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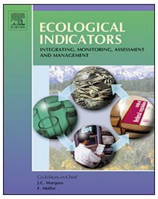

Assessing water security of Rafsanjan Plain, Iran – Adopting the SEEA framework of water accounting

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ABSTRACT

Rafsanjan Plain, located in the central Iran, is a dry area relying solely on its local aquifer for Pistachio production as its dominant economy. During the past few decades, unsustainable growth of Pistachio orchards and correspondingly overexploitation of the local aquifer have resulted in about 18 m fall of the groundwater table with terrible consequences such as reduction in the groundwater yield and about 1.2 m of land subsidence. The aim of the present paper is to analyze water security of the water resources system in the Rafsanjan plain in terms of the system vulnerability to water scarcity. Adopting an analytical framework for assessing the system vulnerability to water scarcity, the paper derives vulnerability indicators based on the data organized in terms of the System of Environmental and Economic Accounting for Water (SEEA-Water) for different water accounts associated to 2001 and 2006. The paper suggests policy options to reduce the system vulnerability using a system dynamics simulation model. The results showed that the water resources system of the study area is highly vulnerable to water scarcity due to large amount of water stress (more than 2), high dependency to groundwater (more than 95%), and high share of water consumption in agricultural sector (more than 90%). To alleviate the system vulnerability, the policy options are suggested to shift partly from agricultural activities to industrial and mining activities. It was shown that the policies could be effective to save water resources volume (more than 40%), improve water productivity (more than 25%), employment productivity (more than 17%), and labor productivity (more than 5%), and enhance per capita income (more than 3%) in comparison to the current state in the Rafsanjan plain.

1. Introduction

In recent years, water resources security has faced various challenges, becoming more vulnerable, and getting more concerned regarding sustainable development of socio-ecological systems. Therefore, the issue of water resources vulnerability is of high importance regarding sustainability of the system (Plummer et al., 2013). Understanding the concept of vulnerability can be useful for policy making in the process of Integrated Water Resources Management (IWRM) and provides a basis for decision makers to prioritize the actions. Moreover, attention to the main sources of vulnerability, vulnerable groups, and vulnerable regions will make opportunities for adaptive management of water resources (Babel et al., 2011).

The concept of vulnerability and vulnerability assessment have been interpreted by different scholars in various ways (see e.g. Turner et al., 2003; Adger, 2006; Gallopin, 2006; Fussel, 2007). A large number of authors have attempted to assess vulnerability in the form of quantitative and mathematical formulas derived from the numerical values (e.g. Adger, 2006; Kaynia, 2007). Addressing vulnerability quantitatively, another group of authors reported vulnerability using numerical indexes in regional scales. The vulnerability indexes might be indicated either in determinative values (Odada, 2000; Wei et al., 2004; Thomas, 2008) or by using maps (O'Brien et al., 2004; Schmidtlein et al., 2008).

Establishing on the premise that the concept of vulnerability is more complex and dynamic (relative to the associated hazard) to be asserted in terms of a formula, other category of research works considered it as descriptive (e.g. Ingram et al., 2006; Hellström, 2007; Ermoliev et al., 2008). In this category of research works, vulnerability is understood as a dynamic concept. It means that interactions among different interrelated sectors are also taken into account. We agree with the latter category to address vulnerability not focusing only on one sector, instead we believe that it should be assessed in a context embracing interactions among different inter-related sectors. Therefore, that requires

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analyzing the system under study systemically and in an integrated fashion (Fussel, 2007).

Adopting the framework for vulnerability assessment developed by Fussel (2007), which defines vulnerability as a function of four dimensions of system, attribute of concern, hazard and temporal reference, this paper is going to investigate vulnerability of a water resource system's attribute(s) of concern to a hazard (in temporal reference).

Vulnerability is a complex concept that cannot be measured directly. Therefore, it is necessary to develop appropriate indicators for assessing vulnerability. For example, Collins and Bolinb (2007) presented a method for assessing vulnerability to water scarcity in spatial terms using biophysical and social indicators. They applied their method in the case of groundwater-dependent and rapidly urbanizing area of Arizona Central Highlands, located 150 km north of the Phoenix metropolitan region, USA. Hamouda et al. (2009) applied a framework for assessing vulnerability of water systems in the Eastern Nile Basin (ENB) with a focus on using indicators and indices that can provide an insight on the situation in the region. Therefore, a list of 31 indicators were used for assessing the system vulnerability. The set of indicators was categorized to separate hydro-physical, socio-economic, and political indicators. The indicators were evaluated for the three countries in the Eastern Nile Basin. They were illustrated in radar diagrams. Babel et al. (2011) used an indicator-based approach to assess the vulnerability of water resources in the Bagmati River Basin in Nepal expressing vulnerability as a function of water stress (represented by water resources variation, water scarcity, water exploitation and water pollution parameters) and adaptive capacity (represented by indicators associated to the natural, physical, and human resources as well as economic capacities). To reflect water stress index, four indicators have been considered for each component of stress. The coefficient of variation of rainfall was considered as a proxy of variation of water resources over years. For the other three water stress components, per capita water availability, total water use with respect to available water, and wastewater discharge as a percentage of available water resources were other indicators taken into account to represent water scarcity, water exploitation, and water pollution parameters respectively. Eleven indicators corresponding to eight vulnerability parameters were adopted which showed an increasingly stressful situation and lack of adaptive capacity. That analysis served to suggest different policy options and helped to decision makers in reaching solutions to reduce freshwater resources vulnerability in the Bagmati River Basin.

Plummer et al. (2012) proposed a systematic review of water vulnerability assessment tools. Their review provided an insight about the assessment tools (710 indicators) into five dimensions and 22 sub-dimensions that addressed environmental and social aspects. Plummer et al. (2013) investigated the water vulnerability of three First Nation communities in Southern Ontario, Canada. The purpose of this paper was building an integrative understanding of water vulnerability, developing an associated instrument, and undertaking the community scale assessments. Although there are a variety of frameworks and methods to develop indicators for the purpose of vulnerability assessment in water resources systems, almost all of the approaches agree to integrate the physical dimension of the system under study with the social-economic dimension. However, more research is still needed to come up with an integrated framework suitable to propose and aggregate efficient indicators.

To come up with an integrated set of indicators, conceptual and analytical frameworks (such as the frameworks for water accounting) would be helpful. Different water accounting frameworks have been suggested to organize the hydrological data in combination with the economic data in an integrated manner to provide a platform for assessment of water resources systems. Australia is a pioneer in implementation of the system of water accounting in a national level (United Nations Statistics Division, 2012). In addition to Australia, there are few examples of water accounting studies in other parts of the world, mostly in the scale of river basins. For instance, Lange et al. (2007) compiled the water accounts (in terms of supply and use accounts) for the Orange River basin in 2000. The accounts were used to compare the contribution to water supply by each riparian state compared to the amount used. The compiling water accounts for the Orange River basin brought an economic perspective to water management at the regional level. In Mauritius, water accounts, in terms of water asset and physical supply and use accounts, were prepared from which different indicators were derived for the purpose of decision making (SADC, 2010).

In Iran, Falaki Elkhchi (2012) compiled economic and physical water accounts for the Zarrinehrood basin in the North-western Iran, where the major source of water is surface water. In addition, Yousefzadeh Chabok (2014) used an integrated approach using SEEA-Water accounts to assess the groundwater resource system of Mashad Plain in the North-eastern Iran. In this research, efficiency indicators were derived from a water accounting framework linked to a system dynamics model of the local hydro-economic system.

There are several water accounting frameworks, such as General-Purpose Water Accounting, Water Footprint Accounting, International Water Management Institute (IWMI) Water Accounting, and System of Environmental-Economic Accounting for Water (SEEA-Water). One of the most comprehensive systems of water accounting is the System of Environmental-Economic Accounting for Water (SEEA-Water) that has been developed by the United Nations Statistics Division (UNSD). SEEA-Water (UNSD, 2012) has been accepted by several countries as a standard framework to develop national as well as basin scale water accounts. By integrating information on the economy, hydrology, other natural resources and social aspects, SEEA-Water can provide the possibility of using integrated policies with an informed and integrated manner (UNSD, 2012). The SEEA-Water conceptual framework includes a set of standard tables that focus on hydrological and economic information. These tables present the interactions between water resources and the economic sectors. Furthermore, SEEA-Water includes a set of supplementary tables which cover information on the social aspects (UNSD, 2012).

The framework of SEEA-Water embraces six accounts of which three have been practiced in different countries and are now agreed on almost globally. Those three categories of accounts are physical supply and use accounts, hybrid physical and economic accounts, and asset accounts. Nevertheless, each country should customize those accounts according to the objectives and conditions which are prioritized to its water resources and basins. The other three categories of accounts, which are associated to water quality, valuation of water resources, and social aspects and the impacts of natural disasters, are still under development. Reaching an agreement on the concepts on how to implement those accounts has not yet become possible, because of a lack of practical experience, scientific knowledge, and consistency with the 2008 version of the SNA[1], or a combination of all those reasons (UNSD, 2012).

The purpose of this paper is to develop a methodology for water resources assessment systemically through customizing the SEEA-Water framework for the case of water resources system in the Rafsanjan plain in order to make a tool for vulnerability assessment of the plain to water scarcity. In order to do this, the water accounting system is adopted to produce indicators to assess the state and performance of the local hydro-economic system. To assess the system performance under the historical conditions for possible policy options, a system dynamics model was applied for simulation of the system. The system of water accounting is built up for the area under study including the first three categories of accounts (i.e. physical supply and use accounts, hybrid physical and economic accounts, and asset accounts) as well as suggested tables for social accounts. The methodology adopted in this

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[1] System of National Accounts.

paper could be applied for the purpose of integrated assessment of water resources systems at basin levels as in the context of integrated water resources planning and management.

The remainder of the paper is organized as follows. In the result section, we discuss the vulnerability of water resources system in the Rafsanjan plain based on the derived indicators in water resources, economic and social dimensions. Furthermore, we analyze the water resources system state under the policy options in the time of water accounts. Finally, the paper ends up with conclusions.

2. Materials and methods

2.1. Study area

The Rafsanjan plain is located in Kavir Daranjir Basin, in Kerman Province, Iran, with a total area of 12,421 km^2 (Fig. 1). The study area is arid with an average annual precipitation of only 90 mm. Due to lack of precipitation, rivers are mostly seasonal. Groundwater is the most important source of water provision for the local uses in domestic, industrial and mining, and agricultural sectors. The agricultural sector is the major water consumer in the area.

Because of a continuous trend of groundwater depletion, the local aquifer has been categorized as prohibited for more exploitation since 1974. Nevertheless, the groundwater withdrawal trend has been growing up during the past decades impacting the aquifer in terms of both quantitative and qualitative concerns as well as imposing other socio-environmental consequences such as land subsidence and degradation of the Pistachio orchards. The situation has been intensified in drought periods in the recent years.

2.2. Methodology

The methodology adopted in this paper consists of three parts. First, a framework has been developed to assess the system vulnerability. As the second part, within the context of vulnerability assessment, the framework of SEEA Water Accounting (UN, 2012) has been applied to organize the hydrological-economic-social data. Finally, the system under study was quantitatively assessed using a system dynamics model. The system dynamics model is capable of assessing the system vulnerability by respecting interactions among different sectors and their effects on each other.

2.2.1. A framework for vulnerability assessment

Inspired by the vulnerability assessment framework developed by Fussel (2007), the paper adopts the framework shown in Fig. 2 to assess vulnerability. Within the framework, the following four dimensions in accordance with those suggested by Fussel (2007) was adapted to the conditions of the study area. Fussel (2007) indicated that the following four dimensions are fundamental to vulnerability assessments.

1. System: The system of analysis, such as a natural system, a geographical region, an economic sector, or a population group that is threatened by a hazard. In this paper, the vulnerability of water resource and social- economic sub-system in the Rafsanjan study

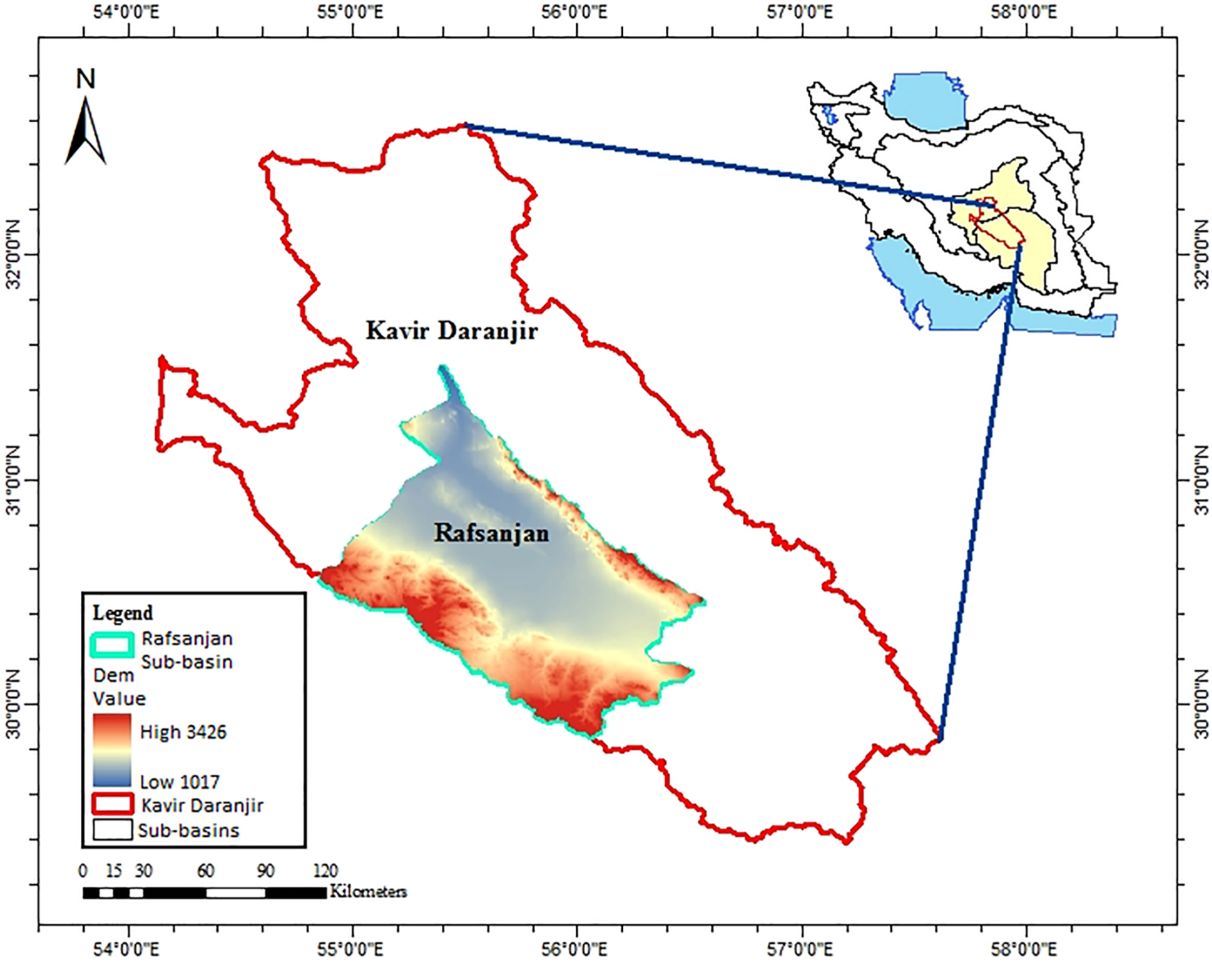

Fig. 1. Location of the Rafsanjan plain.

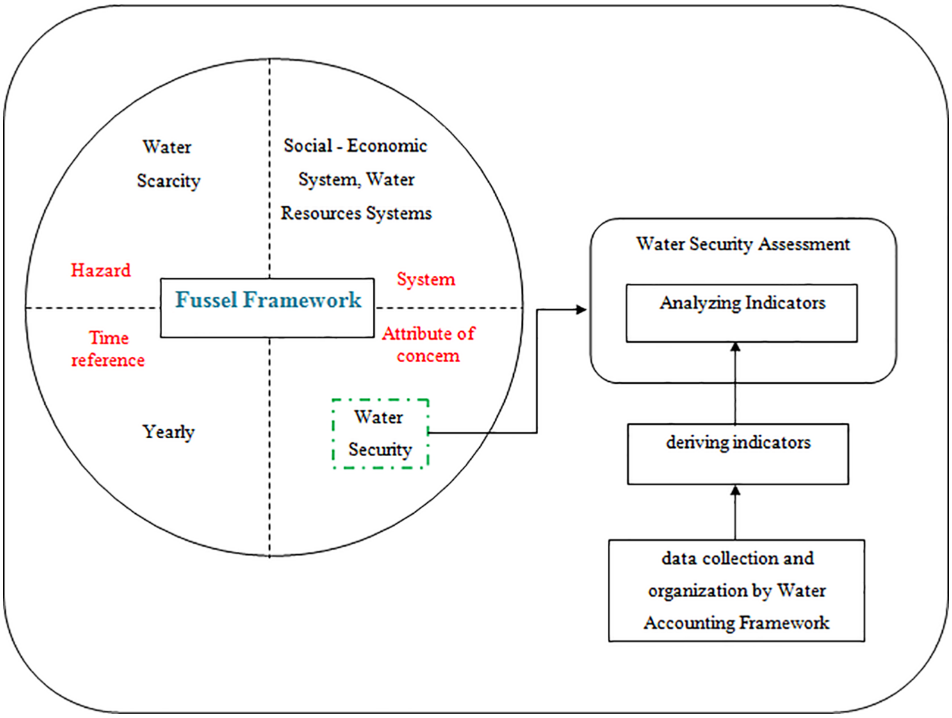

Fig. 2. Framework for Vulnerability Assessment adapted for the Rafsanjan study area.

area will be investigated.

2. Attribute of concern: The valued attributes of the vulnerable system that are threatened because of exposure to a hazard. In this paper, water security will be considered as the attribute of concern of the vulnerable system under study.
3. Hazard: A potentially damaging influence on the system under analysis. In this paper, water scarcity will be considered as the influencing hazard on the system under study.
4. Temporal reference: The point in time or time period of interest. In this paper, the time scale for vulnerability assessment will be considered as yearly.

From the above four dimensions, only the attribute of concern is more complex and needs to be investigated further. Indicators need to be developed to address the system attribute of concern, which has been investigated in the case study in terms of the concept of water security. The indicators were intended to cover environmental, social, and economic aspects of water security.

2.2.2. Water accounting framework

In this paper, The SEEA-Water framework will be used for derivation of indicators for evaluating the attributes of concern of the vulnerable system. To reflect water resources system vulnerability in the Rafsanjan plain, several indicators have been considered for water resources, economic and social dimensions. The major indicators of water resources dimension include internal renewable water resources volume, external renewable water resources volume, outflows to the outside of the basin, total natural renewable water resources (all in Million Cubic Meters (MCM)), dependency to external water resources ratio (%), dependency to groundwater ratio (%), relative water stress index, Consumption index and electric conductivity (EC) (μmhos/cm). The internal renewable water resources volume indicator is defined as the amount of water that is internally made available through precipitation. The external renewable water resources volume indicator indicates the amount of renewable resources that are generated from outside the territory. The outflows to the outside of the basin indicator corresponds to the flows from the territory of reference to other territories. The total natural renewable water resources indicator is the sum of internal and external renewable water resources that would be available in a territory taking into consideration the quantity of flow to other territories. Dependency to external water resources ratio represents the ratio of external renewable resources over total natural renewable resources that varies between 0 and 1. The dependency to Groundwater ratio indicates what part of the total water withdrawal is dependent to groundwater resources. It is obtained as the ratio of groundwater withdrawal over total water withdrawal (groundwater and surface water resources). If dependency to Groundwater ratio is less than 25% it means that the territory of reference is slightly dependent to groundwater resources. If dependency to Groundwater ratio is more than 25% and less than 50% it means that the territory of reference is moderately dependent to groundwater resources. Finally, if dependency to Groundwater ratio is more than 50%, it means that the territory of reference is highly dependent to groundwater resources (Vrba and Lipponen, 2007). Relative water stress index indicates the proportion of water demand pressures from the industrial, domestic and agricultural sectors to the local water supplies. Consumption index is the ratio of water withdrawal for the industrial, domestic and agricultural sectors over the real renewable freshwater resources. Electric conductivity measures the total soluble salts contained within water resources. In the case of Rafsanjan plain, EC was considered as the total soluble salts contained within groundwater resources (aquifers).

In this paper, the indicators of economic dimension consist of: the ratio of water consumption in agricultural, industrial/mining, and urban/services sectors over total water consumption, water productivity in agricultural, industrial/mining, urban/services sectors and in the region, the relative importance of agriculture in the regional economy, the relative importance of agricultural withdrawals in the local water balance, marginal changes of water productivity in agricultural sector and in the region. Water productivity is the most widely used indicator that indicates gross domestic product (GDP) per cubic meter of water used in each sector and in the region. The relative importance of agriculture in the economy is the share of GDP derived from agriculture compared to the total GDP in the territory. The relative importance of agricultural withdrawals in the local water balance represents the importance of agricultural withdrawals, especially irrigation, in reaching water balance in the area. It is computed as the ratio of water withdrawal for agriculture over the local renewable water resource.

The marginal change of water productivity is another important indicator that has been considered in this paper. The marginal value concept is the value of the output resulting from one additional unit of input. The marginal change of water productivity is calculated by the income changes relative to water consumption changes in agricultural sector and/or in the region.

For the social dimension the following indicators were taken into consideration: per capita renewable water resource, the ratio of employment in agricultural, industrial/mining, and urban/services sectors over total employment, labor and employment productivity in agricultural, industrial/mining, and urban/services sectors and in the region, per capita income, marginal change of labor productivity in the region, and marginal change of employment productivity in the region. Per capita renewable water resources is computed as total actual water renewable resources volume over population in the region. The ratio of employment in each sector is the proportion of employment in each sector over total employment in the region. Labor productivity is the gross domestic product per each employee in agricultural, industrial/mining, and urban/services sectors and in the region. Employment productivity indicates the number of employments per cubic meter of water used in agricultural, industrial/mining, and urban/services sectors and in the region. Per capita income is calculated as the income per individual in the region. Marginal change of labor productivity in the region is measured as the number of labor change relative to water consumption change in the agricultural sector or in the region. Marginal change of employment productivity is measured as the employment changes relative to water consumption change in the agricultural sector or in the region.

On the other hand, elasticity is an important indicator that can explain the effect of a single policy on the water resource volume and on water productivity in the region. Elasticity is a measure of a variable's sensitivity to a change in another variable. The elasticity of water productivity, measures the percentage of change in water productivity relative to the percentage of change in any policy options.

Moreover, another important factor that has been considered is effectiveness of policy options. The effectiveness of policy options determines the rate of change in indicators under policy options in comparison to the status quo. All of the indicators are derived from the water accounts.

In this paper, the following four categories were applied as the water accounts in the Rafsanjan study area:

1. Physical supply and use accounts: This category of accounts provides information on the volumes of water exchanged between the environment and the economy (abstractions and returns) and within the economy (supply and use within the economy)) UNSD, 2012).
2. Hybrid physical and economic accounts: This category of accounts aligns physical information recorded in the physical supply and use tables with the monetary supply and use tables of the 2008 version of SNA (UNSD, 2012).
3. Asset accounts: This category of accounts comprises accounts for water resource assets measured in physical terms. Asset accounts measure stocks at the beginning and at the end of the accounting period and record changes occurred in the stocks, during the period of precipitation, evapotranspiration, inflows and outflows, and human activities, such as abstraction and returns (UNSD, 2012).
4. Social accounts: This category of accounts comprises supplementary information to the water accounts. The advantage of the used information in accounts can increase by focusing on the integration between the economy and the environment, with the various social aspects such as employment, population and social welfare.

For expanding part two of SEEA-Water, the paper has presented social aspects such as disaggregating population, employment and income with information on the supply and use of water, as proposed within supplementary tables in these accounts.

In the implementation of part one of SEEA-Water - physical supply and use tables, and hybrid physical and economic accounts - columns are representatives of different users. The classification of industrial economic activities used in SEEA-Water is adapted according to the International Standard of Industrial Classification of all Economic Activities (ISIC) that is used in SNA (UNSD, 2012). In this paper, in order to display an overview of the area, the water users were classified into the following groups: agriculture, industrial and mining, urban and services, ISIC 36 (water collection, treatment and supply). According to the dominance of pistachio in the area, the agricultural sector was exclusively considered as pistachio.

Water accounting tables can be compiled at a river basin scale, an administrative region or any level of geographical disaggregation of a territory that is suitable for planning and water management. The temporal reference of the compilation of accounts of the water is usually every three or five years. In this paper, water accounting tables of the Rafsanjan study area are compiled for 2001 and 2006 and are used for derivation of indicators. Vulnerability situation of the case study is analyzed in an aquifer scale by comparing the indicators derived from the accounts.

Water accounting tables are constructed for the investigation and analysis of the system performance. Therefore, these tables are built for the past temporal references. The reason for selecting these two temporal references for the compilation of water accounts is the availability of required data. Then, based on the lessons learnt from the past system performance, different policy options, associated to allocation and consumption of water, will be analyzed in the same temporal references.

2.2.3. Simulation model

A dynamic model was built for investigating the impact of policy options in the Rafsanjan study area within the period of 2001 until 2006. The model was constructed based on the conceptual model shown in Fig. 3. The basic configuration of the conceptual model is based on the Social-Ecological Systems framework presented by Ostrom (2007) and the water accounting framework proposed by the United Nations Statistics Division (2012). The Social-Ecological Systems framework (Ostrom, 2007) is a simple and very general framework for investigating and analysis of the Social-Ecological systems. The SEEA-Water framework proposed by the United Nations Statistics Division (UNSD), demonstrates the economy, the system of water resources and their interactions. In the conceptual model of the Social-Ecological System of the Rafsanjan study area, the economy, water resources system and their interactions are considered based on the SEEA-Water framework as well as the social sector, which is also added to the model.

As shown in Fig. 3, the conceptual model embraces two sectors including social-economic sub-system, and inland water resources and their interactions. According to the system boundary, exogenous variables such as the ecological factors (environmental conditions, rainfall, temperature) and the exogenous social and economic factors affect the system unilaterally.

The social-economic sector embraces population growth and the increasing community needs which will lead to the pressure on the scarce local water resource sub-system. In this sector, population and employment have been taken into account. The changes in the local population lead to changes in the local labor force supply. The various economic users in the area were divided into agriculture, industries and mines, and services. It should be noted that the regional exchange of goods and labor forces from/to the area was ignored in this research. The inland water resources sector is also limited to the quantity of water resources, including surface water and groundwater resources.

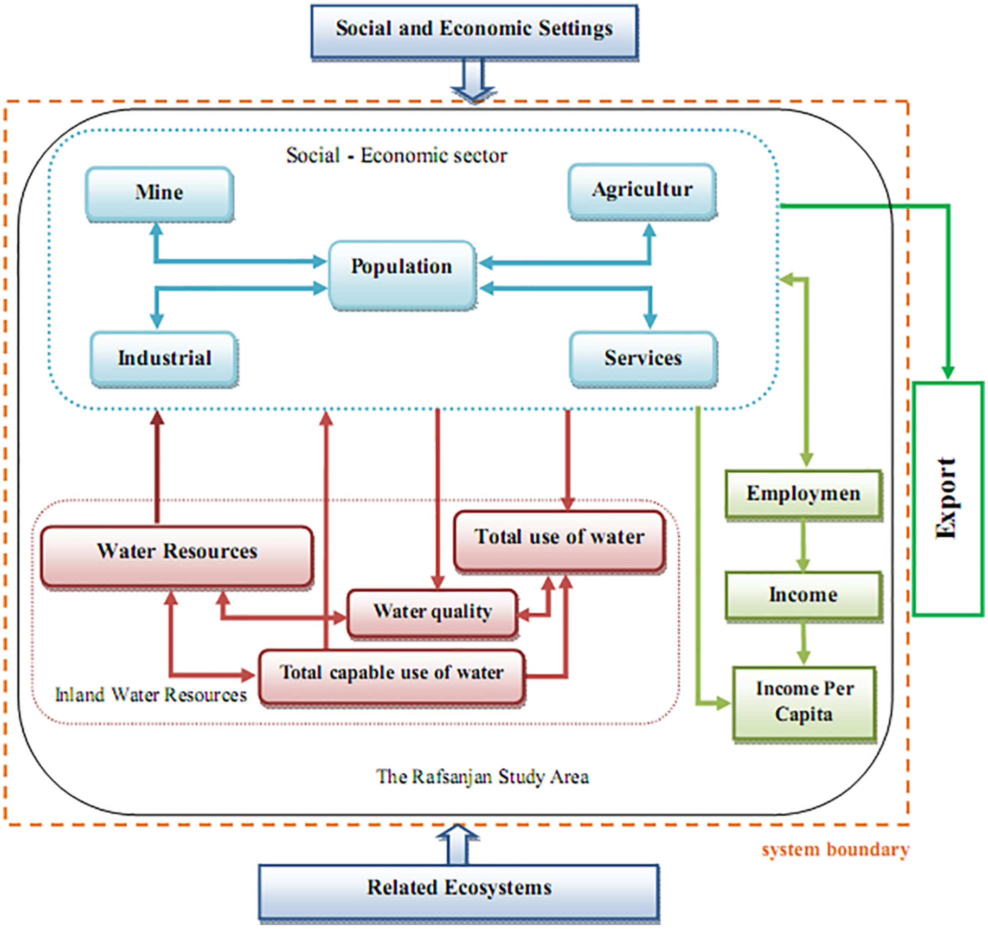

Fig. 3. Conceptual model of the Social-Ecological System in the Rafsanjan study area.

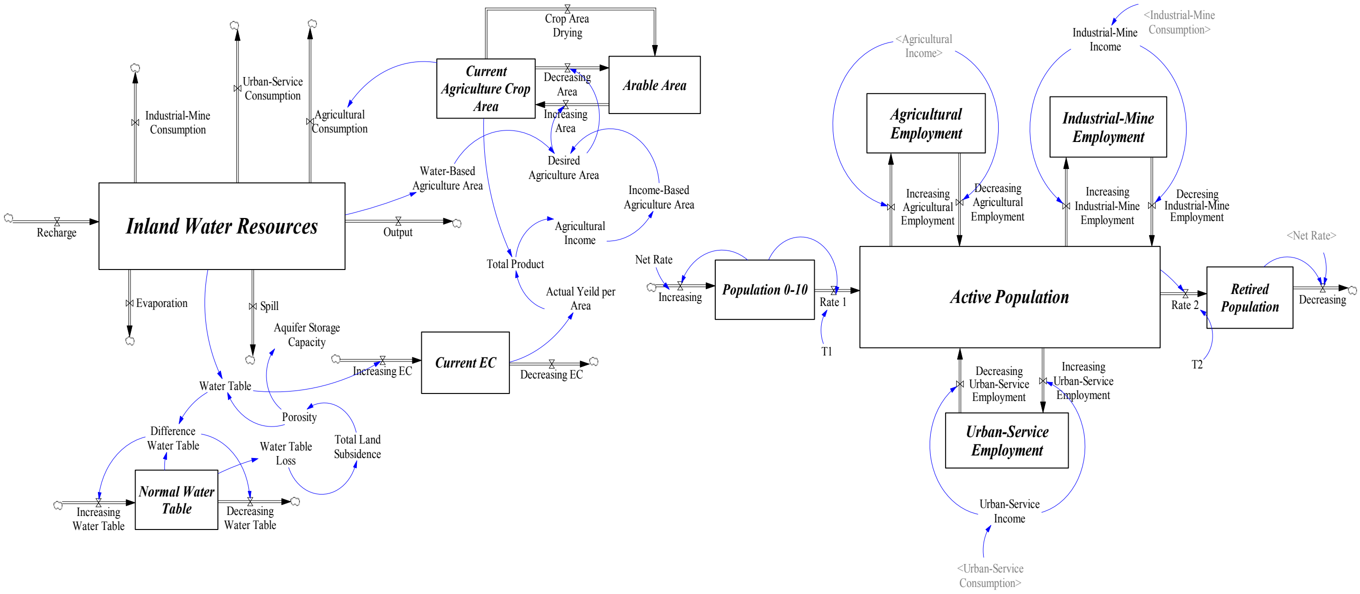

Fig. 4. The System Dynamics Simulation Model of the Rafsanjan study area.

The system dynamics model proposed in this paper is built in VENSIM PLE (Personal Learning Edition) software (Ventana Systems, Inc., 2003). It is a friendly decision making tool to analyze the impact of the different policy options (Fig. 4). The model consists of the following two parts:

1. Social-Economic sector: including population, urban and services, industries and mines, agriculture and the employment corresponding to each economic sector;
2. Environmental sector: including water resource (inland water resource), water supply and water demand, water quality, and land subsidence.

In this model, the simulation of Environmental sub system is carried out based on the quantity and quality of water resource and also land subsidence sub models. The quantitative simulation of water resources relies on the local water balance information. The water quality was simulated based on the groundwater Electric Conductivity. The model is also capable of taking into account the land subsidence and its effects on the aquifer storage capacity, water table, and water quality.

In Social- Economic sub system, cohorts of population (population with ages less than 10, active population and retired population), Income and employment in urban services, industrial and mining, and agricultural sectors have been considered.

3. Results and discussion

The data were organized using the SEEA water accounting framework in terms of physical supply and use, hybrid supply and use, and asset account standard tables for 2001 and 2006 in the Rafsanjan plain. Furthermore, as a novelty to SEEA Water Accounting tables, a social table was also added to the series of tables above. The whole water accounting tables are demonstrated in Tables A1 and A12 in the Appendix. To assess the vulnerability of the system under study to water scarcity, the paper contributes to derive indicators relying on the variables organized in the water accounting tables. The values of the associated indicators are demonstrated in Table 1. The relationship of each selected indicator with the water accounting standard tables has also been indicated in the Table 1.

3.1. Analysis of the status quo of the system corresponding to the time of water accounts

In this study, the vulnerability of water resource system in the Rafsanjan study area is analyzed using water resources, economic and social indicators. Bringing all those aspects together is challenging. The indicators associated to the water resources dimension provide a comprehensive understanding of water resources vulnerability. In addition to the physical information, the sets of social and economic information are also necessary for a comprehensive assessment of water resources. Fig. 5 illustrates radar diagrams of vulnerability indicators in both water resources, and economic and social dimensions in comparison with their reference values in 2001 and 2006. The reference values have been chosen In order to draw the radar diagrams, the values were normalized to a scale of 0–1 using linear normalization method. In this method, values of the indicator is normalized by dividing the value of each indicator for each alternative by the sum of all its values for all the alternatives. Therefore, values of the indicators in 2001, 2006 and their reference values (as alternatives) have been normalized by dividing the value of each indicator and its reference value by the sum of all its values for all alternatives using Eq. (1). Where r_{ij} is the value of the i^{th} indicator for the j^{th} alternative and P_{ij} is the i^{th} normalized indicator for the j^{th} alternative.

$$P_{ij} = \frac{r_{ij}}{\sum_{i=1}^{m} r_{ij}} \tag{1}$$

As depicted in Fig. 5, the results of the vulnerability dimensions are used for analysis of vulnerability in the Rafsanjan study area. The analysis of indicators related to water resources, economic and social dimensions in the study area shows that water security (as the system attribute of concern) in water resources dimension is highly vulnerable because the water resources supply is so low in comparison with the increasing water demands. That is due to serious water stress, completely unsustainable groundwater abstraction and serious aquifer downfall, and degradation of the water security in the area quantitatively and qualitatively. Those problems have led to more dependency on external water resources.

The analysis of indicators shown in Fig. 5 corresponding to the economic and social dimensions shows that the population growth and economic development are likely responsible for increase in the water demand. Economic development is based on the agricultural sector in the area under study. Nevertheless, the agricultural economic water productivity is far less than that in the urban-services and industrial and mining sectors. The highest labor productivity (output per employment) belongs to industrial and mining sectors. In the agricultural sector, with the most water consumption, the employment productivity (employment per water consumption or making more employment for any unit volume of water consumption) is the lowest. Also, due to population growth (2001–2006) the urban water consumption increased, as a consequence the per capita renewable water resource was reduced from 1500 (m^3/person) in 2001 to 1100 (m^3/person) in 2006, meaning that the Rafsanjan study area is in the boundary of water stress and water scarcity.

3.2. Analysis of the system under the policy options in the time of water accounts

The system dynamic model was used to analyze the consequences of different policy options on the system under study. The model was verified by applying structural assessment, extreme conditions, and behavior reproduction tests. At first, the model was run from 2001 until 2006, at an annual time step, without imposing any policy options. In this stage, the vulnerability indicators were calculated according to the output values (such as water resource volume, EC, agricultural crop area, population and employment) generated by the model based on input parameters (such as water balance parameters including runoff and evaporation, etc.). Since the output values generated by the model did not have significant differences from the observed data, the model output values were used as the reference values for comparison with the results generated by the model under policy options. The policy options were designed according to the overarching development program documents as below:

Policy option 1: *Improving the irrigation efficiency by 15% by using the modern irrigation systems given that the agricultural crop (pistachio) area does not change;*
Policy option 2: *Reducing the agricultural crop (pistachio) area by 15%*;
Policy option 3: *Improving the irrigation efficiency by using the modern irrigation systems as well as reducing the agricultural crop (pistachio) area (combination of policy options 1 and 2)*;
Policy option 4: *Replacing 20% of agricultural employment with industrial and mining employment*;
Policy option 5: *Shifting the economic pattern from agricultural activities to industrial and mining activities (reducing agricultural crop (pistachio) area by 20% and increasing in the industrial and mining sector by 30%)*;
Policy option 6: *Restricting the groundwater abstraction to 50% of its renewal rate.*

According to the policy options and their results based on the derived indicators in water resource, economic and social dimensions, the effectiveness of suggested policy options on reducing the system vulnerability of water security (attribute of concern) is shown in Table 2. Water resource volume, total water productivity in the region, water productivity per hectare in the agricultural sector, and employment productivity are the indicators that increased under all of the policy options in comparison to the status quo. In addition, EC also decreased under all of the policy options.

As can be seen from Table 2, policy options 3 and 6 are more effective on water resources volume in the region due to improvement in the irrigation efficiency and reduction in the agricultural crop area as well as restriction in the groundwater abstraction. In spite of reducing water consumption and EC, and increasing in water resources volume

Table 1
Dimensions and sets of the indicators derived from the water accounts for vulnerability assessment.

Dimension	Indicator	Description	Correspondence to the water accounting tables	Year	
				2001	2006
Water Resources	Internal renewable water resources volume (MCM)	The amount of water that is internally made available through precipitation	Physical use table, asset account table	287	266.7
	External renewable water resources volume (MCM)	The amount of renewable resources that are generated from outside the territory		21	81.5
	Outflows to the outside of the basin (MCM)	The flows from the territory of reference to other territories		3	17.9
	Total natural renewable water resources (MCM)	The sum of internal and external renewable water resources that would be available in a territory taking into consideration the quantity of flow to other territories		305	330.3
	Dependency to external water resources ratio (%)	The ratio of external renewable resources over total natural renewable resources that varies between 0 and 1		6.89	24.67
	Dependency to Groundwater ratio (%)	The part of the total water withdrawal which is dependent to groundwater resources		98.61	96.31
	Relative water stress index	The proportion of water demand pressures from the industrial, domestic and agricultural sectors to the local water supplies		2.91	2.73
	Consumption index	The ratio of water withdrawal for the industrial, domestic and agricultural sectors over the real renewable freshwater resources		3.1	3.39
	EC (μmhos/cm)	The total soluble salts contained within water resources		5130.26	5580.18
Economic	Ratio of water consumption in agricultural sector to total water consumption (%)		Physical use table, Hybrid supply table, asset account table, social table	94.71	94.28
	Ratio of water consumption in industrial and mining sector to total water consumption (%)			4.01	3.68
	Ratio of water consumption in urban-services sector to total water consumption (%)			1.28	2.05
	Water Productivity in the region $\left({}^{IRR*}/_{m^3}\right)$	The gross domestic product (GDP) per cubic meter of water used in the region		4107	11211
	Water Productivity in agricultural sector (IRR/m^3)	The gross domestic product (GDP) per cubic meter of water used in agriculture		1635	4483
	Water Productivity in industrial and mining sector (IRR/m^3)	The gross domestic product (GDP) per cubic meter of water used in the industrial and mining sector		37987	113055
	Water Productivity in urban-services sector (IRR/m^3)	The gross domestic product (GDP) per cubic meter of water used in the urban-services sector		80792	138.225
	Relative importance of agriculture in the economy	The share of GDP derived from agriculture compared to the total GDP in the territory		0.38	0.38
	Relative importance of agricultural withdrawals in local water balance	The ratio of water withdrawal for agriculture over the local renewable water resource		2.76	2.58
	Marginal change of water productivity in the region (2001–2006) (${}^{IRR}/_{m^3}$)	The income changes relative to water consumption changes in the region		609940	
	Marginal change of water productivity in agricultural sector (2001–2006) (IRR/m^3)	The income changes relative to water consumption changes in agricultural sector		216247	

(*continued on next page*)

Table 1 (*continued*)

Dimension	Indicator	Description	Correspondence to the water accounting tables	Year	
				2001	2006
Social	Population		Social table, asset account table	197623	295175
	Per capita renewable water resource ($m^3/person$)	Total actual water renewable resources volume over population in the region		1500	1100
	Ratio of employment in agricultural sector to total employment (%)	The proportion of employment in each sector over total employment in the region		29.54	29.54
	Ratio of employment in industrial and mining sector to total employment (%)			17.93	17.93
	Ratio of employment in urban-services sector to total employment (%)			50.21	50.21
	Labor productivity in agricultural sector ($IRR/person$)	The gross domestic product per each employee in agricultural, industrial/mining, and urban/services sectors		72031663	133693865
	Labor productivity in industrial and mining sector ($IRR/person$)			116724538	216642486
	Labor productivity in urban-services sector ($IRR/person$)			28353356	52625546
	Labor productivity in the region ($IRR/person$)	The gross domestic product per each employee in the region		56444750	104764770
	Employment productivity in agricultural sector (Ratio of employment in agricultural sector to water consumption in agricultural sector ($person/m^3$)	The number of employments per cubic meter of water used in each sector		23	34
	Employment productivity in industrial and mining sector ($person/m^{3)}$			325	522
	Employment productivity in urban-services sector ($person/m^{3)}$			2849	2627
	Employment productivity in the region ($person/m^{3)}$	The number of employments per cubic meter of water used in the region		73	107
	Per capita income ($person/m^3$)	The income per individual in the region		18477631	34295622
	Marginal change of labor productivity in the region (2001-2006) ($IRR/person$)	The number of labor change relative to water consumption change in the agricultural sector or in the region		255762166	
	Marginal change of employment productivity in the region (2001–2006) ($IRR/person$)	The employment changes relative to water consumption change in the agricultural sector or in the region		2385	

*Iranian Rial, the base year for reporting the prices is 2012.

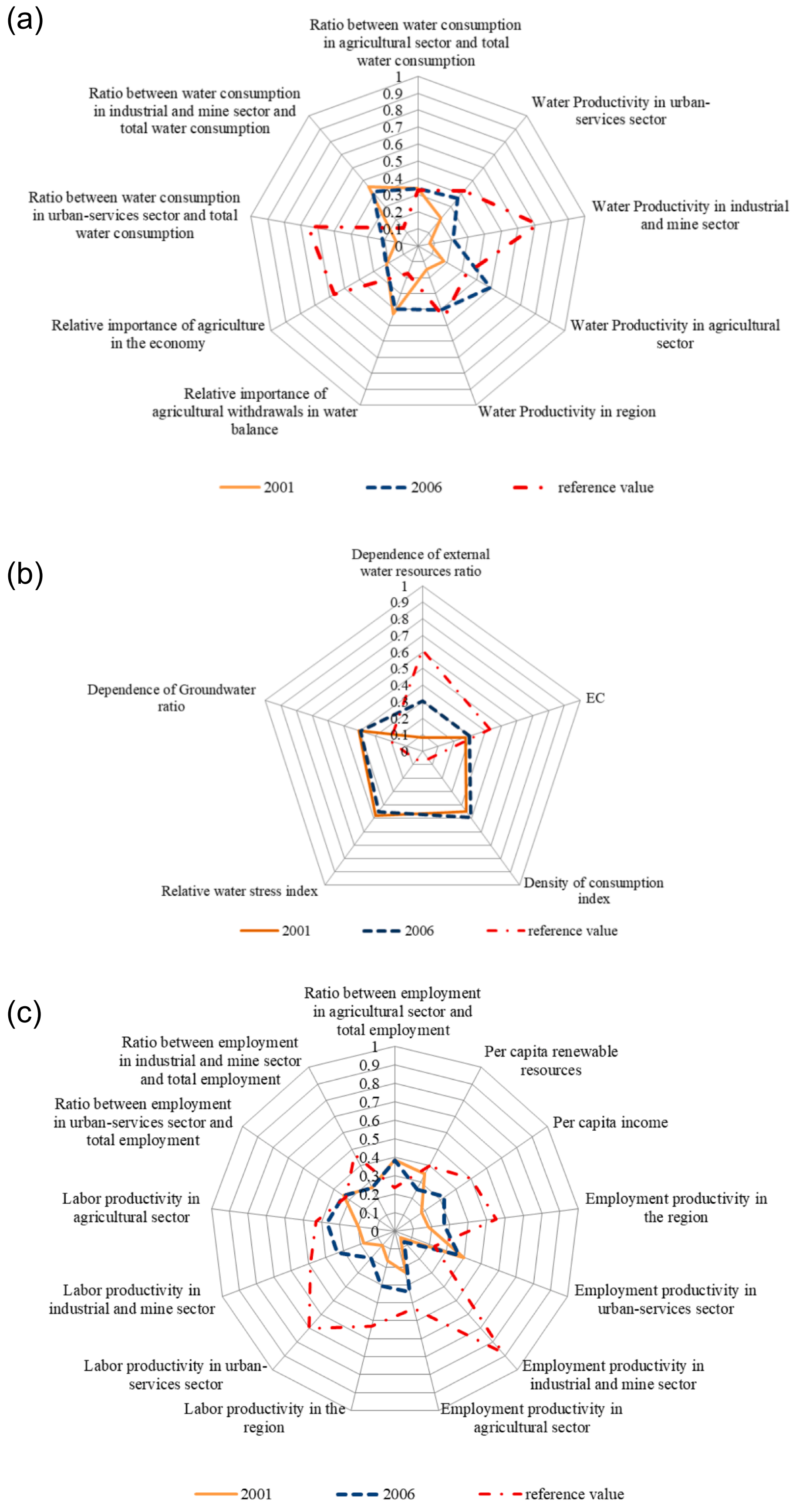

Fig. 5. Radar diagrams of vulnerability indicators of the Rafsanjan study area in 2001 and 2006. a: water resources dimension; b: economic dimension; c: social dimension.

Table 2
The effectiveness of the suggested policy options on reducing the system vulnerability of attribute of concern (water security) in 2006 compared to that in 2001 (%).

Indicator	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Water resource volume	27.52	31.51	54.87	41.28	40.82	51.78
EC	−1.05	−2.38	−7.01	−5.23	−5.20	−3.52
Total water productivity in the region	14.07	9.96	25.42	27.73	26.30	18.37
Water productivity in the agricultural sector	14.98	−0.45	14.96	−0.99	−0.99	−0.66
Water productivity per hectare in the agricultural sector	15	17.21	35.26	24.14	23.39	31.80
Employment productivity	13.54	13.54	20.17	20.83	17.71	26.04
Labor productivity	0	−3.35	−3.33	5.60	7.04	−5.84
Per capita income in the region	0	−5.56	−5.43	4.65	3.81	−9.10
Water consumption in the region	−12.33	−14.12	−24.59	−18.07	−17.81	−23.21
Employment in the region	0	−2.29	−2.17	−0.90	−3.02	−3.46

Table 3
Elasticity of water productivity and water resources volume in the region under single policy options (during 2001–2006).

Indicator	Option 1	Option 2	Option 4	Option 6
Water resource volume	+0.94	−0.66	+1.39	−0.37
Water productivity in the region	+1.83	−2.10	+2.06	−1.04

in the region, the indicators such as labor productivity, per capita income in the region, and employment in the region decreased due to reduction in the agricultural crop area and restriction in the groundwater abstraction. Policy option 3 was more effective in increasing the total water productivity and water productivity per hectare in the agricultural sector than option 6, while policy option 6 was better in improving employment productivity i.

Except for the labor productivity, and per capita income in the region, policy option 4 was more effective in other indicators comparing with policy option 5.

According to improving the irrigation efficiency without changing the agricultural crop area in policy option 1, the following indicators increased in comparison to the status quo in the region: water resources volume (27.52%), total water productivity (14.07%), water productivity in the agricultural sector (14.98%), water productivity per hectare in the agricultural sector (15%), and employment productivity (13.54%). However, EC and water consumption in the region decreased almost 1.05% and 12.33% respectively due to improving the irrigation efficiency.

Reducing the agricultural crop (pistachio) area by 15%, had an increasing effect on the following indicators: water resources volume (31.51%), total water productivity in the region (9.96%), water productivity per hectare in the agricultural sector (17.21%), and employment productivity (13.54%); while the following indicators were affected negatively due to reduction in the crop area and water consumption in the agricultural sector: water productivity in the agricultural sector (0.45%), labor productivity (3.35%), per capita income in the region (5.56%), and employment in the region (2.29%).

Table 3 shows the elasticity of water productivity and water resources volume in the area under single policy options. The elasticity of water productivity due to implementing policy options measures the percentage of change in water productivity relative to the percentage of change in any policy options from 2001 to 2006. For example, under policy option 1, the elasticity of water productivity is measured as the percentage of change in water productivity in the area under policy option 1 to the basic state relative to the percentage of efficiency improvement. If the elasticity is more than 1, water productivity is elastic, which means that 1% change in the policy option relative to the baseline will impose more than 1% change in the water productivity. If the elasticity is equal to 1, it means that1% change in the policy option relative to the baseline will have 1% change in the water productivity. Finally, if the elasticity is less than 1, the water productivity will be inelastic, which means that 1% change in the policy option relative to the baseline will impose less than 1% change in the water productivity. The elasticity of water resource volume is also measured as percentage of change in water resource volume relative to the percentage of change in any policy options. For example, under policy option 1, the elasticity of water resource volume is measured as the percentage of change in the local water resource volume under the policy option 1 relative to the baseline due to the percentage of irrigation efficiency improvement.

The results in Table 3 show that under policy option 1 (irrigation efficiency improvement (15%)) the water productivity is inelastic to irrigation efficiency improvement, while the water resource volume is so elastic. Under policy option 2 (reducing agricultural crop (pistachio) area by 15%), the total water productivity is negatively inelastic, while water resource volume in the region is highly negatively elastic. Under policy option 4 (replacing 20% of agricultural employment with industrial and mining employment), the total water productivity in the area as well as the water resources volume is elastic. Under policy

Table 4
Average vs Marginal values of productivity indices in 2001–2006.

	Average			Marginal changes (2001–2006)
	2001	2006	changes	
The water productivity in the area $\left({}^{IRR}/_{m^3}\right)$	4633	11030	6397	609940
Employment productivity in the area $\left({}^{person}/_{m^3}\right)$	71	96	25	2385
Labor productivity in the area $\left({}^{IRR}/_{person}\right)$	65181663	115459925	50278262	255762166
Water productivity in agricultural sector $\left({}^{IRR}/_{m^3}\right)$	2190	4239	2049	216247

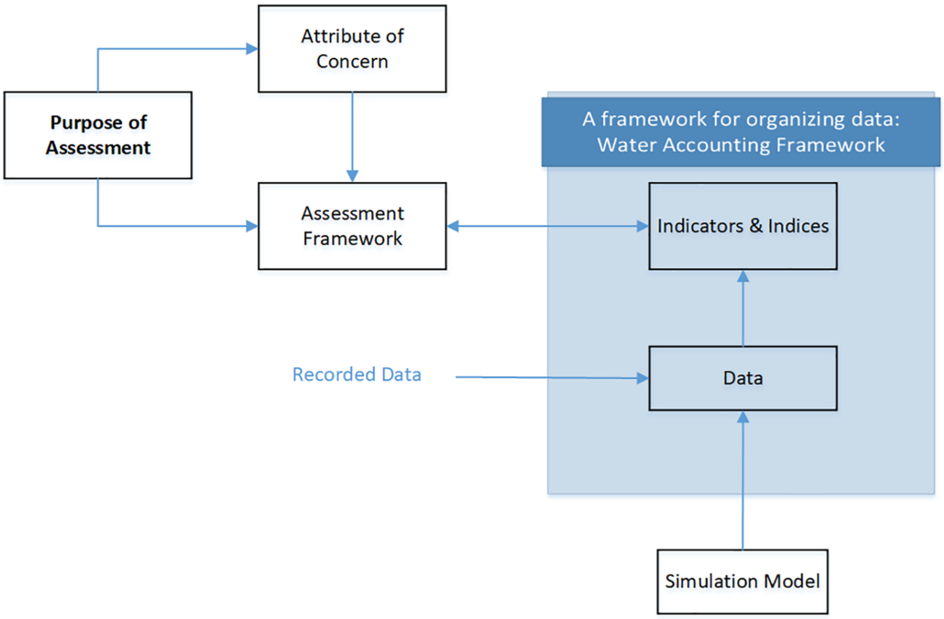

Fig. 6. A methodological framework for assessment of water resources systems.

option 6 (restricting groundwater abstraction to 50% of its renewal rate), the total water productivity in the area showed a negative inelastic behavior, while the water resource volume in the area showed almost a negative linear response.

The comparison of elasticities of total water productivity and water resource volume in the area under single policy options will show how elastic each of those attributes is. Water resource volume is elastic under the following policy options: Irrigation efficiency improvement (15%) (Policy option 1), Reducing agricultural crop (pistachio) area (15%) (Policy option 2), Replacing 20% of agricultural employment with industrial and mining employment (Policy option 4), and Restricting groundwater abstraction to 50% of its renewal rate (Policy option 6). But, the total water productivity in the area was elastic only to the policy of Replacing 20% of agricultural employment with industrial and mining employment (Policy option 4). Therefore, by replacing part of agricultural employment with industrial and mining employment, the total water productivity and water resource volume in the area showed elastic behaviors, meaning that those policy options could be highly effective on the system under study.

Table 4 shows changes of marginal values of total water productivity, labor productivity, employment productivity in the area, and water productivity in the agricultural sector between 2001 till 2006. The marginal concept means that if one more unit is added to the input, how much increase will occur in the output. For example, the marginal change of total water productivity in the area is measured as income change relative to water consumption change in the area by using Eq. (2).

$$\text{Marginal value of total water productivity in the area} = \frac{\text{income change in the area}}{\text{water consumption change in the area}} \tag{2}$$

As shown in Table 4, it is seen that the average values that have been calculated based on the results of the simulation model increased from 2001 to 2006; however, the changes in marginal values were much greater in the same period. The large marginal values can justify why the motivation towards short-term benefits of agriculture (in terms of Pistachio planting) in the area plays a significant role as a strong economic driver in Rafsanjan despite severe water scarcity.

4. Conclusions

In terms of natural environment, water has a key role in sustainable development; therefore, assessing vulnerability of water-associated systems is important especially in the regions facing with water scarcity. This paper presented a methodological comprehensive framework for assessing and analysis of water resources systems (Fig. 6). As depicted in the figure, a purpose should be determined for assessment. The purpose will define what would be the attribute of concern and what type of assessment framework to be adopted. The process of assessment is usually carried out using a set of indicators and/or indices, which are designed in accordance with the assessment framework. Meanwhile, the indicators/indices will also serve as inputs to the assessment framework when they are calculated based on the data obtained from the system under analysis. The source of data can be either from observations and/or historical records, which correspond to the real system, or from outputs of a simulation model, which is intended to generate simulated data corresponding to different scenarios and/or policy options. To organize the data, a water accounting system is recommended. Where water resources assessment consists of physical water resources data as well as social-economic data, a comprehensive water accounting framework, such as the SEEA-Water framework, would be necessary.

The framework developed in this paper can be applicable in managerial decision making and economic planning of water-associated systems to devise more holistic policies respecting a better understanding of system under study.

Adopting the vulnerability assessment framework developed by Fussel (2007), this paper presented a various set of indicators by applying the SEEA-Water accounting framework associated to the Rafsanjan study area located in the middle part of Iran. Comparing the values of water security indicators in two time sections of 2001 and

2006 showed that the water resource system as well as the social-economic system of the study area is highly vulnerable to water scarcity. The indicators corresponding to the water resources dimension showed that an intensive water scarcity crisis is dominant in the Rafsanjan study area.

The analysis of indicators related to water resources, economic and social dimensions in the study area showed that water security (as the system attribute of concern) in water resources dimension is highly vulnerable because the water resources supply is so low in comparison with the increasing water demands. That is due to serious water stress (more than 2), completely unsustainable groundwater abstraction and serious aquifer downfall because of high dependency to groundwater (more than 95%). Those factors have resulted in reducing the quantity and quality of water security in the area, while the study area has got more dependent on external water resources (more than 20%).

Meanwhile, the area is highly dependent on local groundwater with large water consumption in the agricultural sector (more than 90%), but with low water productivity. Therefore, it is advised to change the economic pattern from agricultural activities to industrial and mining activities. Persisting the current trend of water consumption can lead to even more aquifer downfall with no chance of restoration. As it was shown that the local water resource was elastic to the policy of employment shift from agriculture to industry, the policy is expected to affect the system more effectively.

According to the marginal values corresponding to water productivity and employment per water consumption, the dominating economic driving force is oriented towards short-term benefits; thus, the strategic benefits, especially in a long term, are more likely to be neglected. That can tackle any other strategic policies. Therefore, urgent actions are needed to adjust the economic driving force to pave the way for a contextual change (such as enhancing the local governance) in the area.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix

Tables A1–A12.

Table A1
Physical use table (MCM) in the Rafsanjan study area based on the 2006 data set.

	Industries (by ISIC category)							Total
		Agriculture		Industrial and Mining	ISIC 36	ISIC 37	Urban and Services	
		Pistachio	Total					
From the environment	1. Total abstraction	851.282	851.282	33.205	688.240		18.472	902.959
	1.a. Abstraction for own use	851.282	851.282	33.205			18.472	
	1.b. Abstraction for distribution	0.000	0.000	0.000	688.240			
	1.i. From inland water resources:	851.282	851.282	33.205	688.240		18.472	902.959
	1.i.1. Surface water	29.605	29.605	0.000			0.000	
	1.i.2. Groundwater	817.944	817.944	33.205	688.240		18.472	869.622
	1.i.3. Soil water	3.733	3.733	0.000				
Within the economy	2. Use of water received from other economic units	0.000	0.000	0.000			0.000	
	2.a. Reused water		0.000				0.000	
	2.b. Wastewater to sewerage		0.000				0.000	
3. Total use of water (= 1 + 2)	851.282	851.282	33.205	688.240	0.000	18.472	902.959	

Table A2
Physical supply table (MCM) in the Rafsanjan study area based on the 2006 data set.

	Industries (by ISIC category)							Total
		Agriculture		Industrial and Mining	ISIC 36	ISIC 37	Urban and Services	
		Pistachio	Total					
Within the economy	4. Supply of water to other economic units	0.000	0.000	0.000			0.000	
	4.a. Reused water						0.000	
	4.b. Wastewater to sewerage						0.000	
Into the environment	5. Total returns (= 5.a + 5.b)	255.385	255.385	20.204	161.207		14.446	
	5.a. To inland water resources	255.385	255.385	20.204	161.207		14.446	
	5.a.1. Surface water	0.000	0.000	0.000	1.410		1.351	
	5.a.2. Groundwater	255.385	255.385	20.204	159.797		13.095	
	5.a.3. Soil water	0.000	0.000	0.000			0.000	
	5.b. To other sources (e.g., sea water)	0.000	0.000	0.000			0.000	
6. Total supply of water (= 4 + 5)	255.385	255.385	20.204	161.207	0.000	14.446	0.000	
7. Water consumption (= 3–6)	595.897	595.897	13.001	527.033	0.000	4.027	902.959	

*ISIC: The International Standard Industrial Classification of All Economic Activities.
*ISIC division 36: water collection, treatment and supply.
*ISIC division 37: sewerage.

Table A3
Hybrid supply table in the Rafsanjan study area based on the 2006 data set.

	Output of industries (by ISIC category)						Total output
	Agriculture		Industrial and Mining	ISIC 36	ISIC 37	Urban and Services	
	Pistachio	Total					
1. Total output and supply (million IRR)	3815890.305	3815890.305	3753981.000			2553338.869	
1.a. Natural water							
1.b. Sewerage services							
2. Total supply of water (MCM)	255.385	255.385	20.204	161.207		14.446	
2.a. Supply of water to other economic units of which: 2.a.1. Wastewater to sewerage other economic units	0.000	0.000	0.000	0.000		0.000	
2.b. Total returns	255.385	255.385	20.204	161.207		14.446	

Table A4
Hybrid use table in the Rafsanjan study area based on the 2006 data set.

	Intermediate consumption of industries (by ISIC category)						Total industry
	Agriculture		Industrial and Mining	ISIC 36	ISIC 37	Urban and Services	
	Pistachio	Total					
1. Total intermediate consumption and use (million IRR)	2842562.347	2842562.347	2796444.392			1902052.824	
1.a. Natural water							
1.b. Sewerage services							
3. Total use of water (MCM)	851.282	851.282	33.205	688.240		18.472	
3.a. Total abstraction	851.282	851.282	33.205	688.240		18.472	
3.a.1. Abstraction for own use							
3.b. Use of water received from other economic units	0.000	0.000	0.000	0.000		0.000	

Table A5
Asset account table (MCM) in the Rafsanjan study area based on the 2006 data set.

	Surface water		Groundwater	Soil water	Total
	Artificial reservoirs	Rivers			
1. Opening stocks	5.154		15,960	0	15965.154
Increases in stocks					1909.234
2. Returns		1.351	288.683	0.000	290.034
3. Precipitation					1537.700
4. Inflows					81.500
4.a. From upstream territories		41	40.5		81.500
4.b. From other resources in the territory					0.000
Decreases in stocks					2191.859
5. Abstraction	29.605		869.622	3.733	902.959
6. Evaporation/actual evapotranspiration					1271.000
7. Outflows					17.900
7.a. To downstream territories	17.9				17.900
7.b. To the sea					
7.c. To other resources in the territory					
8. Other changes in volume					−282.625
9. Closing stocks	0.000				15682.529

Table A6
Supplementary information to the water accounts: Social table in the Rafsanjan study area based on the 2006 data set.

	Industries (by ISIC category)			Total
	Agriculture	Industrial and Mining	Urban and Services	
1. Total use of water (MCM)	851.282	33.205	18.472	902.959
2. Total supply of water (MCM)	255.385	20.204	14.446	290.034
3. Population				295,175
3.a. Urban Population				175,372
3.b. Population				119,803
4. Population > =10 year				243,488
4.a. Active Population				106,790
4.b. Employed Population				96,628
4.c. Unemployed Population				10,162
4.d. Inactive Population				134,637
3. Employment	28,542	17,328	48,519	94,389
5. Income (million IRR)	3815890.305	3,753,981	2553338.869	10123210.18

Table A7
Physical use table (MCM) in the Rafsanjan study area based on the 2001 data set.

	Industries (by ISIC category)							Total
		Agriculture		Industrial and Mining	ISIC 36	ISIC 37	Urban and Services	
		Pistachio	Total					
From the environment	1. Total abstraction	841.978	841.978	35.647	737.4		11.4	889.025
	1.a. Abstraction for own use	841.978	841.978	35.647			11.4	
	1.b. Abstraction for distribution	0.000	0.000	0.000	737.4			
	1.i. From inland water resources:	841.978	841.978	35.647	737.4		11.4	889.025
	1.i.1. Surface water	9.571	9.571	0.329	0.1		0.044	9.944
	1.i.2. Groundwater	830.018	830.018	35.318	737.4		11.356	876.692
	1.i.3. Soil water	2.389	2.389	0.000				2.389
Within the economy	2. Use of water received from other economic units	0.000	0.000	0.000			0.000	
	2.a. Reused water		0.000				0.000	
	2.b. Wastewater to sewerage		0.000				0.000	
3. Total use of water (=1 + 2)	841.978	841.978	35.647	737.4	0.000	11.4	889.025	

Table A8
Physical supply table (MCM) in the Rafsanjan study area based on the 2001 data set.

	Industries (by ISIC category)							Total
		Agriculture		Industrial and Mining	ISIC 36	ISIC 37	Urban and Services	
		Pistachio	Total					
Within the economy	4. Supply of water to other economic units	0.000	0.000	0.000			0.000	
	4.a. Reused water						0.000	
	4.b. Wastewater to sewerage						0.000	
Into the environment	5. Total returns (=5.a + 5.b)	252.593	252.593	21.652	237.358		9.108	
	5.a. To inland water resources	252.593	252.593	21.652	237.358		9.108	
	5.a.1. Surface water	0.000	0.000	0.006	1.515		1.358	
	5.a.2. Groundwater	252.593	252.593	21.646	235.844		7.75	
	5.a.3. Soil water	0.000	0.000	0.000			0.000	
	5.b. To other sources (e.g., sea water)	0.000	0.000	0.000			0.000	
6. Total supply of water (=4 + 5)	252.593	252.593	21.652	237.358	0.000	9.108	0.000	
7. Water consumption (=3–6)	589.358	589.358	13.995	500.042	0.000	2.292	889.025	

Table A9
Hybrid supply table in the Rafsanjan study area based on the 2001 data set.

	Output of industries (by ISIC category)						Total output
	Agriculture		Industrial and Mining	ISIC 36	ISIC 37	Urban and Services	
	Pistachio	Total					
1. Total output and supply (million IRR)	1376453.048	1376453.048	1354121.365			921030.425	
1.a. Natural water							
1.b. Sewerage services							
2. Total supply of water (MCM)	252.593	252.593	21.652	237.358		9.108	
2.a. Supply of water to other economic units of which: 2.a.1. Wastewater to sewerage other economic units	0.000	0.000	0.000	0.000		0.000	
2.b. Total returns	252.593	252.593	21.652	237.358		9.108	

Table A10
Hybrid use table in the Rafsanjan study area based on the 2001 data set.

	Intermediate consumption of industries (by ISIC category)						Total industry
	Agriculture		Industrial and Mining	ISIC 36	ISIC 37	Urban and Services	
	Pistachio	Total					
1. Total intermediate consumption and use (million IRR)	1025357.988	1025357.988	1008722.500			686101.066	
1.a. Natural water							
1.b. Sewerage services							
3. Total use of water (MCM)	841.978	841.978	35.647	737.4		11.4	
3.a. Total abstraction	841.978	841.978	35.647	737.4		11.4	
3.a.1. Abstraction for own use							
3.b. Use of water received from other economic units	0.000	0.000	0.000	0.000		0.000	

Table A11
Asset account table (MCM) in the Rafsanjan study area based on the 2001 data set.

	Surface water		Groundwater	Soil water	Total
	Artificial reservoirs	Rivers			
1. Opening stocks	5.58			0	
Increases in stocks					1638.303
2. Returns		1.364	261.939	0.000	263.303
3. Precipitation					1354
4. Inflows					21
4.a. From upstream territories		3	18		21
4.b. From other resources in the territory					0.000
Decreases in stocks					1925.696
5. Abstraction	9.944		876.692	2.389	889.025
6. Evaporation/actual evapotranspiration					1067
7. Outflows					3
7.a. To downstream territories	1		2		3
7.b. To the sea					
7.c. To other resources in the territory					
8. Other changes in volume					−300.672
9. Closing stocks	0.000				

Table A12
Supplementary information to the water accounts: Social table in the Rafsanjan study area based on the 2001 data set.

	Industries (by ISIC category)			Total
	Agriculture	Industrial and Mining	Urban and Services	
1. Total use of water (MCM)	841.978	35.647	11.4	889.025
2. Total supply of water (MCM)	252.593	21.652	9.108	283.354
3. Population				197,623
3.a. Urban Population				148,973
3.b. Population				48,650
4. Population > =10 year				163,018
4.a. Active Population				71,497
4.b. Employed Population				64,693
4.c. Unemployed Population				6804
4.d. Inactive Population				90,141
3. Employment	19,109	11,601	32,484	63,194
5. Income (million IRR)	1376453.048	1354121.365	921030.425	3651604.838

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