Chapter 3
Water Management in the Zayandeh Rud Basin: Past, Present and Future

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3.1 Characteristics of the Zayandeh Rud Catchment

The Islamic Republic of Iran is divided into six main hydrological basins: the Central Plateau, the Persian Gulf and Oman Sea, the Caspian Sea, the Urmia, the Ghareghoum, and the Eastern Boundary basin. These basins, again, are divided into 30 main catchments with different sub-catchments. The Zayandeh Rud sub-catchment belongs to the Gavkhuni main catchment which is located in the Central Plateau of the Iran basin (Fig. 3.1).

The Zayandeh Rud, the "life giving river", is the most important surface water in the Central Plateau of Iran, a typical (semi-) arid desert. It originates in the Zagros Mountains in the Chahar-Mahal and Bakhtiari province through a natural merger of small and large rivers at an altitude of around 4200 m. The largest part of its 26,000 km^2 catchment spreads out downstream in the Isfahan Province. On its 405 km course, the Zayandeh Rud runs through extremely different climatic and natural conditions with, as a consequence, various socio-economic characteristics. (Shafaghi 2003; Hossaini Abari 2000, more details in Chap. 14 Faramarzi) The existence of deep and very fertile soils, particularly silts and clay loams, has led to the development of intense agricultural activities along the river (Sarhadi and Soltani 2013; Molle et al. 2009).

The catchment can be divided into three main parts: the (sub-) alpine region and the foothills, the Isfahan lowlands including the marshland and contiguous desert

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Fig. 3.1 Position of Gavkhuni and Zayandeh Rud basins in relation to the 6 main hydrological basin of IRAN (Isfahan Water Authority

(Fig. 3.2). The first region in the western part of the catchment shows climatic conditions typical for Central Asia's high-altitude mountains, with very cold days as low as −30 °C and heavy precipitation. Average annual precipitation is around 1260 mm, mostly in the form of snow, leading to a permanent snow cover of up to 7 m in higher regions (Fig. 3.3). Only in summer (July to September) is there no precipitation. Below the timber line (approx. 2300 m) a mountain forest steppe with oaks and a diverse fauna – like brown and black bears and other large mammals – can be found. Grazing pressure, timber extraction and pruning have led to a retreat of forests and an expansion of thorn hedges and brushwood (Sahafii and Sadeghi 1997). In this area, around 100,000 people live on agriculture (stock and arable farming) and forestry under difficult conditions, and for years there has been a heavy rural exodus, to Isfahan city in particular.

The foothills are located in the Isfahan province. Here, the Zayandeh Rud dam is located, with its reservoir of around 1400 MCM as the main source of water for the entire catchment (Sarhadi and Soltani 2013). The foothills' wide landscapes form the transition to semi-arid regions with around 430 mm of precipitation and snowfall in winter. In addition to oak forests, almond trees and agriculturally cultivated areas can be found. Around 250,000 people live in villages and smaller

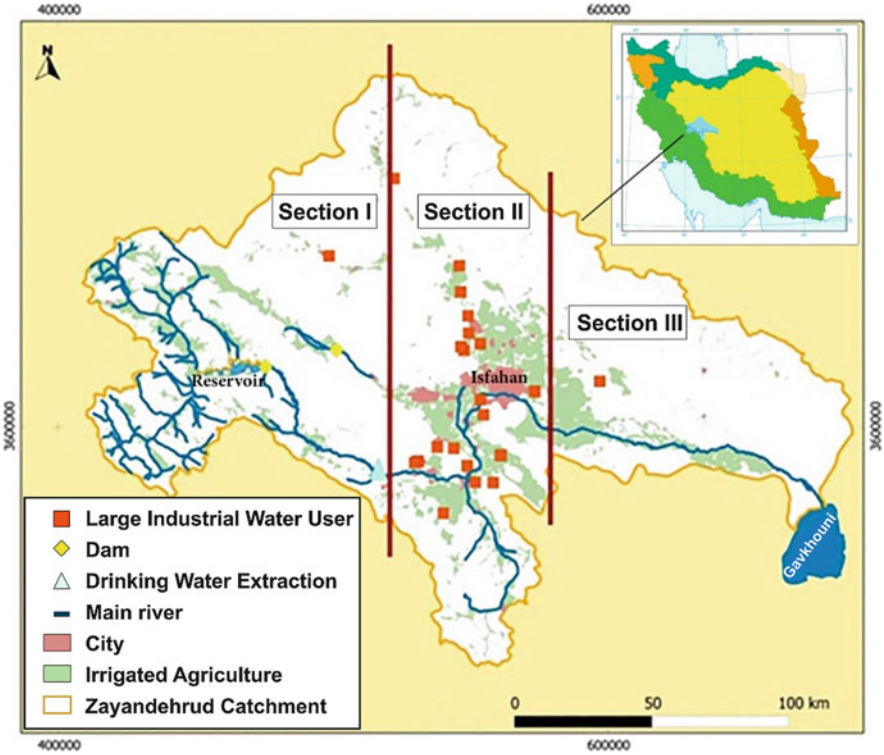

Fig. 3.2 Three main parts of Zayandeh Rud catchment and the location of main water users

towns and work mainly in agriculture but also in small craft and industrial enterprises. In the agricultural areas primarily wheat, almonds, potatoes and rice are grown. Molle et al. (2009) point out that today irrigated nut and almond orchards located in the Chahar-Mahal and Bakhtiari province are expanding, while traditionally, irrigation was restricted.

In the first part the water flows in what can be described as quite good quality around 100 km from the Zayandeh Rud dam to the Chamaseman dam, the extraction point of Iran's biggest water works (Mohajeri and Dierich 2008). During the last few years, the region around the Chamaseman reservoir has become a famous recreation destination. Here, the drinking water for the 4.5 million citizens of the Isfahan province and other cities outside of the catchment area (such as Yazd, Kashan or Naein) is extracted.

In the elongated Isfahan lowlands, annual precipitation decreases from around 200 mm in the western part to 85 mm in Isfahan city and its surroundings (Fig. 3.3). This part of the catchment, a flood plain with fertile soils ranging around 150 km to the east and west of Isfahan city, is used for intensive agriculture, mostly of staple foods and fodder (Molle et al. 2009). As a result of intense cultivation and irrigation measures, agriculture shapes the actual grass land and steppe landscape. In this part

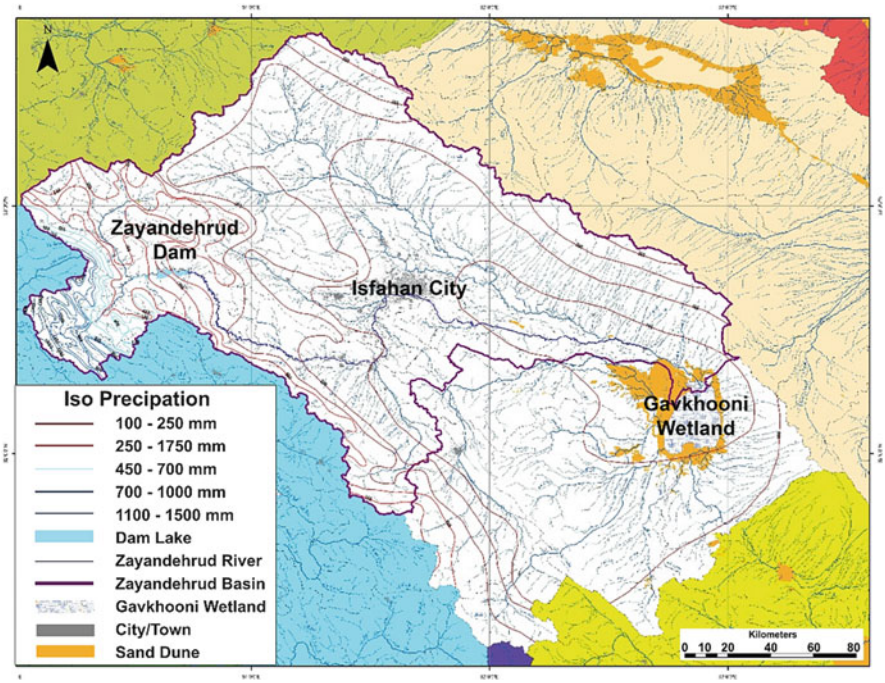

Fig. 3.3 Iso precipitation Map of Zayandeh Rud Basin

of the catchment, most small and big towns and villages were founded in a long track along the river, and most inhabitants of Central Iran live in this area (Hossaini Abari 1991). Isfahan is Iran's third biggest city, and its historical buildings were declared UNESCO World Heritage. During the last decades, the region became Iran's largest industrial area, with mainly ironworks, steel industry, oil refineries, and chemical industry. Here the river water is heavily polluted through waste water and agricultural drainage water.

Marshland and desert east of Isfahan city form the last large area in the catchment. Annual precipitation is only around 55 mm, and with heavy winds and frequent sand storms the region belongs to the arid parts of the country. The character of the ecosystem depends on the distance from the Zayandeh Rud River: In the (former) flood area of the river is marshland which turns into Artemisia Steppe and desert further away from the river. Due to irrigation measures, onions and other vegetables can be cultivated close to the city of Isfahan, while further downstream primarily cotton is grown. Climate change has been forcing more and more of the 200,000 inhabitants to leave this area.[1] Around 125 km southeast of Isfahan, the river flows into the Gavkhuni salt lake, a marshland internationally

[1]Particularly in summer, water shortages lead to problems regarding drinking water supply. Many people therefore move to cities during this time.

acknowledged by the Ramsar Convention in 1975 and important for staging and wintering for several species of migratory water birds.[2] Moreover, it forms an important barrier against the desert. Figures on how much water the Gavkhuni wetland requires to be a functionally healthy wetland ecosystem range from 70 MCM (Salemi and Murray-Rust 2002) to 243.5 MCM (Sarhadi and Soltani 2013). Over the last 15 years, however, neither of these amounts has been met, and the water arriving at the Gavkhuni Lake has been almost exclusively agricultural drainage water.

3.2 Increasing Water Demand

20 years ago there were "serious concerns that it will be extremely difficult, if not impossible, to meet expected demands for water for Isfahan and neighbouring cities over the next 25 years" (Murray-Rust and Droogers 2004).

Between 2000 and 2010, an average of 2 BCM of water was used in the Zayandeh Rud catchment for agriculture, industry, drinking water supply and transfers to neighbouring provinces. This was more than the water available from the dam and from groundwater recharge put together. The situation is aggravated by the fact that there have been great fluctuations in water outflow from the Zayandeh Rud reservoir, varying from 533 MCM to 1720 MCM per year (figures provided by the Isfahan Water Authority). Molle et al. (2009) stated that prior to the next flood season, all the water entering the reservoir would be released. This situation of "no significant year-to-year carry-over storage [...] maximizes the production from irrigated agriculture (at the expense of security in supply), and part of the variability in supply is handled by resorting to groundwater". As a result, groundwater levels have decreased considerably and the aquatic habitat has been destabilized.

The different water uses in the catchment lead to diminishing water quantity, but also quality. Research has revealed that on its way from the dam to the salt lake, the river water is used and fed back into the river more than three times. As a result of return flows from agriculture and no or inadequately cleaned urban and industrial effluents, the water shows high concentrations of salt and other pollutants in downstream regions (Salemi et al. 2000). Groundwater resources in several sub-catchments are salinized or at risk to salinization because of deep extraction, so that they can be used only for certain purposes such as cooling water for industry (Iranian Ministry of Energy 2003; Kalbassi 1992). Decreasing water quality, in this respect, aggravates the problem of water quantity.

With almost 90%, the biggest share of surface and ground water resources in the catchment area is being used for irrigation (see Chap. 6 Agriculture). It is in the nature of things that in dry years with little rainfall, water demand for agriculture rises further. Agriculture, thus, has suffered in particular from recent water supply

[2]See https://rsis.ramsar.org/ris/53 (accessed July 27, 2015).

problems. For the distribution of surface water, irrigation systems with multiple distribution structures and channel systems were built in the 1970s and late 90s. Additionally, a lot of ground water is extracted from 45,000 wells for irrigation purposes. Traditionally, farmers irrigate their fields with flood irrigation. Water demand for agriculture has not been met in recent years, not even quantities guaranteed by law. Many *Qanat* systems, sloping underground channels with a series of vertical access shafts, which have been traditionally used for oasis cultivation, had and have to be abandoned due to a disturbed hydrological balance as a result of deep wells. Regardless of that, government and farmers intend to increase agricultural areas and intensify cultivation. Without changing irrigation modes or technologies, this means that water demand will continuously grow.

The Zayandeh Rud also provides water for the second largest industrial area in Iran, with some highly water intense businesses (see Chap. 7 Industry). Since further industrial settlements are planned in the future, the Ministry of Energy's requirement is that the industrial surface water withdrawal must not exceed 200 MCM per year.

Population growth will presumably lead to higher water demands for drinking water purposes in the future (see Chap. 8 Drinking Water). According to forecasts, population in the catchment will rise from around 4.5 million today to more than 5 million in 2020 (according to scenarios developed throughout the project). In case of constant drinking water consumption, the Ministry of Energy estimates an increase in drinking water supply with water resources from the Zayandeh Rud to a total of 400 MCM by 2020. There is a growing responsibility to provide water for other cities with several hundred thousand inhabitants like Yazd, Kashan, Naein, Natanz and Ardestan. Further water transfer projects to Shahrekord, Broojen and Ben are currently under construction.

Water demand of the Gavkhuni Marshland at the river's estuary has not been met for years, and without changes in water management the situation is expected to worsen. Fauna and flora of the salt lake highly depend on inflows from the Zayandeh Rud River. In general, wetlands are very vulnerable systems and highly sensitive to changes in water quality or quantity. In order to preserve this diversity of aquatic and amphibian habitat, a steady, sufficient inflow would be necessary. Current inflow is estimated to be less than 30 MCM per year on average. Additionally, the water that reaches Gavkhuni is of very low quality because of extreme sulphate load and high oxygen depletion (Pourmoghaddas 2006).

All the different ecological conditions and settlement structures described affect the quantity and quality of water resources. With constant yearly renewable water availability of 2 BCM, the deficit between water demand and water availability in the Zayandeh Rud catchment will continue to grow.

3.3 The Role of the Zayandeh Rud in the Region's History

The history of Isfahan and its great reputation is strongly tied to the Zayandeh Rud. Since access to water has always been crucial in the history of civilization, the Zayandeh Rud River played and still plays a vital role in this hot arid zone, as it is the main source of water in the middle of the Iranian plateau. The Zayandeh Rud with its unique characteristics has been widely noted in historical documents as the main source of water in central Iran (Mustawfi 2002; Shafaghi 2002; Mafrukhi 2006) giving life to the land and villages of the provinces of Isfahan, Chahar-Mahal and Bakhtiari and Yazd, thereby being the foundation for an evolving and flourishing civilization on the banks of the river.

According to historical evidence, early human settlements were formed in the Isfahan plain. In Palaeolithic times people were drawn towards the river of Zayandeh Rud as a reliable source of water (Conard et al. 2005) which is underlined by findings of Biglari et al. (2009). They found artefacts and tools in a cave called Qaleh Bozi overlooking the river, the origin of the stones used for tool making were the shores of the river, showing that the river had an impact on almost every part of life in the Palaeolithic age. Furthermore the Isfahan plain was inviting to live in due to good weather, the flow of the Zayandeh Rud and the fertile soil on the banks of the river (Shafaghi 2002). As a further development in human civilization in Iran, the origin of agriculture can be found in the foothills of the Zagros Mountains, this being part of the Fertile Crescent (Riehl et al. 2013). These characteristics make the Zayandeh Rud catchment one of the most important regions in Iran, having always contributed to the history of Iran.

The city of Isfahan goes back to the ancient region called Aspadana. During the empire of the Median dynasty (ca. 675 – 550 BCE), Aspadana was part of the area where the Median tribe Paretaceni resided in an area called Jey today, formerly Gabbay (Schwarz 1969; Diaconof 2011). In the pre-Islamic era, Jey referred to the vast area including the north and south banks of Zayandeh Rud River and the river flowed through the lands of Jey. Today, Jey refers to a region of Isfahan including the lands on the north banks of the river (de Planhol 2006). It is also well known as one of the most historic neighbourhoods in modern Isfahan.

The regions of the Persian and Median empires were united by Cyrus the Great, creating the beginning of the Achaemenide era (ca. 650 – 330 BCE), a prosperous time in terms of cultural, political, religious, social and economic development of Isfahan (Miller 2004). Jey, being located in the intersection of the main roads of Iran, was one of the most important regions in the Achaemenide Empire; consequently the Achaemenide kings resided in this region for better control of the area.

After the invasion and conquest by Alexander the Great, the city of Jey further established its role as a trade city (Hosseini Abari 2008). In the following Sassanid era (ca. 225–650 CE), the Zoroastrian city of Jey and the Jewish city Yahudiya, which was located around three kilometres north of Jey, merged into the city of Isfahan (de Planhol 2006).

Isfahan was home to a number of noble families and a place for the military education of the crown princes. A further indication of the importance of Isfahan during this period is the fact that it was ruled by the crown prince. This is in accordance with Sasanians tradition, which demands an important area to be ruled by the crown prince as training for kingship (Honarfar 2010).

After the capture of Isfahan by the Arabs, marking the beginning of the Islamic era, the region was ruled by the Al-Buyid dynasty (934–1062 CE). During the Al-Buyid era, small villages and cities were integrated into the city of Isfahan and new neighbourhoods were created. This led to further urbanization and prosperity (Hosseini Abari 2008; Omrani Pour et al. 2012) and provided the foundation for further development in the region. The succeeding dynasty of Turkish Seljuqs (1037–1194 CE), in particular its founder Toghril Beg who resided in Isfahan for twelve years, made the city of Isfahan the capital of the empire. Under these circumstances the city grew and flourished (Honarfar 2010). In the twelfth century, the most important aspect of the city in relation to the Zayandeh Rud was the existence of the network of fresh water channels and irrigated gardens in the city of Isfahan (Omrani Pour et al. 2012) which distinguished the city from other Persian cities.

After the fall of the Seljuq dynasty, Isfahan experienced periods of decline until the seventeenth century when it became the Safavid dynasty's capital and the golden years of splendour started. It is said that the Zayandeh Rud and its influence on fertility in Isfahan region was one of the main reasons that Shah Abbas decided to move the capital from Qazvin to Isfahan in 1598 (Baykal 2007). Isfahan experienced several years of urbanization before flourishing during the time of the Safavid dynasty. The distinctive characteristic of Isfahan, including the unique geographical location in central Iran and particularly, the flow of Zayandeh Rud and its surrounding fertile lands, made Isfahan one of the most important regions in central Iran. During the early centuries of Islam, the region of Isfahan included thirty rural areas (Rustag) and more than one thousand small villages. In this period, Isfahan was well-known for its higher quality of agricultural products as one of the main reasons for its economic prosperity (Hosseini Abari 2008).

It was the geographical interaction between the Zayandeh Rud and Isfahan that led to development and urbanization in the Safavid period. Because of the political and economic activities directed by Shah Abbas, the population grew through immigration by migrants from the Caucasus region. This population increase resulted in a pressing need for higher agricultural production so as to provide enough food for the population and the imperial system. Therefore, an efficient distribution system for the water of Zayandeh Rud was needed (Omrani Pour et al. 2012). With this in mind the history of the flourishing years of the city during the Safavid dynasty is inextricably interwoven with the existence of the Zayandeh Rud. There were, for instance, around 100 streams called Madis flowing from the river in the city towards the Jey lands. Madis are man-made channels, the name being adopted from the Mad dynasty which ruled the country three to five centuries BCE. Twelve bridges, some examples of magnificent architecture, were also constructed, with the special features of serving both as bridges and dams (Hosseini Abari 2008,

p. 75; Omrani Pour et al. 2012). The function as dams, and thereby giving an option for active water management, was particularly important as low water resources have always been one of the main problems in Iran impacting all aspect of social and cultural life. Hence, dealing with the water problems was a critical issue for the dynasties and empires. It was specifically more critical in the semi- arid areas in central Iran including Isfahan region. Throughout history in the region of Isfahan the existence of the Zayandeh Rud has been tied to the development of civilization in the area, displaying the relationship between human culture and natural resources.

3.4 Historical Water Distribution Rights: Sheikh Bahaei Water Share Scroll

Due to the essential role that Zayandeh Rud has consistently played in irrigating the fertile lands in the Isfahan plain, the ways of distribution of water have always been a critical issue, sometimes leading to conflicts and tensions among water users in the region.

Regarding the historical texts, the use of Zayandeh Rud water was always based on a specific pattern throughout its history. Since individuals using water of Zayandeh Rud built streams branched from Zayandeh Rud – the Madis – some scholars believe that the basic concept of the water distribution pattern of Zayandeh Rud can be traced back to the Median Empire (Mehryar 1999; Islami 2009). In this sense, the history of developing an efficient water distribution system is also the history of using the water of Zayandeh Rud as the main source of water in central Iran. One important feature of the distribution system has to be the consideration of water shortage and the equal status of all stakeholders in the access to water resources at the same time.

Based on what has been written in historical texts, the history of the Sheikh Bahaei water share scroll goes back to a special water distribution pattern attributed to the famous scientist and scholar Sheikh Bahaei. It was set in the Safavid Dynasty after the reign of Shah Abbas I (1571–1629), under the regency of Shah Ismail III and was later adapted during the Shah Tahmasp II era to the water needs in this time period. It was used as a guideline for water use and water distribution in the Isfahan region (Mehryar 1999). The scroll is a legacy of insight into the historical, cultural and social evolution of agriculture of the Zayandeh Rud basin. Although this historical document was referred to as the Sheikh Bahaei scroll, it is not perfectly clear why this document was attributed to Sheikh Bahaei. The scroll based water distribution pattern has been tried and implemented during centuries, and has adapted itself to the necessities of the region.

The scroll has special peculiarities which have given authentication to its practicality:

1. Its importance and historical value as a world heritage in water distribution within areas with low precipitation and severe water dependence.
2. A historical example for participative cooperation and decision making in the right to water and its distribution, maintenance, utilization and surveillance.
3. Consideration of varying necessities due to different cultivation patterns, plantation sequences and water rights of the Zayandeh Rud.
4. General acceptance of this distribution pattern by all people and observance of its regulations.
5. A successful and dependable pattern for a multilateral cooperation of stakeholders in water utilization of an area with the most sensitive and tangible social concerns.

According to the historical document the water of Zayandeh Rud should be allocated among the Madis mentioned in the scroll. Although the amount of water allocated to each share was not mentioned clearly in the scroll, there were two main criteria to identify the pattern of water distribution which included time and the location of the Madis (Mehryar 1999). In this way, the water of Zayandeh Rud was distributed in terms of 33 shares which have been divided into seven blocks including Lenjan, Alenjan, Marbin, Jey, Baraan, Kararaj and Roudashtein (Islami 2009). The exact distribution is listed in Table 3.1 and will be explained below.

The scroll based water distribution pattern of Sheikh Bahaei has organized the spatial and temporal water distribution to some 405 cities, villages and farmlands. The implementation of the said scroll, with its vast and huge territory, containing so many cities and villages with its social, agricultural diversities, was solely decided by the stakeholders or their representatives. Even the highest ranking organizational person on utilization of the river being called “water head distributor”, which today corresponds to the managing director of the Water Board Co., was elected every spring by stakeholders for a period of one year and was introduced to the Government. This structure is depicted in Fig. 3.4.

In order for downstream users to supervise water extractions by upstream users according to the scroll, there was a nominated surveillance board which was selected by downstream water rights owners (Fig. 3.5).

The head of water distribution, supervised by the downstream users, along with the stakeholders advise and regulate the upstream head of distribution and the water staff, this being the executive releasing the water to the users. The water staff consists of the head watchmen and the block stream distributors of the seven blocks, which are the final consuming blocks.

The main pattern of the Sheikh Bahaei water share scroll is based on a crop calendar and percentage of available water. This means that in the first 75 days and in the last four months of a year the water of the Zayandeh Rud is shared among water rights holders. In other words, in this free extraction period, water is extracted by water rights holders commonly. After the first 75 days the scroll based distribution is executed, spanning over a period of 165 days, which starts from June 5th (15th Khordad) lasting until Nov 20th (30th of Aban). The exact distribution basis is listed in Table 3.1. According to the scroll, the Zayandeh Rud water is divided

Table 3.1 Distribution of water among the scroll-based blocks: Roudastein, Kararaj & Baraan, Marbin & Jey, Lenjan & E Lenjan (Source: Islami 2009)

Month	Irrigation days	Block			
		Lenjan & E Lenjan	Marbin & Jey	Kararaj & Baraan	Roudastein
May 22–Jun 21 (Khordad)	16–30				15 days seeding water
Jun 22–Jul 22 (Titr)	1–18	18 days			
	19–30		12 days		
Jul 22–Aug 22 (Mordad)	1–15	9 days			
			6 days		
	16–30	9 days			
			6 days		
Aug 22–Sep. 22 (Shahrivar)	1–15	9 days			
			6 days		
	16–30	9 days			
			6 days		
Sep 22–Oct 22 (Mehr)	1–18	11 days			
			7 days		
	19–28	10 days sowing			
Oct 22–Nov 22 (Alban)	29 Mehr–8 Alban		10 days sowing		
	9–15			7 days sowing	
	16–30				15 days budding water

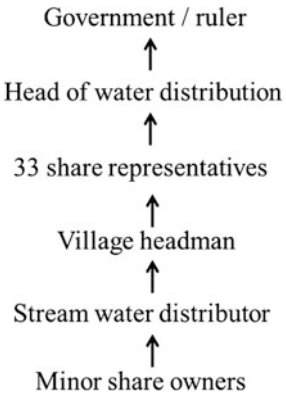

Fig. 3.4 Organizational chart of Zayandeh Rud utilization body elected by all stakeholders within the territory

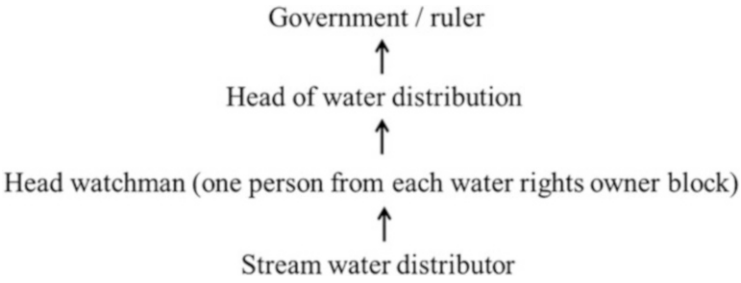

Fig. 3.5 Organizational chart of the surveillance board nominated by down-stream water-head distributor for supervision of water extraction

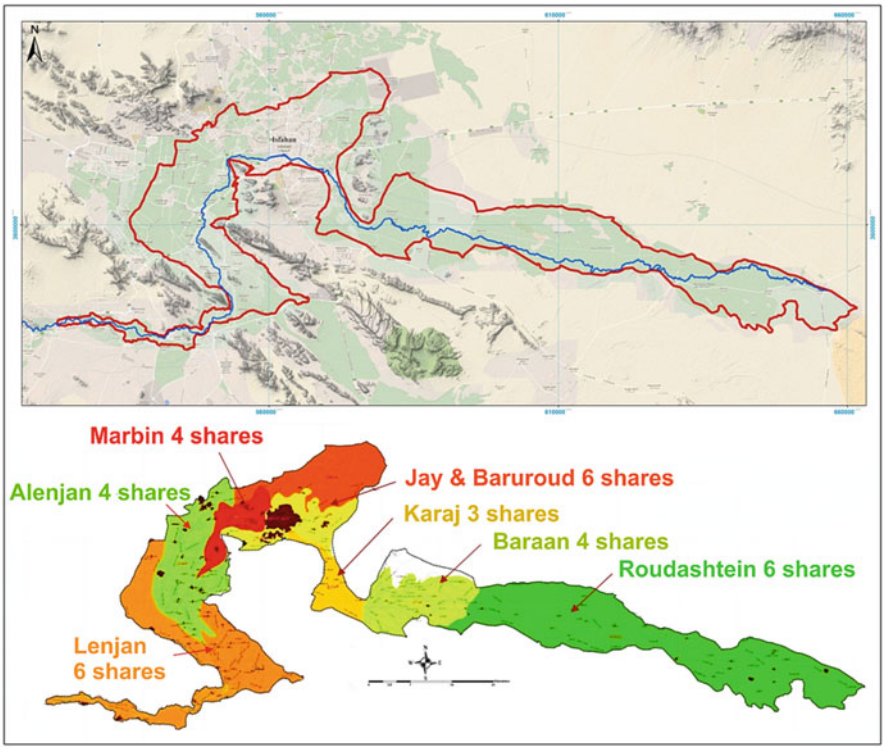

Fig. 3.6 Distribution of water based on the scroll-based in seven right-owner blocks (Source: Isfahan Water Authority)

into 33 major shares, and for each major share, five days of extraction have been allocated. In order to support the principles of the Sheikh Bahaei scroll, the water from the nearby river Kuhrang is transferred through the first Kuhrang tunnel to the Zayandeh Rud. This water is also divided into 33 shares and distributed between the blocks (Fig. 3.6).

Table 3.2 Subdivision of major shares to minor and retailed shares in the Sheikh Bahaei water distribution scroll

	Lenjan	Alenjan	Marbin	Jey-Barzroud	Kararaj	Baraan	Roodasht
↓33 major water shares	6 shares	4 shares	4 shares	6 shares	3 shares	4 shares	6 shares
↓275 minor water shares	113,5 shares	47,5 shares	29 shares	37 shares	12 shares	14 shares	22 shares
3098 retailed water shares	357 shares	315 shares	282 shares	674 shares	387 shares	840 shares	243 shares

Regarding the diversity of cultivation in the upper, median and lower parts of the Zayandeh Rud, within the limits of the scroll, each of the 33 shares is entitled to extract water in a limited time. In this irrigation sequence, special attention has been given to cultivation sequence of rice, kitchen garden, crops and considering the time spans in which plantations are water-sensitive (budding time, flourishing, seeding). Furthermore, the scroll has allotted a water right for Isfahan metropolitan with some priorities.

Table 3.1 shows the irrigation sequence and temporal distribution of water based on the scroll. In the irrigation sequence, each of the scroll blocks can extract water for a certain time span. This irrigation sequence is applicable similarly for each major share and all shares in every block.

In the scroll, there are seven right-owner blocks and 33 shares of water from the Zayandeh Rud. Each of the 33 shares in terms of water extraction is identical and equal to 5 days of extraction. Therefore, due to different river discharges (flow) in different months, the volume of water is changeable in different blocks. In the scroll the major shares are subdivided into minor and retailed shares, with regards to local and regional specifics, the number of villages, traditional networks, ownership of lands and vast farming areas. The major shares are broken into 275 minor shares and 3098 retailed shares. The exact basis of subdivision is listed in Table 3.2. It is noteworthy that although the minor and retailed shares in one area are equal, in different blocks these shares are not equal in terms of time-span extraction and volume.

3.5 Current Water Distribution Issues in the Catchment

While changes in the catchment and general socioeconomic conditions have led to changes in the system of water distribution in Isfahan, what was written in the Sheikh Bahaei scroll still remains to be the main acceptable pattern to distribute water of the Zayandeh Rud among traditional water users, in particular local farmers. The distribution found in the Sheikh Bahaei scroll was adopted by law in 1954 as the main pattern of water distribution in Isfahan including the mentioned

water rights holders. This distribution was also referred to by the Law of Equitable Distribution of Water adapted in 1982. However, it has not been clear and is still a subject of ongoing discussions, what amount of water from the Zayandeh Rud should be allocated to traditional water rights holders and how new stakeholders like industrial companies should be considered.

At present the amount of water distributed is based on time, location and particularly the percentage of water available in the river. This means that based on water availability in the river, the water is allocated among the 33 water shares (Mehryar 2000). As a result, in times of water shortage the process of water distribution has always become a critical issue in the region. As mentioned before with regards to changes, like the extension of cultivated lands leading to the development of new irrigation networks, the water distribution system has always been changed consequently.

Among several causes, the extension of cultivated lands and the development of irrigation canals to address the population growth and the establishment of industrial settlements in the region of Isfahan are the main reasons leading to increasing numbers of water users within the catchment. Water managers today face the daunting challenge of securing an increasing water demand with decreasing water resources. Conflicts between the main water users and uses arise. A sustainable reallocation that is adjusted to satisfy all users' demands is the major challenge in the catchment.

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