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Comparative analysis of agricultural water pricing between Azarbaijan Provinces in Iran and the state of California in the US: a hydro-economic approach

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1 **Comparative analysis of agricultural water pricing between**  
2 **Azarbaijan Provinces in Iran and the state of California in the US:**  
3 **A hydro-economic approach**

4  
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6 Razavi<sup>4</sup>

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8  
9  
10 **Abstract**  
11

12 Iranian water authority has recently announced that one of the effective ways to avoid unprecedented high  
13 water consumption in Iran's agriculture sector is to increase water price. This paper analyzes the feasibility  
14 of this policy by using a hydro-economic approach with the aim to consider the role of water pricing in  
15 agricultural water management. Such an analysis was conducted through comparing price of water  
16 consumed for producing selected agricultural crops (i.e. wheat, sugar beets, onion, tomato, barley, potato,  
17 corn, alfalfa hay and watermelon) in a case study on two provinces (East Azarbaijan and West Azarbaijan)  
18 in Iran to that in the state of California (CA) in the USA. According to the paper, the method uses the  
19 Purchasing Power Parity (PPP) Index for the first time to analyze the water prices of agricultural crops in  
20 the case study due to the specific regional circumstances in the Case Study (i.e. severe fluctuations and  
21 continuously changing currency) that prevent using the norm of Nominal Exchange Rate Index (NERI).  
22 The results show there is no significant difference between the water price for producing the selected crops  
23 in West Azarbaijan (W.AZ) and East Azarbaijan (E.AZ) provinces and that in the state of California if PPP  
24 Index is applied. Water price for producing each kilogram of some crops such as wheat, sugar beet, onion  
25 and watermelon (except potato and barley) is estimated to be between 60 to 80 percent of that in the state  
26 of California. However, this ratio is ironically equal to 116% for alfalfa hay and 105% for corn. As a result,

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27 considering the obtained results, one may realize that the whole problem can be hardly attributed to the low  
28 price of agricultural water in our case study and raising agricultural water price would never be effective  
29 for reducing water consumption in the studied area unless price adjustment accompanies developing  
30 necessary infrastructures. Unlike the views that advocate raising water prices, there are two distinct views:  
31 The first declares that agricultural water should be free of charge to the farmers because it returns to the  
32 hydrological cycle. The second view stipulates that instead of raising water prices in agriculture sector, the  
33 cost of water supply for agriculture should be reduced by new technologies. It is advised that before  
34 adjusting agricultural water price, institutional reforms are required based on the experiences of other  
35 countries and establishing local water distribution cooperatives.

36

37 **Key words:** Water pricing; Water policy reform; Sustainability; Purchasing Power Parity Index

## 38 **1. Introduction**

39

40 An excessive exploitation of Iran's aquifers besides unscrupulous management of groundwater resources  
41 through the recent decades have led to a severe water crisis in Iran (Zahedi, 2017; Yousefi et al. 2019).  
42 Inefficient agriculture arising from traditional trench irrigation has caused this sector consumes over 90%  
43 of total water demand in Iran while Iranians are currently using more than 70% of their renewable  
44 freshwater resources (Madani, 2014). On the one hand, Irresponsible management along with officials'  
45 passive motions withholds Iran of having efficient regional cooperative agricultural management  
46 institutions (Madani et al. 2016). However, an efficient machinery utilization, advanced irrigation  
47 strategies, water quality monitoring and a Suspended Sediment Load (SSL) estimation might lead to  
48 decrement of environmental impacts as well as a de-escalated water/energy consumption (Nabavi-  
49 Pelesaraei et al. 2019, Kaab et al. 2019, Shamshirband et al. 2019, Chen and Chau 2016). Regarding this  
50 fact that agriculture and environment are closely intertwined, increase in environmental awareness has  
51 increased significantly in Iran through the recent years to mitigate the adverse environmental impacts due  
52 to fast depletion of groundwater resources (Tahbaz, 2016). Indeed, due to low water price and subsidies in  
53 the agriculture sector, there is no incentive for farmers to constructively contribute towards water resources  
54 conservations. The current inefficient method of agriculture has intensified groundwater depletion and  
55 caused abrupt drops in groundwater tables (Nikouei and Ward, 2013).

56 Water pricing policies followed by a relevant decision making depends on a number of factors and varies  
57 in different countries. Improvements in agricultural productivity, in any country or region, promote officials  
58 to have large-scale investments on hydro-agricultural infrastructures (Brelle and Dressayre, 2014).  
59 Actually, water can be considered as a public, a private, a common-pool and a club good. These  
60 characteristics conclude that water cannot be a traditional marketable good and poor designing of markets  
61 can lead to poor allocations. On the other hand, if the unique characteristics of water uses are taken into  
62 account, certain aspects of water resources are matched by market processes (White, 2015). Statements

63 made by some of the authorities support the idea of providing bigger subsidies for agriculture, while the  
64 opposite decision makers focus on implementing full-cost charges for irrigation water at the farm level  
65 (Massarutto, 2015). In most of the developing countries, charges to users for irrigation generally fall well  
66 short of full cost and few countries are trying to set up rules conducting farmers to pay full operation and  
67 maintenance costs (Toan, 2016). A number of countries such as Iran still continue to subsidize water by  
68 government (Mombeini et al. 2015). One of the efficient policies to decrease water consumption is to  
69 consider an elevated water price as experienced in different countries. Evidently, effective management of  
70 agricultural water in water-scarce areas requires efficient approaches (Zhang et al. 2018). Undoubtedly,  
71 Water pricing can be a key for increasing productivity of irrigated agriculture (Wang et al. 2010). Indeed,  
72 motions to the real value of water can have twofold results. Firstly, farmers will be more aware of the  
73 economic importance of water and its scarcity. Secondly, it provides incentives to farmers for shifting  
74 towards a more productive cropping pattern (Li et al. 2019). Most of research works related to water pricing  
75 have dealt with raising water prices to real values and rejected full subsidies for irrigation (Tahamipour et  
76 al. 2014; Hek et al. 2018). However, institutional theory also gives a plan to researchers who investigate on  
77 the water pricing strategies based on institutional reform.

78 Although Shen et al. (2015) express that water is not regarded as an economic good, water pricing is a  
79 complex problem that intertwine with economic, policy, environmental and social factors. Economically,  
80 water price needs to provide all the expenses of supply related to withdrawal, transmission and distribution.  
81 Failure to do this can cause some problems in management, policy and social acceptance. For example, the  
82 water supply tariff in China before 1980s was lower than water supply cost, resulting in operation and  
83 maintenance problems and after that time when they tried to change the water tariffs they had a serious  
84 problem to regulate the new tariffs to the farmers' income because the additional costs and charges in the  
85 water tariff increased the farmers' burden. Finally, by specific arrangements, China decided to decrease the  
86 final costs of water supply instead of increase in charges. de Andrade Resende Filho et al. (2015) state that  
87 despite the fact that charges for water use in Brazil are low, representatives of the agricultural sector argue

88 that they should not be charged because between 28%<sup>1</sup> of water withdrawals for agriculture return to the  
89 hydrological cycle. Barraque and Montginoul (2015) explain that people with low income shall be  
90 considered by policymakers while tariff for water prices is determined. This group of people should be  
91 cared by the government so that one can find “water associative houses,” in which deprived people can get  
92 support for other needs and recover minimal dignity. Hernandez-Sancho et al. (2015) state two-part tariffs  
93 could be the solution in drought periods to attain an efficient water consumption. Fixed charges shall be  
94 known as the first part. Particularly, costs related to water reuse and fresh water supply can be classified  
95 into this part. Therefore, a structure for determination of fixed charges should be initially designed to ensure  
96 that all fixed costs are covered. Volumetric charges are the second part in tariffs that shall be added up to  
97 the fixed costs and met by consumers. Hence, the costs related to operation and maintenance activities,  
98 pumping infrastructures, and monitoring water quality (i.e. all volume-related costs) are categorized into  
99 this section. Montginoul et al. (2015) emphasizes that various components are engaged in calculation of  
100 irrigation costs. If most water users fail to pay the full price for any reason, other users with lower water  
101 consumption would have to incur charges, implying a degree of inefficiency and welfare losses for society  
102 at a large scale. It should be noted that presence of environmental and resources costs of water and failure  
103 to account for those costs can have impact on environmental sustainability (Bithas, 2011). In opposition,  
104 subsidies can be often harmful to the environment in terms of increasing wastes and emissions (OECD<sup>2</sup>,  
105 2005). These wasted materials are known as pollutants and they might cause an absolute reversed effect on  
106 water quality and health indicators of the downstream lands (Alizadeh et al. 2018). However, increasing  
107 irrigation prices is expected to reduce the use of pesticides and fertilizers by changing cropping patterns  
108 and irrigation methods as well as employing new technologies ending in reduction of the amount of  
109 irrigation (Bartolini et al. 2010 and Khanali et al. 2017). Consequently, the relationship between irrigation

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<sup>1</sup> There are two definitions for this issue: One- only water withdrawals to groundwater has been considered as the returned water ( $\approx 28\%$ ); two- The total amount of water coming back to hydrological cycle has been considered as returned water ( $\approx 90\%$ ).

<sup>2</sup> Organisation for Economic Co-operation and Development

110 prices, subsidies and environmental issues should be considered by decision makers even though the  
111 estimation of costs. Raising water prices based on considering environmental damage for water services  
112 leads to significant political challenges (OECD, 2012). In developing countries, institutional reforms in  
113 water pricing have been found more efficient rather than removing subsidies and introducing cost recovery.  
114 Meanwhile, in developed countries, such as South Korea and Australia, eco-environmental institutions  
115 retreat to subsidies in some cases effecting cost recoveries, even if most farmers accept to pay the full cost  
116 (Toan, 2016). Tardieu (2005) expresses that irrigation is often portrayed as a public good in developing  
117 countries, since it provides an incentive for the rural poor to stay in rural areas, thereby confining challenges  
118 arising from relocation to crowded urban spaces. Nearly absence of knowledge over public and private  
119 benefits from the perspective of water users in irrigation has escalated lack of transparency in the developing  
120 countries (Tang et al. 2013). Agrawal et al. (2000) confirm that full cost recovery for irrigation water  
121 includes three main components: supply cost, resource cost, and environmental cost (Figure, 1). Table 1  
122 illustrates the level of subsidy to the irrigation sector over the last two decades.

123

124 **Figure 1. General principles for cost of water (Agarwal et al. 2000)**

125 **Table 1. Cost components of charges in irrigation water sector of selected countries (Toan 2016)**

126 In addition, Henderson & Quandt (1985) have formerly presented a concept known as the law of demand  
127 in micro-economy. They argue that when other parameters in a micro-economic law are assumed to be  
128 fixed, price and demand follow an inversely proportional pattern. In Iran, following the law of demand in  
129 micro-economy, irrigation pricing adjustment and modernization of irrigation systems have been remarked  
130 in the sixth program of economic, social and cultural development plan as the most recently imparted  
131 national mid-term program for development. This shall be attributed to an intensified water consumption  
132 in agricultural sector and low price of irrigation water (World Food Program, 2017).

133

134 Figure 2 indicates the dominant strategy of Iranian decision makers based on the law of demand by  
135 assuming constant conditions.

136

137 **Figure 2: Dominant strategy of controlling water crises by Iranian decision makers (Tahamipour et al. 2014)**

138

139 Since hydro-economy has engaged in the topics related to water market and pricing, one would have to  
140 initially reply to this question that water belongs to which kind of goods. In particular, while water resources  
141 can be allocated for use in economic sectors, some issues such as careful design and strong legislation shall  
142 be inevitably considered to secure efficient and equitable outcomes. Again response to this question,  
143 whether water should be considered a private, a public, a club or a common good depends on the type of  
144 resources and the exploitation manners (White, 2015). Investigations on water pricing policy mainly focus  
145 on the subsidy payments and the parameters that should be considered in the calculation of water price. On  
146 the other hand, several recently published research works have concentrated on the positive impacts of  
147 water price increase on the environment.

148 In fact, the current paper aims to discuss the accuracy of this hypothesis saying that increase in water prices  
149 would be effective to reduce water consumption, considering concerns of policy-makers about the low price  
150 of available water to farmers in Iran. The policy of raising water prices to reduce water consumption has  
151 been also mentioned in Iran's sixth program of economic, social and cultural development plan as one of  
152 the most important ways to reduce water consumption. It should be noted that policy-makers in Iran would  
153 tend to increase water price by emphasizing the difference between water prices in Iran compared to the  
154 average price in the world based on NERI. Indeed, NERI is a common method to compare prices  
155 internationally (to exchange prices in to United States Dollar (USD (\$))). However, the main weakness of  
156 this approach is that local currency fluctuations can affect the estimated values of goods without affecting  
157 the production method. As an example, in Iran, NERI (local currency per USD (\$)) has increased from

158 50000 IRR<sup>1</sup> to 143600 IRR between April and September 2018. Therefore, during the time, the price of  
159 goods in Iran, including water has been decreased about 65% in terms of USD (\$) without considering  
160 effective factors on production (technology, etc.). To avoid this problem, Economists apply PPP index  
161 instead of NERI to calculate various economic indicators in different countries such as Gross Domestic  
162 Product (GDP), investment rate and prices level in terms of one currency (i.e. USD (\$)). In fact, PPP index  
163 indicates the real power of each currency to buy a specific unit of a product or basket of goods. In other  
164 words, this index illustrates the purchasing power of two different currencies depending on differences in  
165 the rate of inflation and the cost of living. For example, if the price of a Big Mac is 4.00 USD (\$) in the  
166 U.S. and 2.5 Pounds sterling in Britain, we would expect the exchange rate to be 1.60 ( $4/2.5 = 1.60$ ). If the  
167 exchange rate of dollars to pounds is any greater, the price of Big Mac would be overvalued in Pounds, and  
168 if it is any lower, then the Big Mac price would be undervalued.

169 Following the above explanation, it should be also notified that development of effective ideas with the  
170 competence of turning into an effective policy, studying all aspects of a decision and finally implementation  
171 of the policy are real challenges for developing countries. Iran, as a developing country, has always been  
172 involved in agricultural policy problems, specifically agricultural water pricing. That may be the underlying  
173 reason why the Iranian government emphasizes on finding rational methods of water saving and preventing  
174 overexploitation of resources using strict water pricing policies. On the other hand, governmental officials  
175 in Iran have consistently compared the water price in Iran with that in other countries based on Nominal  
176 Exchange Rate Index (NERI) without considering averaged income of farmers. Accordingly, they argue  
177 that agricultural water price in Iran is much lower than the average value in the world and hence, have  
178 intended to control agricultural water consumption with rising water prices in the "Sixth program of  
179 economic, social and cultural development plan". Therefore, among the main purposes of the current  
180 research work is to explore whether the allegations about impaired water pricing system in Iran are valid or

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<sup>1</sup> Unit of Iran's Currency: Iranian Rials.

181 not. In the line with this purpose, our group considered California State as a reference region in a developed  
182 country (USA) to compare agricultural water pricing policies in both countries. Referring to the open  
183 literature (Wichelns 2010), agricultural water pricing in the State of California is regulated based on  
184 cropping pattern types. It means that different crops have been indexed with their water consumption as  
185 well as their vitality for the region and are produced with dissimilar price of water. On the contrary, in West  
186 and East Azarbaijan provinces, agricultural water subsidies have been allocated to almost all crops  
187 (Statistical Yearbook of West Azarbaijan and East Azarbaijan provinces 2015), causing many policy  
188 makers in Iran believe that agricultural water subsidies are the main reasons behind low water efficiency in  
189 the case study.

190 As a result, the current research work tries to have a fundamental view by answering the following  
191 questions; firstly, is the water price in Iran lower than its real value? Secondly, if the answer to the first  
192 question is positive, how much increase in the price of agricultural water would be effective to control the  
193 water crisis?

194 In summary, This study focuses on the above questions by analyzing the water price of the selected crops  
195 in the Case Study of West Azarbaijan and East Azarbaijan provinces in Iran compared to water price of the  
196 same crops in the state of California to specify agricultural water price using PPP index.

197

## 198 **2. Materials and Methods**

199

200 The main purpose of the present study is to find a proper reply to this question; whether water price has  
201 been disregarded in producing major agricultural crops or not? In order to have a precise analysis on the  
202 above issue, one requires to take note of the following process to calculate price of water consumed for  
203 producing agricultural crops.

204 The initial step is to calculate the price of one cubic meter water used for producing major agricultural  
205 crops in the Case Study (W.AZ and E.AZ provinces), and as the second step the above value should be  
206 compared to the one cubic meter water used for the same crop in the comparing region.

207 Regarding inaccessibility of required information for evaluating the price of water used to produce per  
208 unit weight of agricultural crops in Iran, Virtual Water Content (VWC) should be utilized in order to  
209 calculate this factor. To complete the second step, it is also necessary to explain that water price in the  
210 state of California in the US.

211 Water scarcity in the state of California has caused many rivers, streams and aquifers to dry up. The  
212 landowners in these formerly naturally irrigated areas are currently forced to pay exorbitant prices to get  
213 water. The regional authorities of California takes water away from these districts to satisfy regional water  
214 demands regardless if it is fair at a local level in the views of these landowners (MacDonald, 2014). In other  
215 words, both districts have encountered similar problems in various areas such as drought, wide divergence  
216 between the actual cost of water and the water price which is currently paid and finally unclear policies in  
217 agricultural sector having ended in major problems in both regions (MacDonald, 2014).

### 218 **2.1. Step 1: Water price calculation in Iran**

219 The price of water consumed for producing one kilogram of each crop in IRR ( $C_{wi(Kg)}$ ) would be calculated  
220 using the statistical information related to the water cost per one hectare of agricultural crops in IRR ( $C_{wi(H)}$ )  
221 as well as crops productivity in one Kilogram per one hectare ( $X_{i(H)}$ ) considering the information  
222 available in Momeni et al. (2019) as:

$$C_{wi(Kg)} = \frac{C_{wi(H)} \frac{IRR}{Hectar}}{X_{i(H)} \frac{Kg}{Hectar}} = \frac{IRR}{Kg} \quad (1)$$

223

224 If the cost of water to produce a kilogram of crop  $i$  in Kilogram ( $C_{wi(Kg)}$ ) is equal to the multiplication of  
225 the amount of water consumed for producing a kilogram of crop  $i$  in cubic meter ( $Q_{wi}$ ) to the price of one

226 cubic meter of water ( $P_{wi}$ ), then, the following formula (Eq. 2) would be used to calculate the price of each  
227 cubic meter of water consumed for production of one kilogram crop  $i$ .

$$P_{wi} = \frac{C_{wi(kg)}}{Q_{wi}} \quad (2)$$

228  
229 Referring to inaccurate evaluations about the volume of water consumed for producing one kilogram of  
230 each crop, Virtual Water Content ( $VWC_i$ ) can be appreciated as a reliable parameter to express the amount  
231 of consumed water for producing a kilogram of a crop. It would be possible, therefore, to calculate water  
232 price per each kilogram of each mentioned crop considering the information available in Momeni et al.  
233 (2019) as:

$$\text{If: } Q_{wi} = VWC_i \rightarrow P_{wi} = \frac{C_{wi(kg)}}{VWC_i} \quad (3)$$

234  
235 As a result, one calculates price of water used for producing a kilogram of a crop in IRR per cubic meter.  
236 It seems that the above-mentioned method offers more advantages rather than the model only relying on  
237 water requirement of each crop and can be cited as a reliable approach to estimate the real price of water.  
238 In fact, Momeni et al. (2019) have remarked that the amount of water consumed for producing agricultural  
239 crops is more than the evaluated water requirement of each crop and it is more likely that an overestimation  
240 has stuck on calculated water price based on crops' water requirements.

## 241 **2.2. Step 2: Calculation of Water Price Comparative Index**

242 Now that the water price has been calculated for selected major crops, it is necessary to set criteria to  
243 analyze the valuation method. It should be notified that an agricultural water price in California has been  
244 considered as a basic criterion for water valuation in Iran, regarding the relevant similarities of the present  
245 Case Study (W.AZ and E.AZ provinces) to the state of California.

246 In order to present a reliable comparison of the above regions, it is inevitably required to convert the water  
 247 price of same agricultural crops in USA and Iran to a common unit. For this purpose, Nominal Exchange  
 248 Rate Index (Local Currency Unit (LCU) per USD (\$), period average) is usually applied. Based on the  
 249 present statistical data from World Bank in 2014, Exchange Rate was equal to 25,941 IRR; In other words,  
 250 One USD (\$) was equal to 25,941 IRR<sup>1</sup>. Hence, water price for crop *i* can be calculated using the following  
 251 equation (Eq. 4):

$$\dot{P}_{Wi(USD)} = \frac{P_{wi(IRR)}}{ExR} \quad (4)$$

253  
 254 Dividing USD (\$) price of water consumed for production of crop *i* in the Case Study, by the water price  
 255 of similar crops in the state of California gives  $\alpha_i$  that can be obtained through Eq. 5.

$$\alpha_i = \frac{(\dot{P}_{wi(USD)})_{WEAZP \text{ West Azarbaijan and East Azarbaijan provinces}}}{(P_{wi(USD)})_{CA}} \quad (5)$$

256  
 257 If  $\alpha_i > 1$ , the Case Study's water price for producing crop *i* is more than that in California for a similar  
 258 crop; or if  $\alpha_i < 1$ , this value is naturally lower in our case of study region.

259 Indeed, the NERI plays a key role in this analysis, and it should be taken into account that the Exchange  
 260 Rate in Iran is almost set based on imperative policies dictated by governments. Therefore, the above  
 261 method is likely to generate inaccurate results considering effects of fluctuations. By the aim to avoid  
 262 imprecisions, PPP Index is applied to minimize the estimated errors and unify the price of water in the Case  
 263 Study and the state of California. Purchasing Power Parity (PPP) is an economic index which is used to  
 264 determine the value of national currency in different countries through a basket of goods. PPP is a price  
 265 relative, showing the ratio of the prices in national currencies of the same good or service in different

---

<sup>1</sup> In early 2018, Iranian Rials has devalued and Each USD (\$) is exchanged to 143600 IRR in the free market.

266 countries (Schreyer and Koechlin, 2002). PPP conversion factor is the number of units of a country's  
 267 currency required to buy the same amounts of goods and services in the domestic market as USD (\$) would  
 268 buy in the United States (World Bank, 2015). In other words, the equality of purchasing power between the  
 269 (A) and (B) countries is the number of national currency units of country (A), whose value is as much as  
 270 the purchasing power of a national currency of country (B). Accordingly, PPP can be calculated from the  
 271 following equation:

$$PPP_{B,A} = \frac{P_A^i}{P_B^i} \quad (6)$$

272  
 273 where  $P_A^i$  is the price of goods or basket of goods (i) for national currency of country (A) and  $P_B^i$  is the  
 274 price of goods or basket of goods (i) for national currency of country (B). PPP can provide international  
 275 comparisons as an exchange rate or a conversion factor in terms of a common currency by converting the  
 276 value of different economic indicators (Schreyer and Koechlin, 2002).

277 So the equation 7 can be reformed as follows:

$$\dot{P}_{Wi(USD)} = \frac{P_{wi(IRR)}}{PPP} \quad (7)$$

278  
 279 According to the present statistical data from World Bank (2015), one USD (\$) was found to be equal to  
 280 7364 IRR when the exact value of exchange rate was calculated based on PPP. Imagine, a service costs 1  
 281 USD (\$) in the United States. This service should cost 7364 IRR based on the PPP index in Iran, while  
 282 the actual price of the service is around 0.284 USD (\$) in Iran. In fact, when it comes to analysis based on  
 283 the PPP index, price of a basket of goods and services is no more equal to the exchange rate.

284 Finally, equation 8 can be obtained from conflation of equations 5 and 7 as follows:

$$\alpha_i = \frac{(\dot{P}_{wi(USD)})_{WEAZP}}{(P_{wi(USD)})_{CA}} \quad (8)$$

285 As formerly mentioned,  $\hat{\alpha}_i$  presents all features related to  $\alpha_i$ .

286

287

288

### 289 **3. Case Study**

290

#### 291 **3.1. East Azarbaijan and West Azarbaijan Provinces**

292 East Azarbaijan (E.AZ) and West Azarbaijan (W.AZ) provinces are located in the north-west of Iran and  
293 surrounded by Kordestan and Zanjan provinces from the south, Turkey and Iraq from the west and Armenia,  
294 Republic of Azerbaijan, and Nakhchivan autonomous republic from the north side of the limited area  
295 (Figure 3). The area of the Case Study is about 82,550 km<sup>2</sup> with an elevation between 140 and 4,151 meters  
296 above mean sea level (AMSL). The mean annual temperature of the Case Study is about 16 C°. The average  
297 annual precipitation amount in this region (358 mm) is higher than the average value in Iran (250 mm).  
298 Moreover, neighboring regions have close identical climatic characteristics with the Case Study such as  
299 Van province (in Turkey with 386 mm), Nakhchivan autonomous republic (280 mm) and Ardabil province  
300 (335 mm). The study area shares parts of four drainage basins including Aras, Urmia Lake, Sefid rood and  
301 West border. The areas of these shared drainage basins are given in Table 2.

302

303 **Figure 3: Location of the Studied-Area**

304

305 **Table 2: Areas of all drainage basins in the studied-area**

306

307 Based on Table 2 and Figure 4, Lake Urmia Basin covered most of the current studied area. According to  
308 the sustainable development index of The United Nations Educational, Scientific and Cultural Organization  
309 (UNESCO) for water resources, this basin is belonged to the high risk category (40% <). Figure 4 shows

310 the location of all basins in the studied area. The total amount of water consumption in the studied area is  
311 approximately 10.91 Billion Cubic Meters (BCM). The estimations indicate the total amount of water  
312 consumption in agriculture sector is approximately 10.02 BCM (91.8%), while 712 Million Cubic Meters  
313 (MCM) (6.5 %) is consumed for health and domestic sectors and 184 MCM (1.7 %) is consumed for  
314 industrial uses. Out of the total water used in agriculture, 9.52 BCM is used for a number of selected crops  
315 including wheat, sugar beets, onion, tomato, barley, potato, corn, alfalfa hay and watermelon , which are  
316 analyzed in this study.

317

318 **Figure 4: Location of all basins in the Case Study**

319

### 320 **3.2. California as a comparing region**

321 The state of California is located in the Pacific Region of the United States of America. This area has settled  
322 in the south west of USA stretching from the Mexican border along the Pacific Ocean and occupying third  
323 place in terms of states' land areas with 423,970 km<sup>2</sup>. Its terrain includes cliff-lined beaches, redwood  
324 forest, the Sierra Nevada Mountains, Central Valley farmland and the Mojave Desert. California's climate  
325 varies widely, from arid to humid, depending on latitude, elevation, and proximity to the coast. The State  
326 is surrounded by the state of Oregon from the north, the state of Nevada from the East and Mexico From  
327 the south while having a direct access to the Pacific Ocean from the West. The State expands from 114° 08'  
328 (W) to 124° 24' (W) and 32° 30' (N) to 42° 00' (N) with the elevation of -85 to 4421 meters above mean  
329 sea level (AMSL). The mean annual temperature of the State is about 16 C° and the average annual  
330 precipitation amount is approximately 544 mm (Figure 5). The reason for selecting the state of California  
331 for comparing to W.AZ and E.AZ provinces was the identical risks threatening both regions in terms of the  
332 water crisis.

333 According to the current drought years in California, a big fraction of the essential storage source and  
334 reserves of California's water system was consumed to deliver enough water to the state. As water in

335 California becomes less abundant, or less available due to competing demands, the water use by irrigated  
336 crops would need to be balanced against the economic and nutritive benefits of those crops (Fulton et al.  
337 2018). A 2011 study indicated that the Central Valley Aquifer is losing an amount of water each year  
338 equivalent to nearly 29 million acre-feet of water found in Lake Mead, the nation's largest surface reservoir  
339 on the Colorado River (Dimick 2015).

340 To make a clear view for both regions, table 3 illustrates the areas of planting crops as well as crop yield of  
341 each region for all selected crops in W.AZ and E.AZ provinces and the state of California.

342

343 **Table 3: Areas of planting crops and the crop yield of selected crops in W.AZ and E.AZ provinces and the**  
344 **state of California**

345 **Figure 5: Location of comparing region (the state of California)**

346

#### 347 **4. Results**

348

349 Referring to the explanations of the previous section, price of water consumed for production of each  
350 agricultural crop -within the Case Study region- should be estimated. Table 4 demonstrates estimations  
351 related to the price of one cubic meter water used in production of selected crops in W.AZ and E.AZ  
352 provinces:

353

354

355 **Table 4: Estimated price of one cubic meter water used in producing selected agricultural crops in E.AZ and**  
356 **W.AZ provinces (IRR).**

357

358 As the next action, it is required to convert the currency of Iran (IRR) to USD (\$) for comparing the price  
359 of one cubic meter water in both regions. The Exchange Rate proportion in the year 2014 (IRR vs. USD  
360 (\$)) has been utilized for this purpose. Table 5 indicates this issue, as follows:

361

362 **Table 5: Comparing the price of one cubic meter water used in producing selected agricultural crops in**  
363 **W.AZ and E.AZ provinces to that in the state of California by converting IRR to USD (\$)**

364

365 As it is perceived,  $\alpha$  index has been calculated to be lower than 1 for all of the selected crops. Moreover,  
366 one can find out that the price of water used for producing the selected crops in the Case Study is lower  
367 than that in the state of California, whereas the results would be different using Purchasing Power Parity  
368 (PPP) Index.

369

370 **Table 6: Estimation of the price of one cubic meter water used for producing selected crops using Purchasing**  
371 **Power Parity (PPP) based on USD (\$)**

372

373 According to the results presented by Table 6,  $\alpha$  index is lower than 1, nearly for all of the selected crops  
374 except alfalfa hay and Corn. In other words, the price of water used for producing most of the selected crops  
375 in the Case Study is lower than that in the similar regional condition, the state of California.

376 It needs to be mentioned that price of water consumed for producing some crops such as Wheat, Sugar beet,  
377 Onion and Watermelon, in the Case Study, is estimated to be between 60 to 80 percent of water price in the  
378 state of California while a significant difference was only observed on potato and barley.

379 Therefore, in response to this question; whether water price for producing specific agricultural products in  
380 W.AZ and E.AZ provinces are lower than that of analogous crops in California or not, one might notice  
381 that water price for nearly 22% of the studied crops in the Case Study was found to be higher. In 44% of  
382 the crops, water price in the Case Study was estimated to be between 60 to 80 percent of the cost in the

383 comparing region. Contrary to the public perception, the water price for producing only 33% of the studied  
384 crops in the Case Study was found to be lower than a similar case of study. As a result of the above  
385 explanation, it is a doubtful statement saying that low price of water in W.AZ and E.AZ provinces (even  
386 Iran) is the sole underlying reason behind the current water crisis.

387 In line with the above analysis, it should also be recognized whether price adjustment contributed to  
388 avoiding dire consequences of the impending water crisis or could at least ease the effects. As a response  
389 to this question, one might declare that based on techniques of Institutionalism, adjustment or water price  
390 manipulation could be the final legislative phase and before that, necessary institutional reforms are  
391 required (Stiglitz, 2002). Indeed, success or failure of the price adjustment policy of water input in Iran  
392 depends on the success of the state in preparing the above-mentioned platforms.

393 It needs to be noted that, some countries are trying to increase their irrigation efficiency by planning on  
394 supportive policies and pricing the real value of water in their agriculture sector. As it is obvious, agriculture  
395 sector in many countries is the most important demander of water input and clearly, supportive policies can  
396 axiomatically be considered as the first step to face water crisis. In other words, it is expected that a specific  
397 framework should be provided to control the water resources crisis through price adjustment strategies and  
398 empowering the agriculture sector through setting supportive policies. Table 7 indicates important  
399 supportive policies for agriculture sector in some countries.

400

401 **Table 7: Supportive policies for agriculture sector as the main demander of water in some countries (Allen**  
402 **2016)**

403

404 Agriculture sector demands the biggest share of water resources by consuming over 90 percent of annual  
405 volume of water extraction (Banouei et al. 2015). Therefore, it seems that setting supportive policies in this  
406 sector has a high importance in the course of confronting and controlling water crisis. In this context, some  
407 of the supportive policies such as varied insurances for farmers, tax exemptions and guaranteed prices could

408 be mentioned. Probably, due to specific reasons such as the differences in the details of these policies and  
409 applied performance procedure, the level of achieving desired goals in Iran was different to other countries.

410

## 411 **5. Conclusions**

412

413 Results of the study represented that level of the water price for each kilogram of the mentioned agricultural  
414 crops in W.AZ and E.AZ provinces is not significantly different from the same crops in the state of  
415 California. Therefore, it seems that a hypothesis saying that "water price in Iran is far less than the rest of  
416 the world" has stemmed from a comparison between water prices in Iran with the international level of  
417 costs based on the NERI. Indeed, if PPP index was involved in the policy analysis -as a valid index to  
418 compare the level of water prices in different countries- instead of NERI, the results of the studies would  
419 be different.

420 Based on a microeconomic analysis, although, an increase in the price of goods is expected to reduce  
421 demands for it, water is naturally a different substance on which people's lives essentially depend on.  
422 Considering several economic theories, demands for essential goods like water are categorized into the  
423 class of inelastic or relatively inelastic demands. Such kinds of demands can be barely affected by price  
424 adjustment policies as usage of these goods is of such importance to consumers, that it would not be easy  
425 to reduce their consumption or replace them by other goods after raising prices. Likewise, as a basic  
426 intermediate input, water shall be consumed in the process of manufacturing several principal products and  
427 any increases in the price of water may lead to impose elevated costs to consumers in agriculture sector.  
428 Hence, it is not easy to argue that the price adjustment could work successfully as the main strategy to  
429 reduce water demand and cope with the water crisis in Iran.

430 In this regard, four levels of social analysis have been elucidated by Williamson (2000) considering  
431 analytical framework of Institutionalism. Quote to his explanation; while "culture" as the first level and the  
432 most significant part develops its components, and the second level affairs such as legal bases, institutions

433 and infrastructures are well-regulated and finally management, implementation and oversight in the third  
434 level act more desirable, one can expect that the desired achievements categorized into the fourth level are  
435 appeared. Therefore, in water pricing issue, any administrative policy-making requires to have harmony  
436 with the culture of people who are the main targets of the policy. This would definitely result in achieving  
437 public acceptance in the target community. Secondly, legal requirements (for guarantee) as well as  
438 infrastructural requirements (for fulfillment) must be provided in the target society. Overall, before  
439 considering water as a type of goods such as common good, public good, private good, and club good, it is  
440 necessary to set a collection of institutional infrastructures as well as prerequisites that create public  
441 acceptance of the policy adopted through the use of public education programs for the development and  
442 modification of water use patterns. Following this policy, we can anticipate that the mentioned institutions  
443 would enable making effective decisions for an optimum pattern of water consumption and its types of  
444 good for different consumptions. That entails considering varied supportive facilities and promotions to  
445 public users, more importantly in agriculture sector. The logic behind such a policy is to let policy-makers  
446 control consumers' behavior and gain their companionship with subsequent price reforms.

447 In addition, the studies on the price of water consumed for producing selected agricultural crops in the state  
448 of California indicated that water pricing process followed a programmatic approach in this state.

449 Alfalfa hay and corn, for instance, were excluded from this compatibility as both were undeniably  
450 recognized major food requirements in the US. Regarding Environmental Working Group (EWG) (2016)  
451 information, during only the year 2016, over 13 million USD (\$) have been paid to local farmers in  
452 California for corn subsidies. Moreover, Fox (2015) argues that importance of Dairies, in the state, forces  
453 policymakers to keep the price of irrigation at a low level in California. What should be taken into account  
454 is that the ultimate price of alfalfa hay provision –as the primary source of livestock food-is critical to Dairy  
455 industries distressing the cost of related products. Therefore due to the importance of dairy supplies in the  
456 health sector and considering this fact that both alfalfa hay and corn are vastly utilized as intermediate  
457 inputs in the production chain of other commodities, subsidies shall be inevitably enforced.

458 Referring to the results mentioned in the paper, However, referring to Table 6, one might easily construe  
459 that there is no highlighted discrepancy between the total agricultural water price in the case study and  
460 comparing region using USD (\$) equivalent prices based on Purchasing Power Parity (PPP) index.  
461 Moreover, taking advantages of PPP index instead of NERI revealed this fact that agricultural water prices  
462 in California for corn and alfalfa hay are slightly lower than that in our Case Study. As a result, one might  
463 suggest that increasing agricultural water prices can hardly be an ideal solution and its only effect is  
464 escalating farmers' living costs instead of an efficient water price adjustment.

465 As stated by Stiglitz (2002), based on the techniques of Institutionalism, adjustment or water price  
466 manipulation could be the final legislative phase and before that, necessary institutional reforms are  
467 required. Therefore, Iranian interdisciplinary researchers working in the field of "Environmental Economy"  
468 believe that price manipulation would render insignificant effects on agricultural water consumption as long  
469 as Iranian officials evade institutional reforms in agriculture sector. In particular, there are a number of  
470 essential measures that have to be taken by the authorities; such as planning to allocate water subsidies to  
471 only strategic crops, promoting farmers to change their cultivation patterns based on the regional limitations  
472 and providing appropriate infrastructures for farming. Hence, based on findings of the present paper,  
473 implementation of the "Sixth Development Plan" might to some extent ease the problems of agriculture  
474 sector in our case of study but there are still essential details that have to take into account for guaranteeing  
475 the success of a decision or policy.

476  
477 The current paper would present following suggestions as future plans to confront the impending water  
478 crisis:

- 479 1. It is necessary to investigate the issue of water crisis in a rational space considering all aspects such  
480 as the nature and vital features of water. This is a key to avoid any premature decision making.
- 481 2. Success of the policies relating to water consumption patterns depends on providing adequate  
482 infrastructures that enable consumers to accept optimal profiles and follow relative instructions. In

483 line with the above purpose, significant measures shall be taken such as culture making and public  
484 education, providing supportive financial facilities to farmers, crop insurance premiums in  
485 catastrophic situations, facilitating farmers to gain access to modern technologies, improving water  
486 distribution systems, providing funds to support research activities, discovering novel methods of  
487 cultivation /irrigation and adopting supportive policies to promote planting suitable and eco-  
488 friendly agricultural crops.

489 Limited access to accurate, reliable and updated statistical sources was one of the serious problems of the  
490 present research work. Specifically, finding annual reports with an overlapped area of information for the  
491 case study and the comparing region as well as making the comparison based on correlated information and  
492 row data for both regions were genuine challenges in the process of this research. For future works, the  
493 authors would suggest studying prerequisites of an effective policy making such as necessary measures that  
494 shall be taken before putting a decision into practice. Some infrastructures are also required prior to  
495 implementing price adjustment. In addition, costs and benefits of the above proceedings should be evaluated  
496 as real matters of concern.

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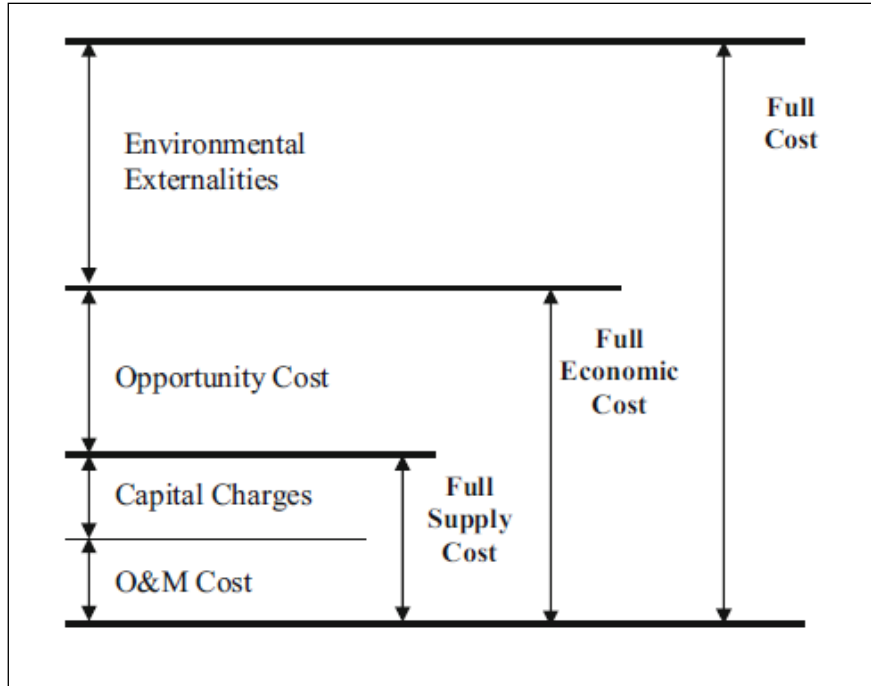


Figure 1. General principles for cost of water (Agarwal et al. 2000)

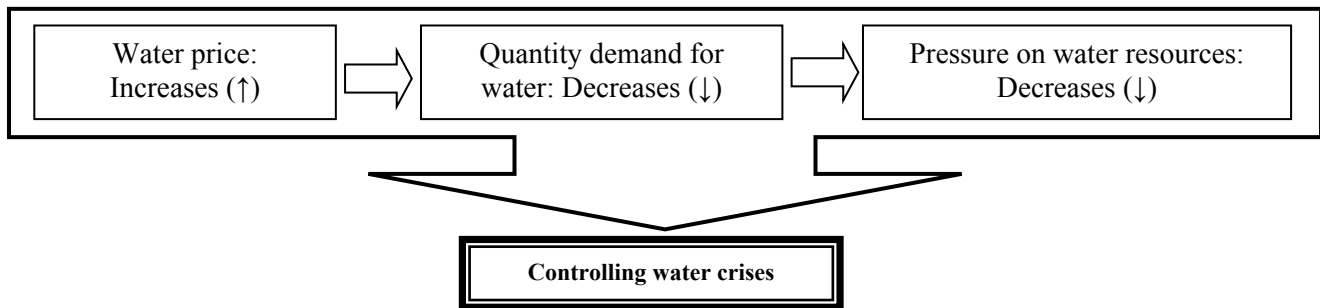
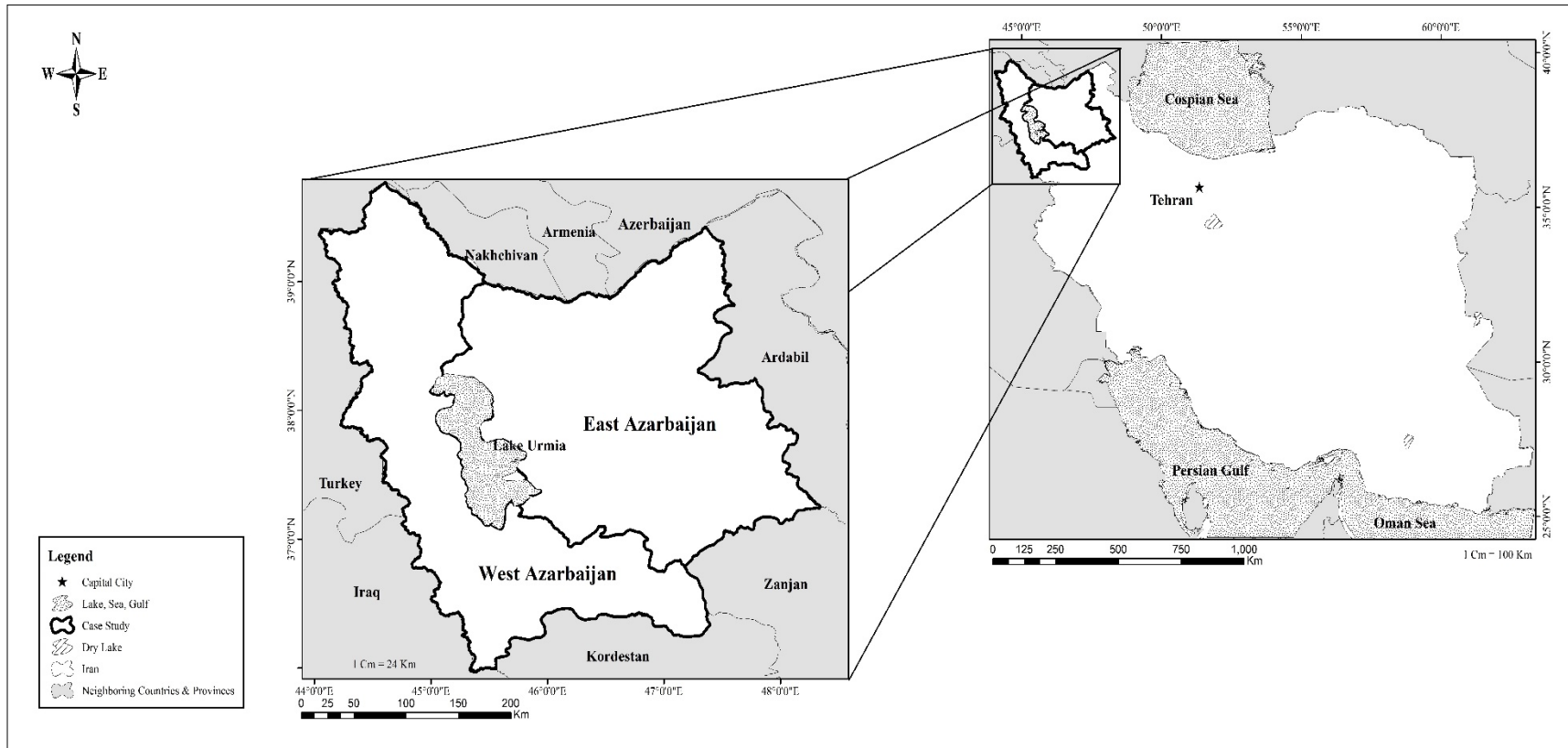


Figure 2: Dominant strategy of controlling water crises by Iranian decision makers (Tahamipour et al. 2014)



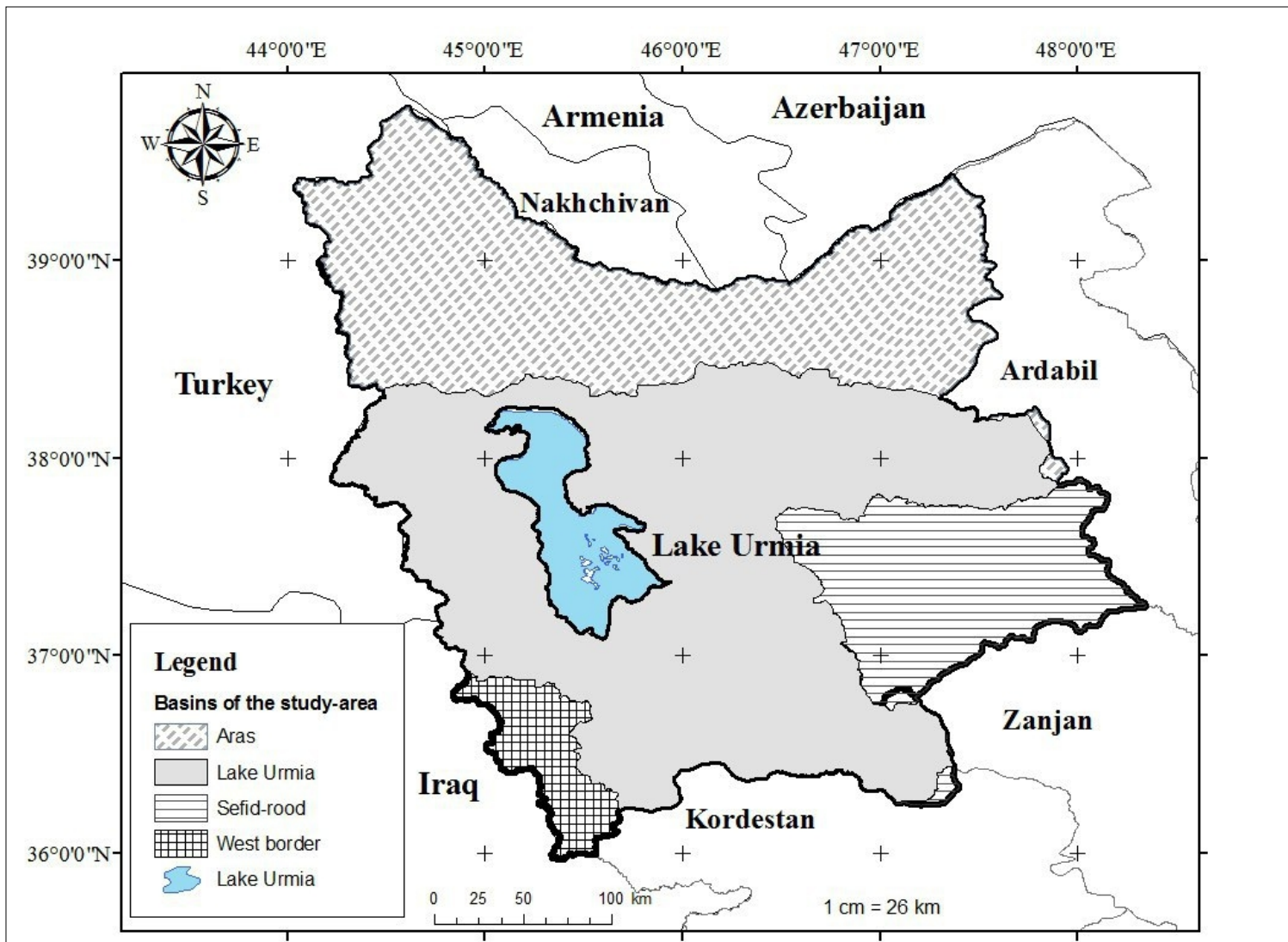


Figure 4: Location of all basins in the Case Study

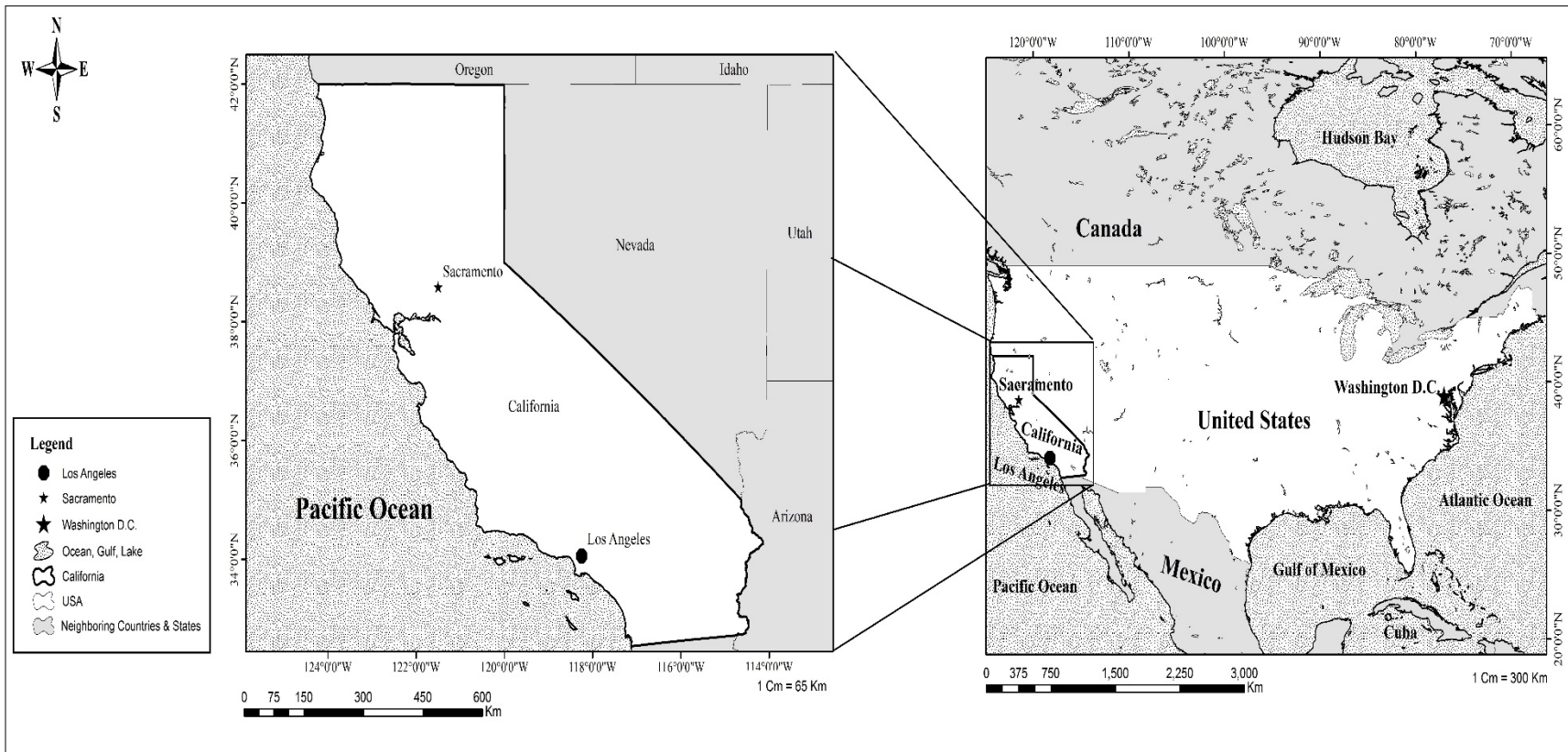


Figure 5: Location of comparing region (the state of California)

Table 1. Cost components of charges in irrigation water sector of selected countries (Toan 2016)

Countries	Pricing Agency	Subsidies <sup>a</sup>	Countries	Pricing Agency	Subsidies
United States	State agencies	All of resource costs and Env. costs <sup>b</sup>	Chile	Public agencies	Part of capital costs and all of Env. costs
Croatia	Government agencies	Part of O&M and all capital costs	Egypt	No charges	Subsidies all to farmers
Greece	Government agencies	Part of capital costs	South Africa	Government agencies	Part of capital costs and all of resource costs and Env. costs
Portugal	Public agencies	Small part of O&M and most of capital costs <sup>c</sup>	India	State agencies	Part of O&M costs, all of other costs
Spain	Basin authority and Irrigation districts	Part of capital costs, all of Resource costs and Env. Costs	Kingdom of Jordan	Government agencies	Part of O&M costs, all of other costs
UK	Regions	None	Pakistan	Provincial government	Part of O&M costs, all of other costs
Italy	Public agencies	Part of capital costs	Turkey	Water users' organizations	Most of capital costs, all of resource costs and Env. costs
Australia	Rural water businesses	Part of capital costs and all of Env. costs	Iran	Government agencies/ Provincial water authorities	Part of O&M costs, most of Capital costs <sup>d</sup> , all of resource costs and Env. costs
New Zealand	Irrigation Companies	All of resource costs and Env. costs	China	Government agencies	Part of O&M costs, all of other costs
Japan	Land improvement districts	Part of capital costs, all of resource costs and Env. costs	Thailand	Government agencies	Subsidies all to farmers
South Korea	Exempt from Charges	Subsidies all to farmers	Vietnam	Government agencies	Most part of O&M costs and all of other costs

- <sup>a</sup> Subsidies include O&M costs, capital costs, resource costs and environmental costs.
- <sup>b</sup> The state of Georgia refuses to charge farmers for irrigation water, albeit issuing permits that legalizes irrigation by farmers.
- <sup>c</sup> Considering irrigation schemes designed by a private ownership, farmers would have to pay full supply cost of water services (this type of ownership occupies nearly 75 percent% of irrigation schemes).
- The components of costs shown in the above table are as below:
  - O&M costs: operation and maintenance costs.
  - Capital costs: replacement cost, interest costs, and major repair costs.
  - Resource costs: opportunity costs of alternative water uses.
  - Environmental costs: environmental damages due to abstraction, storage, impoundment, discharge, etc.
- Meaning and magnitude of signs: All: all element cost is subsidized (nearly 100 %); Most: a major part of the element cost is subsidized (more than 80 %); Part: a significant proportion of the cost is subsidized (between 20% and 80%); Small part: a small proportion of the cost is subsidized (less than 20 %).
- <sup>d</sup> The information related to circumstances of irrigation water in Iran has been reported from Tahamipour et al. 2014; 16; Iran Investment and Business Guide (IIBG) 2016; and Ul Hassan et al. 2007.

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Table 2: Areas of all drainage basins' in the studied-area

Aras	Urmia lake	Sefid rood	West border	Total
25698 Km <sup>2</sup>	41817 Km <sup>2</sup>	11732 Km <sup>2</sup>	3303 Km <sup>2</sup>	82550 Km <sup>2</sup>

Table 3: Areas of planting crops and the crop yield of selected crops in W.AZ and E.AZ provinces and the state of California

Types of Crops	Regions			
	E.AZ and W.AZ provinces		the state of California	
	Tons /Hectare	Hectare	Tons /Hectare	Hectare
Wheat	2.82	165948.4	5.88	137264.6
Barley	2.99	42263.1	3.27	10119.1
Sugar beets	58.86	31363.6	120.40	10117.15
Corn	46.14	9393.4	50.16	147128
Alfalfa hay	7.93	155759.7	21.98	248605.9
Onion	44.66	6159.6	47.67	9307.778
Tomato	40.28	12654.6	136.19	114642.3
Potato	31.97	12900.4	47.04	12423.86
Watermelon	32.81	2646.2	95.34	5058.575

(\*Source: Based on Statistical Yearbook of West and East Azarbaijan (2015) and UC-Davis (2015) for the state of California)

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Table 4: Estimated price of one cubic meter water used in producing selected agricultural crops in E.AZ and W.AZ provinces (IRR).

Types of Crops	$C_{wi(H)}^*$	$X_{i(H)}^*$	$C_{wi(kg)}$	$Q_{wi}$	$P_{wi}$
	$IRR / Hectare$	$Kg / Hectare$	$IRR / Kg$	$m^3 / Kg$	$IRR / m^3$
Wheat	3053512	2821	1082	2.65	408
Barley	2153532	2981	722	6.91	105
Sugar beets	8623914	51584	167	0.34	498
Potato	1192161	29957	40	0.51	79
Onion	6707698	41749	161	0.31	516
Tomato	9300126	40703	228	0.42	548
Watermelon	10321168	33103	312	0.49	638
Alfalfa hay	4611926	7883	585	0.65	902
Corn	9026111	45679	198	0.24	814

(\*Source: Based on Statistical Yearbook of West and East Azarbaijan (2015))

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Table 5: Comparing the price of one cubic meter water used in producing selected agricultural crops in W.AZ and E.AZ provinces to that in the state of California by converting IRR to USD

Types of Crops	$(P_{wi(IRR)})_{WEAZP}$	$(P_{wi(USD)})_{WEAZP}$	$(P_{wi(USD)})_{CA^*}$	$\alpha_i$
Wheat	408	0.016	0.07	0.22
Barley	105	0.004	0.07	0.06
Sugar beets	498	0.019	0.10	0.19
Potato	79	0.003	0.21	0.01
Onion	516	0.020	0.12	0.17
Tomato	548	0.021	0.17	0.12
Watermelon	638	0.025	0.15	0.17
Alfalfa hay	902	0.035	0.11	0.33
Corn	814	0.031	0.07	0.43

(\*Source: the state of California Data has been obtained from UC-Davis (2015) database)

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Table 6: Estimation of the price of one cubic meter water used for producing selected crops using Purchasing Power

Parity (PPP) based on USD (\$)

Types of Crops	$(\hat{P}_{wi(USD)})_{WEAZP}$	$(P_{wi(USD)})_{CA^*}$	$\alpha_i$
Wheat	0.06	0.07	0.78
Barley	0.01	0.07	0.20
Sugar beets	0.07	0.10	0.68
Potato	0.01	0.21	0.05
Onion	0.07	0.12	0.60
Tomato	0.07	0.17	0.43
Watermelon	0.09	0.15	0.59
Alfalfa hay	0.12	0.11	<b>1.16</b>
Corn	0.11	0.07	<b>1.51</b>

(\*Source: World Bank (n.d). International Comparison Program database,  
<https://data.worldbank.org/indicator/PA.NUS.PPP?end=2017&start=2002>)

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Table 7: Supportive policies for agriculture sector as the main demander of water in some countries (Allen 2016)

Supportive Policies	Countries											
	Northern Ireland	Norway	Switzerland	Australia	Brazil	Canada	China	Iceland	New Zealand	South Korea	Turkey	USA
A- Direct payments to farmers	+	+	+	-	-	-	+	+	-	+	+	-
B- Market price support	+	+	+	-	+	+	+	+	-	+	+	+
C- Rural Development programs	+	+	+	+	+	-	+	-	+	-	-	+
D - Facilitate farming during droughts	-	-	-	+	-	-	+	-	+	-	-	+
E- Regional programs to stabilize prices	-	-	-	-	+	-	-	-	-	-	+	-
F - Agricultural insurance	+	+	+	+	+	+	+	+	+	+	+	+
G- Payments for returning farmland to forests and Agri-environmental management	-	-	-	+	-	-	+	-	+	-	-	+
H- Irrigation and drainage infrastructure facilities	-	-	+	-	-	-	+	-	-	+	+	-
I- Reducing taxes / Exempting from tax payments, an integrated loan program to support agriculture	-	-	-	+	-	+	+	-	+	-	-	+

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