey, the accelerated transfer program progressed much faster than planned, and there was no opportunity to prepare such a law. The associations were established by reference to three laws: the Village Act (No. 442), the Local Government Act (No. 1580), and the Provincial Governance Act (No. 5442). The need for a new law to determine the principles of WUA functioning was articulated by different agencies. In 2005, WUAs were brought under the jurisdiction of legislation pertaining to Local Administrative Unions (Law No. 5355, *Mahalli Idare Birlikleri Kanunu*, May, 26, 2005). That legislation did not bring about major change.

WUAs finally gained public legal authority status following the legislation of the 2011 Water User Association Law[4] (Özerol 2013). Many changes are brought to the structure and functioning of WUAs. According to the 2011 Law, WUAs are set up by the local authorities in an irrigation zone and apply to the DSI in order to sign the transfer agreement and protocol which gives them the right to collect fees and assigns them the responsibility of distributing water and maintaining the canals. According to the law, WUAs are responsible for their operation, management, maintenance, and repair.

Each association has a chairperson, a council, an executive committee, and an audit committee. Prior to the 2011 Law on Water User Associations, the headmen – the principal elected authority in a village – and the mayor (if there is a municipality within the borders of the WUA zone) occupied the permanent seats in the council.

[3] A cooperative is different from WUAs as it is “owned and operated by its members who share its profits or benefits” (Svendsen and Nott 1999a:17). All members of a cooperative participate in the general assembly meetings, and there is direct democracy rather than the representative structures of the WUAs.

[4] Law No. 6172, 08.03.2011.

Although councilors were to be elected by the farmers who owned or rented land within the irrigation zone of an association, this practice was abandoned in some localities due to tension and conflict. In some places, the representatives were not elected from the water users at large but appointed by the headmen. Therefore, it was possible for large landowners to become chairs or councilors and to favor the interests of large farmers (Unver and Gupta 2002). This kind of elite capture led to allegations of corruption and embezzlement in some of the WUAs.

The Law on WUAs changed the "one farmer, one vote" principle by increasing the weight of those farmers who own or rent tracts larger than the average in their WUA. Currently, the number of votes in the election of councilors depends on the amount of land a farmer owns or rents (for a period of more than 5 years) – with a maximum of five votes per farmer.

According to the 2011 law, the chairperson of the association is elected by the members of the WUA assembly (parliament) for a 4-year term and is the head of the executive committee, which decides on matters related to the management of the associations. Technical staff are hired to operate the system (Palerm-Viqueira 2004). According to the law, the associations are not allowed to spend more than 30% of their annual budget on personnel expenditure.

The revenues of the association consist mostly of fees collected from users. The fees (per donum[5]) depend on the crop that will be cultivated and are set by each association (Unver and Gupta 2002). Self-auditing mechanisms for WUAs existed but were not widely used. Prior to the 2011 law, a group of councilors could be selected to audit the accounts, question the chair, and scrutinize the annual report submitted to the council by the chair (Naik and Kalro 2000). The law established an audit committee selected from the councilors. However, the extent to which the committee can perform its duties depends on the local power dynamics. There are also external checks and balances in the system, in that it is the responsibility of the governor's office to monitor the activities of the WUAs and approve their fees and budgets. The governor's office is responsible for establishing an audit commission to scrutinize the finances and administration of the associations.

WUAs collect water-demand forms (based on the cropping pattern and evapotranspiration) before the start of each irrigation season (usually in April), and forward the total amount required to the DSI, which allocates the water from the reservoir. During the off-season (November to April), the WUAs clean the secondary and tertiary canals. The associations' technicians carry out repair work, if necessary, in order to ensure a healthy distribution of water. Another key duty of the association is to clean the drainage canals.

During the irrigation season, the association is responsible for making sure that all users get the necessary water to irrigate their crop. The distribution of water is organized in a variety of ways. The most common is the rotation system for different tertiary canals combined with a distribution order among farmers set by technicians. Ideally, farmers submit water demand forms to the field technicians 3 days prior to irrigating their fields. The number of siphons they can use to divert water from the

[5] Donum is the measurement unit used among farmers and corresponds to approximately 919.3 m^2.

canal to their field is determined by the amount of land under irrigation, and the field technician monitors the process. The irrigation order is sometimes determined randomly by a lottery. In either case, field agents monitor whether farmers over-irrigate their land or take water when it is not their turn. There are serious questions as to whether this monitoring is effective in some contexts.

Harris (2005) claims that state agencies in Turkey had high expectations of the WUAs, which were expected to increase efficiency, promote the sustainability of irrigation resources, and establish horizontal networks. However, there are divergences in farmer satisfaction from the services they receive from the WUAs (Kadirbeyoglu and Ozertan 2015). Furthermore, WUAs were unable to implement participatory irrigation Operation and Management in some local contexts characterized by power asymmetries (Kadirbeyoglu 2008). In such settings, the associations are sometimes captured by powerful and large landowners, who can use the association resources for their own benefit. In other contexts, the local, participatory management of irrigation enabled a more efficient co-management of irrigation, especially at times of drought. The state agency and associations were able to devise new payment mechanisms to reduce the amount of irrigation without endangering the crops (Kadirbeyoglu and Ozertan 2015).

While the fee collection rate of the state agency prior to the transfer was on average 38% between 1989 and 1994, it had already reached an average of 72% in 1995 under the governance of WUAs (Svendsen and Nott 1999b). However, it should be noted that there was an undercover farmer support system which was at the root of the state agency's inability to collect irrigation fees. The Public Debt Act stipulated that debt would incur a 10% penalty only if the farmer failed to pay on time. Subsequently, even if the farmer paid 5 years later, (s)he would still owe the original amount plus 10%. In an economy where annual inflation rates were on average 70% during the 1980s and 1990s, this left no incentive to pay on time. Since WUAs depend on the fees they collect to survive financially and pay their personnel, they had to collect their fees and prevent those who did not pay from accessing water the following season. There is variance in the proportion of fees that the associations can collect from their users: whereas some can collect only 60% of their budgeted water fees, others approach 100% (Unver and Gupta 2002:13; Kadirbeyoglu 2008).

The sustainable use of irrigation water and the elimination of over-irrigation, which causes problems such as salinity and waterlogging, were not addressed by the establishment of the WUAs. These problems relate more to the type of infrastructure constructed: especially with open canals and insufficient drainage systems, we cannot expect WUAs to bring about sustainable water use.

7.5 Challenges for the Irrigation Sector in Turkey

Since irrigation is likely to continue to be a bulk consumer of water, serious challenges need to be tackled: scarce water resources, erratic and unevenly distributed precipitation, the overexploitation of aquifers, the effect of climate change, decreasing water quality, competition among water user sectors, and increased demand for irrigation. In addition to poor water use efficiency, irrigated agriculture in Turkey has several serious structural problems, including the small size of agricultural holdings, fragmented and scattered fields, the deterioration of infrastructure, insufficient and/or inappropriate drainage, and shallow water table management, as well as a lack of investment. These factors compromise the potential benefits of irrigation. Some are briefly discussed below.

7.5.1 Infrastructure Deterioration

Most irrigation schemes in Turkey were built about three or four decades ago. The continuous deterioration of irrigation infrastructure (particularly supply canals) has led to substantial conveyance losses during the transportation and diversion of water. These mainly consist of operational losses, evaporation, and seepage, the latter being by far the main loss. Average conveyance losses of up to 8.6% in main canals, 5% in trapezoidal secondary canals, and 7% at the tertiary level have been reported for several irrigation schemes (e.g. Akkuzu et al. 2007). The most common reasons for high seepage losses include low concrete quality, poor joint construction, inadequate compaction, wear and tear, and consequent cracking. Furthermore, the inappropriate construction of water intake structures, such as constant head orifices and outlets on the main canal, as well as the misuse or damaging of the canals by breaking and/or dumping all types of waste/rubbish into the canals may often cause slippage of the fixed concrete legs and/or blockage of the flow, consequently flooding the roads and fields (Yenigun and Aydogdu 2010). Another source of loss from the canals is weeds and plants growing on the slopes of the canals, on which the DSI and WUAs spend considerable amounts of money every year. Besides infrastructure deterioration, the lack of automation at control structures, insufficient flow monitoring and measuring structures also cause the overuse of irrigation water, consequently lowering water-use efficiency and resulting in salinity and shallow water table problems.

7.5.2 Climate Change Impacts on Water Resources and Irrigation Sector

Recent analyses of Turkey's climate data indicate that the average summer temperature of the 2000s was about 1.5 °C higher than the 1960s or 1970s. While only a moderate decrease in the total amount of precipitation has been reported, the temporal distribution pattern of winter rainfall has significantly changed; the decreasing trend in precipitation, particularly in winter months, is correlated with drought events (Sen et al. 2012). Global climate change is expected to worsen climate conditions by causing lower and more erratic rainfall combined with increased temperatures, resulting in higher rates of evaporation, more severe and frequent drought events, and increasing water stress and water requirements for crop production (Sen et al. 2012). Evaluation of annual minimum, maximum, and mean stream flows of all the Turkish rivers showed significant decreases in most basins in the western part of the country (e.g. Topaloglu 2006). A study conducted in the Seyhan river basin showed that as a consequence of lower rainfall, both surface and groundwater resources would decline drastically in the Mediterranean region (Tezcan et al. 2007).

The snow-fed Euphrates and Tigris rivers will undergo surface temperature increases across the entire basin. The increase is comparatively greater in the highlands in winter, which would mean a reduction in the snow cover and change in the seasonality of surface runoff. The annual surface runoff is projected to decrease by 26–57% on average in Turkey by the end of the present century. All other countries in the basin are expected to feel such stress (Bozkurt and Sen 2013). Similarly, other transboundary river basins, such as the Maritza (Meric) and Orontes (Asi), as well as rivers in western Turkey, are at great risk of climate change-induced extreme weather events, both droughts and floods.

Irrigated agriculture is inherently extremely vulnerable to climate variability and change, due to the natural connections and dependencies that exist between climatic conditions, water availability, and plant development. A variety of climate drivers can impact agricultural productivity, both directly and indirectly. Frequently occurring flooding of low-lying areas of the river deltas and coastal cities has resulted in damage to physical assets and disruption to operations in large agricultural areas. Therefore, insurance premiums may increase, or insurance may become unavailable, and the value of exposed assets may decrease.

Several studies suggest that climate change may lead to moderate increases in irrigation water use at the global scale but to larger changes at the local and regional scale. Crop water requirements will increase in many agricultural districts of Turkey, including but not limited to the Aegean, Mediterranean, and central and southeastern Anatolia regions (e.g. Sen et al. 2012).

7.5.3 Environmental and Ecological System Degradation

The natural hydrology of watersheds is disturbed during the storage and conveyance of water allocated for irrigation as well as during the discharge of drainage and return flows from irrigated areas. Overexploitation of groundwater, changing flow regimes of rivers, and rising water tables (which may trigger salt accumulation), soil erosion due to poor agricultural practices, particularly the surface irrigation of sloped fields and/or deforestation of the upstream areas, are some of the environmental issues to be addressed. Furthermore, large bodies of water stored in dams and diversion channels can cause significant changes in local climate, and the extent of wetlands, which have the important ecological functions of biodiversity, nutrient retention, and flood control, can be reduced. The Ereğli and Eşmekaya reedbeds are only two examples of wetlands which are “natural sites” and “wildlife protection areas” (Karadeniz et al. 2009). Due to the excessive use of agrochemicals, such as fertilizers and pesticides, in irrigated agriculture, surface and groundwater resources in some regions are contaminated with heavy metals and nitrates. In west Turkey (Bornova-Izmir) and middle Anatolia (Niğde), groundwater resources are polluted mainly by the industrial sector, municipality, and agriculture, while the rivers including but not limited to the Gediz, Ergene, Sakarya, Kızılırmak, Yeşilırmak, Seyhan, Asi, and Tigris have also been affected by the discharge of wastewater from those three sectors (e.g. Harmancioglu et al. 2001; MoEU 2011; Varol 2011; Muluk et al. 2013). Horticultural production in the irrigated areas of the Marmara, Aegean, and Mediterranean regions accounts for over 70% of Turkey’s total pesticide use; however, the intensity of pesticide use in the country is low compared with that in other OECD countries (OECD 2011). Note that drainage systems are used not only to remove excess irrigation return flows from agricultural lands but also wastewater from the industrial sector and municipalities. Moreover, the poor maintenance of drainage systems reduces the effective removal of excess water.

The European Water Framework Directive (WFD), in which Turkey has taken great interest since its adoption in 2000, emphasises water quality and ecological aspects; however, neither sufficient networks for monitoring nor trained personnel for measuring and analyzing the data are available yet. Building and sustaining such an extensive network would also require additional funding (Çiçek 2010).

Overall, due to excess water application and excess irrigation, in addition to a lack of drainage facilities, about 3 and 1.5 million ha of irrigated land is at risk from water logging and salinization, respectively, or is already affected (Küsek 2010). The hilly topography, soil conditions that facilitate water erosion (i.e. fine texture, low organic matter, poor plant coverage due to semiarid climate), inappropriate agricultural practices (e.g. excessive soil tillage and cultivation and irrigation of steep lands), and forest fires/deforestation are the main causes of intense erosion in Turkey. Soil erosion caused by land degradation is the main reason for the loss of fertile agricultural soil in Turkey; it is estimated that around 83% of agricultural land is currently at risk from severe water erosion (Ozsahin and Uygur 2014).

Regional development projects, such as GAP and KOP, will also cause various forms of degradation of the relevant watersheds if timely adequate measures are not taken. For example, waterlogging and salinity, largely due to unsustainable irrigation methods, insufficient drainage, and poor land management in the GAP areas have caused an increase in soil salinity. Hence, the salt-affected areas in some parts of the plains, mainly in Akcakale in the lower part of the Harran plain, totaled 5500 ha in 1987, 7498 ha in 1997, and 11,403 in 2000 (Cullu et al. 2002; Kapur et al. 2009). Furthermore, most of the irrigation projects in the Tigris basin are situated in areas that are subject to a significant risk of erosion.

Given the levels of environmental degradation in Turkey, it is important to ask whether the government and civil society mobilize around issues of environmental protection and biodiversity conservation. Although Turkey has had a body of environmental legislation and a ministry since the 1990s, the legislation has not been very efficacious, and environmental degradation and biodiversity loss have been rampant in recent decades (Sekercioglu et al. 2011). Aydin (2005) states that lip service is being paid to problems such as air/water pollution, deforestation, and desertification in official documents, and NGOs are tolerated as long as they do not challenge the development policies. Overall, an emphasis on the need for economic growth has overshadowed concerns for the environmental impact of development projects (Karapinar 2010). The post-1990 period saw growing numbers of environmental NGOs and social movements in Turkey. Although there is a participatory discourse at the governmental level, in reality participation is mostly on paper, is ineffective, and becomes impossible when NGOs take up issues such as water regimes, nuclear energy, mining, and international waters (Paker et al. 2013).

In the field of agriculture and irrigation, a stakeholder survey conducted with private sector associations, international NGOs, media, university and research institutions, domestic NGOs, political parties, and governmental institutions revealed that they think agriculture in Turkey is not sustainable and that there is environmental degradation (Karapinar 2010). The same study, however, shows that although these stakeholders agree that the growing intensity of agriculture tends to aggravate environmental degradation, there is a clear distinction between the domestic NGOs and government representatives and private sector associations, whereby only the former think that environmental protection should be prioritized (Karapinar 2010). The differing priorities cannot be incorporated into policymaking unless there is a more bottom-up approach, favoring the participation of different groups which are affected by such policies. The WFD requires stakeholder participation, which is as yet very limited. Only the Environmental Impact Assessment procedure has institutionalized forms that allow direct public participation in decision-making on water resource development (Scheumann et al. 2011). However, even then participation tends to be treated as just a formality to be fulfilled and in fact does not allow for input from the community into the project design or implementation (Kadirbeyoglu and Kurtic 2013). EIA applies only to individual projects, not to the setting up of river basin management plans or the totality of its infrastructure components.

7.5.4 Investment and Financing

The cost of irrigation development in Turkey varies between US$ 5000/ha for small schemes and US$ 15,000/ha for large schemes (including pumps). The costs of operation and maintenance (O&M) vary from US$ 330/ha for schemes smaller than 1000 ha to US$ 180/ha for schemes larger than 1000 ha (including dams) (DSI 2012). There is a general consensus among stakeholders – the state bureaucracies, WUAs, chambers of agricultural engineers, and other relevant NGOs – that irrigation investment should continue to reach the potential of economically irrigable land, i.e. 8.5 million ha. However, there is also an emphasis on irrigating with modern technology under proper land consolidation and reform programs.

Since the 1920s, water for irrigation has always been subsidized. Pricing policies have aimed at recovering service costs (O&M&R) and, to a lesser extent, capital costs. If levied per area and crop, irrigation costs are only a proxy of the amount of water used, and incentives to save water are difficult to introduce. Given the technical difficulties of volumetric measuring, it is not easy to implement charges as a stimulant for water savings. While transferring the O&M of irrigation systems to WUAs has improved O&M cost-recovery, state financial transfers are still needed for the rehabilitation and maintenance of irrigation and drainage systems (Topcu 2011).

Although almost 44% of the DSI's total investment (3.48 billion out of 7.98 billion Turkish Lira) was allocated to the regional development projects GAP, KOP, and DAP in 2012, a lack of investment has significantly impeded agricultural development in general. In 2009, following the GAP Action Plan of June 2008, the allocated budget for irrigation investment to the GAP Project increased tenfold compared to 2008 (DSI 2009). The annual share of the GAP within the country's investment was 7% in 1990–2007, 12% in 2008, and 14% in subsequent years. The new action plan for the period 2018–2022 envisages continuing the investment at a similar pace (GAP 2016).

GAP is an expensive project: the total cost has been estimated at US$ 32 billion, half of which has been spent so far. Due to the sensitivity of the transboundary flows involved, the Turkish government was unable to secure international finance (an exception being German and Swiss credit which was obtained to purchase equipment). The severe economic and budgetary crisis in Turkey, along with, for example, the slow pace of land redistribution, caused considerable delays in the project implementation. Despite these drawbacks, Turkey is persistently pursuing its plans to harness the Euphrates and Tigris rivers (Tigrek and Kibaroglu 2011).

Urgent rehabilitation and modernization of irrigation facilities are needed not only to increase the irrigation ratio (share of net irrigated area within the area equipped for irrigation) but also to raise irrigation efficiency. Hence, 80% of the total cost of this has been covered by the DSI and the remaining 20% by the WUAs. As per Law No. 6200, 80% of the total cost incurred by the DSI (within the tertiary canal levels) must be reimbursed by the WUAs. The DSI would only put the projects in its investment programs if the WUAs provided an advance payment of about 5% of the total cost of rehabilitation and rejuvenation (DSI 2012).

7.5.5 Prospects and Pitfalls in Irrigation Management

About two thirds of Turkey's crop production relies on irrigation; consequently, irrigation will continue to be a bulk consumer of water. There is significant potential for improving water use efficiency, and options might cover a combination of physical (engineering), agronomic, environmental, institutional, and managerial, as well as sociopolitical measures (Howell 2001).

Physical measures include the rehabilitation and modernization of the irrigation network, and the completion of on-farm works to increase the irrigation ratio and decrease conveyance losses, converting from an open canal distribution network to a piped system using flow meters. Diverting and applying irrigation water can prevent water wastage and increase efficiency (Topcu 2011). Introducing new irrigation methods in order to increase irrigation efficiency requires greater assistance from the extension services as well as close collaboration between farmers and the agricultural extension services, which has never been a great success story in Turkey.

In recent decades, notwithstanding several projects aimed at combating desertification and drought, adapting to climate change, and improving water use efficiency in irrigated agriculture, irrigation development in Turkey nonetheless still mainly focuses on the construction of new dams, pools, canals, and other infrastructure. Less and/or mostly delayed attention has been paid, and limited investment has been made into developing a comprehensive and integrated management approach that is environmentally sound and sustainable. Integrated River Basin Management (IRBM) takes a much broader approach than traditional water management and includes significant attention to land-use planning, erosion control, land consolidation, agricultural policy, environmental management, and the continuous monitoring of water quality and quantity. IRBM, however, is a new concept in Turkey, and existing political/institutional structures do not facilitate the necessary change in mentality; its implementation will therefore be a major challenge. Obstacles that threaten the successful implementation of IRBM in Turkey are (i) incomplete water resources development, (ii) administrative problems, and (iii) lack of participatory approaches (Divrak and Demirayak 2011). The DSI made preparations so that IRBM could be implemented in 11 river basins, while 4 river basin plans are under revision.

Industrial and municipal waste, as well as drainage water from agricultural areas, is degrading the water quality of the rivers and groundwater resources. This in turn threatens the irrigated land in terms of salinity and also heavy metals. In order to prevent the negative effects of excessive organic and inorganic fertilizer use, soil analysis has been made obligatory for farmers owning agricultural landholdings of more than 5 ha in order to benefit from fertilizer/manure subsidies. Wastewater treatment plants have been increasingly installed in cities. Most of this water is flowing into rivers and lakes, while a significant volume of untreated wastewater is discharging into lakes and ponds, and onto land. The use of wastewater for irrigation is so far limited to arid/semiarid areas, such as the central and southeastern regions. According to the very few available records and reports, about 200,000 ha of land was irrigated using wastewater in various provinces by the year 2004 (Gokcay 2004), and some small wastewater irrigation projects comprising a few thousand hectares were initiated in the Konya and Ergene basins, as well as in Afyonkarahisar, some of which were implemented for urban and suburban agriculture (e.g. Duman 2017). Irrigation return flows can also be reused in the lower part of the irrigation schemes, like in the Seyhan and Harran plains, where water is not sufficient and/or irrigation infrastructure has not yet been completed.

7.6 Conclusion

Agriculture is the biggest water user in Turkey. Most of the country is very dry during the summer months. Therefore, agricultural production, particularly in fertile regions, such as western, southern, and southeastern Turkey, can only be achieved by supplying irrigation water. State authorities assert that an additional two million jobs will be generated once the targeted areas have been developed for irrigation by the year 2023.

Given agriculture's significant share of water consumption, this chapter has provided a closer examination of the irrigation sector. We found that Turkey is eager to continue with investments in large-scale irrigation systems, particularly within the context of regional development projects: the GAP, KOP, DAP, DOKAP, and YHGP. We also observed that technological change has been under way in the irrigation sector since the late 1990s. To illustrate, the share of pipelines conveying and distributing the water to the fields in irrigation schemes increased substantially. However in many old schemes, surface irrigation in Turkey continues to be dominated by gravity-fed systems, such as furrow, border, and even wild flooding.

We observed that there has been drastic institutional change in the management of irrigation systems. The (partial) transfer of the management of large-scale irrigation systems to a variety of organizations from the early 1990s had mixed results. Key policy entrepreneurs in the devolution of irrigation management in Turkey have been national and international bureaucrats, namely those of the DSI and the World Bank as donor agency. Successive governments have seemed quite content with the "reform process" in irrigation management, and the World Bank has pronounced Turkey a "success" (Kibaroglu et al. 2012). A coalition against the accelerated irrigation management transfer process, however, has leveled considerable criticism. The Chamber of Agricultural Engineers has led the objections, focusing on a number of issues. The participatory aspect of the transfers in particular has been questioned, owing to the exclusion of irrigators from WUA general assemblies and boards. In addition, the top-down approach that was adopted rather than generating grassroots involvement from farmer interest and involvement has caused fierce debate over the characterization of the associations as democratic. Critics stress that the maintenance, rehabilitation, and modernization of the irrigation canals, some of which are 40 years old, cannot be accomplished due to deficiencies in the WUAs' technical, administrative, and legal capacities.

In addition to the technological and institutional problems, further challenges for the irrigation sector include infrastructure deterioration, risks of drought, environmental and ecological system degradation, including that associated with large dams and small run-of-the-river hydropower projects, insufficient investment, and the financing of continuing projects, as well as the maintenance of existing infrastructure.

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