Water Security Status in Saudi Arabia: A Threat for Food Security (2000-2014)

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Water Security Status in Saudi Arabia: A Threat for Food Security (2000-2014)

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Abstract Provoked by the threatening situation of water scarcity, this paper aimed at analyzing the current situation of supply and demand for water in Saudi Arabia. The analysis depends on data from, Statistics of Ministry of Economics and Planning, Ministry Water and Electricity in Saudi Arabia, various issues of Statistical Year Book of the Central Department of Statistics and Information and FAO statistics. The authors employed descriptive statistics for analyzing the supply and demand for water in Saudi Arabia during the period 2000-2014. Water scarcity index was estimated for the study period. Regression analysis was employed for estimating the supply and demand functions for water during the period 2000-2014. Results obtained indicated that the increase in total supply of water may be attributed to the increase of, desalinated water, treated sewage water, and treated agricultural drainage water. Based on results, the highest water consuming sector is the agricultural sector as compared to municipal and industry sectors. Results indicated that demand for water is positively affected by the harvested area, population size and number of industries; however a negative relationship between demand for water and per capita gross domestic product is detected. Regarding supply of water, results obtained indicated that the supply of water is positively influenced by the production of desalinated water and the storage capacity of dams. However, a negative relationship between supply of water and the cost of production of desalinated water is observed. Results on per capita supply and demand for water, proved the threatening current and future situations of water security and food security in Saudi Arabia. This results, is confirmed further by high values of water scarcity index. Results on total harvested area and wheat production indicated negative trends during the study period, attributable to the risks associated with water scarcity.

Keywords Food Security, Water Security, Water Scarcity Index, Desalination

1. Introduction

Water security is one of strategic vital issues that attract the attention of researcher especially in the Arab region which is threatened by severe water scarcity in some of its countries. The situation is further complicated by population pressure and increasing demand for water by different sectors. The importance of the topic stems from the fact that water is the vital element in many aspects related to food security specially availability of food, which is the first pillar of food security.

Bakker argued that water security is a convenient adequate level of water-related uncertainties to human beings and ecosystems, coupled with the obtainable adequate amount with reasonable quality to backup livelihoods, national security, human beings health and ecosystem services, as in [1].

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Based on the results obtained by Elmulthum, [2], availability of water on per capita basis in the Arab World, lessens from 3430 m^3 in 1960 to 1250m^3 in 2000 to 876 m^3 in 2010. A further reduction in available water on per capita basis to 667m^3 in 2025 and 500m^3 in 2050 is anticipated. In addition, results obtained by Elmulthum, [2] indicated that food consumption gap in the Arab world raised from $1.1 billion in1973 to $27 billion in 2010. This situation could be explained by a number of factors including population growth, lower levels of real income, and the effect of climate change, which negatively influenced availability of water and agricultural production. This situation indicated a threatening situation for food and water security in the Arab World during the current century putting in mind that the water poverty line was estimated at 1000m^3.

"Arab countries face a serious food security challenge and that poverty rates are much higher than official numbers suggest. It blames the situation on vulnerability to volatile food prices, natural disasters and water scarcity" as in IFPRI. [3].

The concept of water security was reviewed by Cook and Bakkle from both academic and policy prospective. [4]. The authors compare the approaches followed by researchers in analyzing water scarcity and the definitions applied in natural and social sciences. The authors considered the preferences and prejudices of narrow versus broad and integrative framings of water security. They recognized their usefulness with reference to consolidated water wealth handling. Based on their results, they argued that an integrative approach to water security provide good governance the highest priority, thus provide a new promising tactic to water management.

According to Bakker and Morinville [5], in addition, to week administrative resolutions, low optimum governance procedures, deficiency in science, rising environmental stress, increasing water insecurity arises from power relations, and rivalry between political and socioeconomic benefits related to land and water ownership and control. Hence, special attention should be given to the political and institutional aspects of water governance as well as issues of social power represents a paramount field of focus for water security potentials.

According to the argument used by Fereres et al [6], given the rivalry for water confronted by the agricultural sector, and the risks characterizing climate change, upgrading the efficiency of water use in both rain-fed and irrigated sectors is the major path to confront the challenge of foreseeable rise in demand for food for the coming decades.

Aiming at identifying social, economic, and engineering aspects affecting the domestic demand and consumption pattern of domestic water, in Riyadh, Saudi Arabia, Elzahrani et al [7] collected data on a number of variables related to domestic water consumption from a sample of households in Riyadh city applying social survey method. Based on Elzahrani et al [7], results positive and neutral trends towards rational use of water resources increase the prospects of improving trends in water consumption patterns. In addition, [7] emphasized the importance of media in increasing awareness in relation to the rational use of water. Moreover, a comparatively low water bill in relation to actual cost coupled with weakness of government oversight negatively affect water consumption patterns.

According to Elzahrani and Moneer [8], argument, although Saudi Arabia managed to achieve food security during the last three decades it faces a number of challenges that threatens sustainability of these achievements. These challenges include among others scarcity of natural resources, especially water, increases in population growth rates, urbanization, and increases in household per capita consumption of water.

Public consciousness of water deficiency problem in Saudi Arabia was measured by Ouda [9], using questionnaires in Al Khobar city in Eastern province of Kingdom of Saudi Arabia. Results from the survey showed low scales of water shortage consciousness among respondents. Based on Ouda [9], argument comprehensive work is stringently required to raise water consciousness through water media campaigns. Moreover, the author proposed the revision of the existing water pricing system and application of the pricing system as an economic incentives instrument for water conservation.

Based on FAO [10], water resource administration in Saudi Arabia is characterized by heavily dependence on desalination. In addition, being a high income country it offers water almost for free. Moreover, in spite of huge operations and investments in water, considerable unfairness still remains coupled with weighty weaknesses in institutional capacity and governance. Furthermore, the water sector is seen as embodying great prospect for development and growth, it is expected that more than US$200 billion will be invested over the next 20 years on water and power projects, especially in water treatment plants, sewage plants, and desalination projects. The government is also moving forward in improving the water sector's regulatory framework, and smoothing the way for privatization, especially in power and water desalination projects.

2. Methodology

This section describes the methodology employed for the purpose of fulfilling the objective of this paper. Data on supply and demand of water was obtained from, Statistics of Ministry of Economics and Planning [11], and Ministry of Water and Electricity [12], in Saudi Arabia, various issues of Statistical Year Book of the Central Department of Statistics and Information [13], and FAO statistics [14]. Data on harvested area was obtained from Ministry of Agriculture in Saudi Arabia [15]. The authors employed descriptive statistics for the estimation of supply and demand for water. Assuming that water demand is affected by harvested area, population size, number of industries, and per capita gross domestic product, we used the following specification:

$$D_t = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 \quad (1)$$

Where,

D_t is the total demand for water in millions cubic meter, X_1 is the harvested area in 1000 hectares, X_2 is the population size, X_3 is the number of industries, and X4 is the per capita gross domestic product in Riyals.

As far as the supply of water is concerned it is assumed that water supply is affected by the production of desalinated water, cost of production of desalinated water, and the storage capacity of dams. The following specification is used for the supply function.

$$S_t = \sigma + \mu_1 Y_1 + \mu_2 Y_2 + \mu_3 Y_3 \quad (2)$$

Where, S_t is the total supply of water in millions cubic meters, Y_1 is the cost of water desalination in riyal per cubic meter, Y_2 production of desalinated water in millions cubic meters, and Y_3 is storage capacity of dams in 1000 cubic meters.

Based on Ali [16], water Scarcity index is calculated using the following equation:

$$Ws = (WU / WA) * 100 \quad (3)$$

Where, Ws = National water scarcity index

WU = Total water use in the country (m^3/yr)

WA = National water Availability (m^3/yr)

The national water scarcity percentage is a measure of availability of water from conventional sources (ground and surface water). Hence if the water Scarcity percentage is equal to 100% this gives an indication that water from conventional sources meat the national demand for water. However, a value of the index higher than 100% indicates the need of water supplement from nonconventional sources through withdrawal of nonrenewable groundwater resources or use of desalinated and other supplemental water resources that are not included in the total annual water resources.

For the purpose of estimating the impact of water scarcity on food security we estimated Simple correlation coefficient between water scarcity index and harvested area.

3. Results and Discussion

Figure (1) depicts water supply in Saudi Arabia from conventional sources during the period 2000-2014 which include surface and renewable groundwater and non renewable groundwater. It is clear from figure (1) that the water supply from conventional sources decreased from 20740 million m^3 in 2000 to 13620 million m^3 in 2014 with an annual reduction rate of 2.3%. However, regarding water supply from non conventional sources results indicated a steady increase by an annual rate by an annual rate of 10.3% during the period 2000-2014. It is clear from figure (2) that the supply of water from desalination industry increased from 971 million m^3 in 2000 to 2070 million m^3 in 2014. Desalination water plants had the highest contribution to water supply from non conventional sources averaging around 76% during the study period followed by Sewage and Agricultural drainage water contributing around 21% and 3%, respectively. Hence, faced by increasing role of desalination water as water source sustaining ground water in meeting increasing demand for water in Saudi Arabia, the big challenge is to raise the economic efficiency of the desalination industry, figure (2).

Agriculture is considered as the highest water consuming sector in Saudi Arabia, representing around 89.3% and 78% of total water consumption in 2000 and 2014, respectively. Results obtained indicated that total water demand in Saudi Arabia decreased at a rate of 1.42% during the period 2000-2014. This reduction may be attributed to the reduction in water use in agriculture at a rate of 2.07% during the study period. However, the demand for water for industrial and municipal purposes increased at a rate of 7.3% and 3.2%, respectively during the same period which exceeded the rate of population growth during the same period.

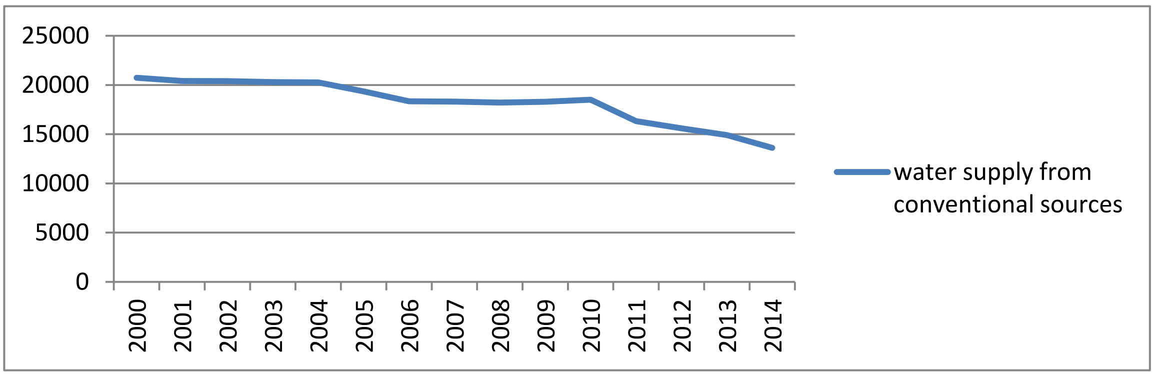

Figure 1. Water supply from conventional sources in Saudi Arabia in millions m^3 (2000-2014). Source: Authors' presentation based on data from [11] and [12]

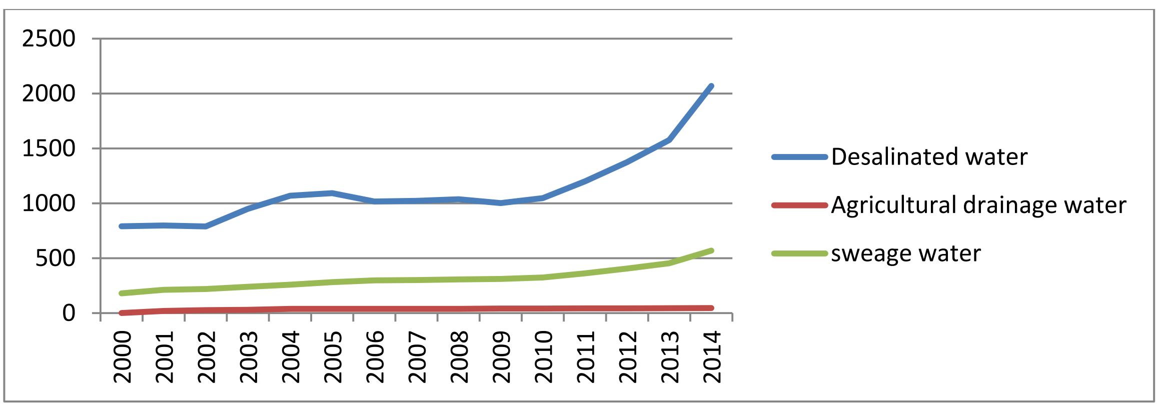

Figure 2. Water Supply from non conventional sources. Source: Authors' presentation based on data from [11] and [12]

However, the impact on total demand is affected by the reduction of water demand in agricultural sector which outweighed the increase in municipal and industrial sectors. The reduction of water demand in agricultural sector may be explained by government policy of reliance on international market for supplying domestic market with staple food items based on consideration of water scarcity problem Figure (3).

Results in figure (4) proved the threatening situation of water insecurity in Saudi Arabia where, per capita supply of water decreased from 1035 m^3 in 2000 to 466 m^3 in 2014 by an annual rate of 3.6%. The per capita demand for water decreased from 1035 in 2000 to 558 m^3 in 2014 by an annual rate of 3.1%. This, situation is a real threat to Saudi Arabia since, on the basis of Al Gezira Center [17], the water poverty line is estimated at 1000m^3.

Results in figure (5) indicated that the harvested area in Saudi Arabia during the period 2000-2014 increased from 1219 million Ha in 2000 to 1305 in 2001 then started to decrease annually with the exception of 2006 and 2007 where the harvested area is more or less constant. This result could be attributed to the concerns given by policy makers to water scarcity. Hence, Saudi Arabia is highly dependent on international markets for supplying local markets with food consumption requirements. Based on data from [14], the value of food imports in 2012 was 88.6% of total agricultural imports in Saudi Arabia.

Emphasizing the impact of water scarcity to food security, results in figure (6) indicated that Saudi Arabia followed a decreasing trend in wheat production reaching its lowest value in 2013 during the study period. The above results confirm the government policy of reliance on the international market for assurance of availability of wheat as a pillar of food security. This, policy may be attributed to concerns by policy makers to the limited water resources in Saudi Arabia.

Estimating equation (1) above for the demand for water we obtained the following regression equation

$$D_t = 793.84 + 0.03X_1 + 0.045X_2 + 0.089X_3 - 0.0023X_4 \quad (4)$$

$$(2.382) \quad (2.06) \quad (3.02) \quad (-1.91)$$

$$R^2 = 0.99 \qquad \bar{R}^2 = 0.97 \qquad F = 137.21$$

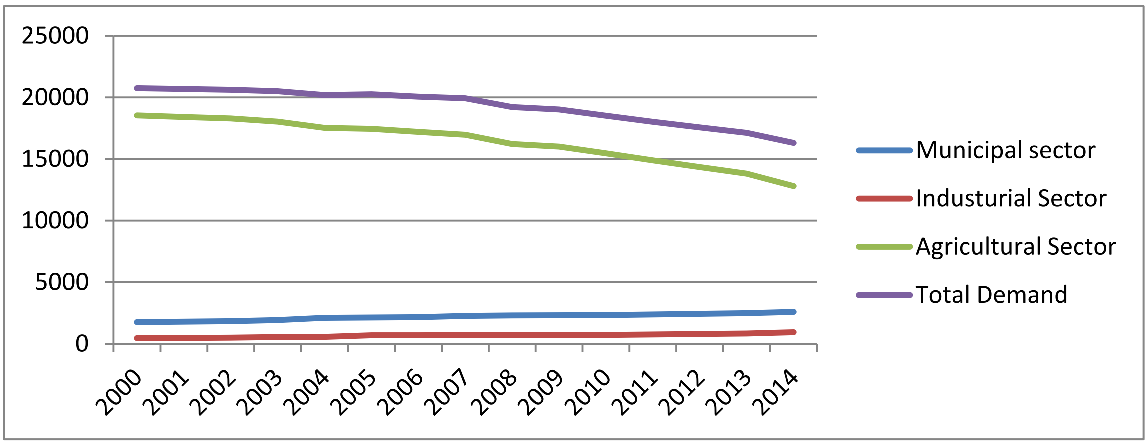

Figure 3. Demand for water in Saudi Arabia by sector in millions m^3 Source: Authors' presentation based on data from [11] and [12]

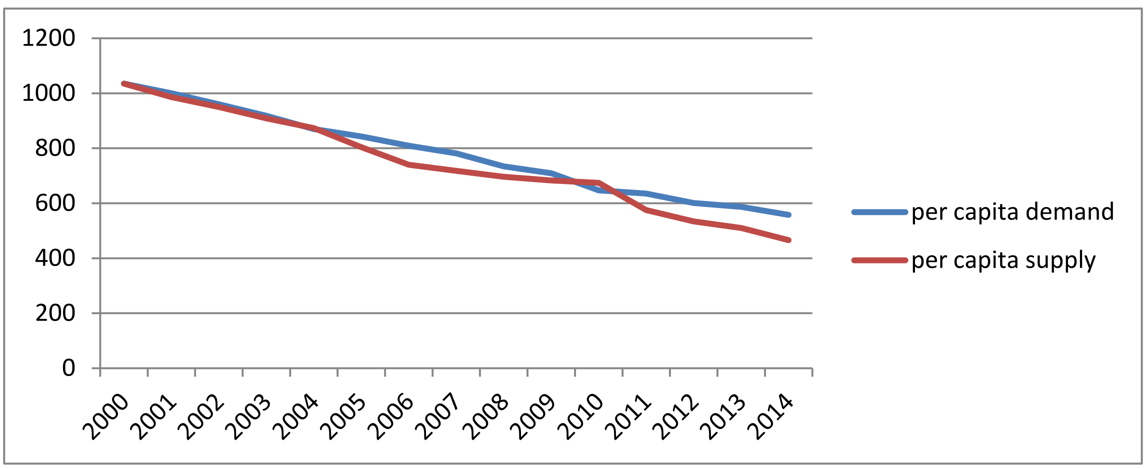

Figure 4. Per capita supply and demand for water in Saudi Arabia in m^3. Source: Authors' presentation based on data from [11], [12], and [13]

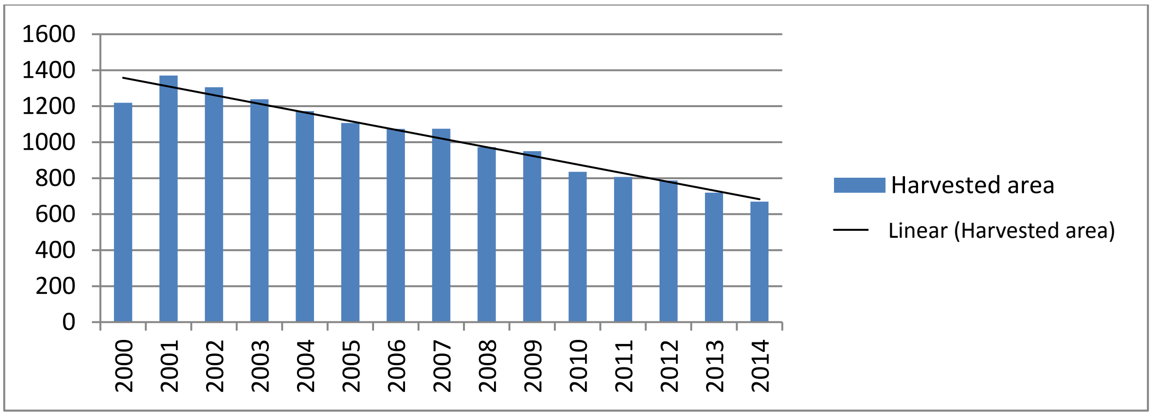

Figure 5. Harveated area in million Ha. in Saudi Arabia (2000-2014). Source: author's presentation based on data from [15]

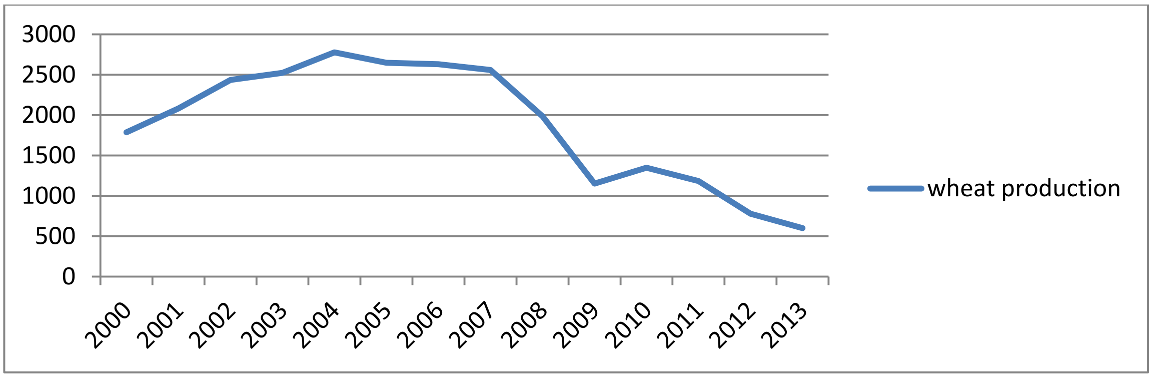

Figure 6. Wheat production in (000) tons in Saudi Arabia (2000-2013). Source: Authors' presentation based on data from [14]

Figures between brackets are t values of the estimated coefficients. The estimated equation (4) indicated the significant relationship between the demand for water and the selected explanatory variables. However, with the exception of per capita gross domestic product the direction of relationship is positive for all other variables. The negative relationship between the demand for water and the per capita gross domestic product may be explained by the recent awareness campaigns in Saudi Arabia for the rational use of water with expectations of greater response with higher per capita gross domestic product. The t statistics indicated significant positive relationship at 5% level of significance between water demand and population size, number of industries, and harvested area. Regarding per capita gross domestic product the t statistics indicated significant relationship at 10% level of significance. The F statistics indicated that the model is significant at 1% level of significance. R^2 indicated that 99% of the variations in the demand for water is explained by the selected explanatory variables.

Estimating equation (2) above for the supply of water we obtained the following regression equation

$$S_t = -3976 - 29824Y_1 + 4086Y_2 + 0.068Y_3 \qquad (5)$$

$$(-1.97) \qquad (2.05) \qquad (1.99)$$

$$R^2 = 0.89 \qquad \overset{-2}{R} = 0.74 \qquad F = 15.74$$

Figures between brackets are t values of the estimated coefficients. The estimated equation (5) indicated positive significant relationship at 5% level of significance for the production of desalinated water and the storage capacity of dams. However, based on the estimated equation a significant negative relationship between supply of water the cost of production of desalinated water is proved. The F statistics is significant at 5% level signifying the overall significance of the model. The selected explanatory variables explained around 0.89% of the variations in the supply of water as indicated by R^2 value.

Most of the Arab countries suffer a serious water scarcity problem including Saudi Arabia where the water scarcity percentage estimated from equation (3) is higher than 100% in almost all of the years. Based on Ali, [14], values above 100 percent indicate withdrawal of nonrenewable groundwater resources or use of desalinated and other supplemental water resources that are not included in the total annual water resources. Results in figure (7), is a signal for the water scarcity situation in Saudi Arabia where the value of the water scarcity percentage increased from 100% in 2000 to 119% in 2014. This situation necessitates reliance on non conventional water sources to fill in the gap in water supply from conventional sources, a situation which threaten water and hence food security in Saudi Arabia. A high negative correlation was detected between the harvested area and the water scarcity index (-0.77) in Saudi Arabia which further sustains the threats facing food security in Saudi Arabia.

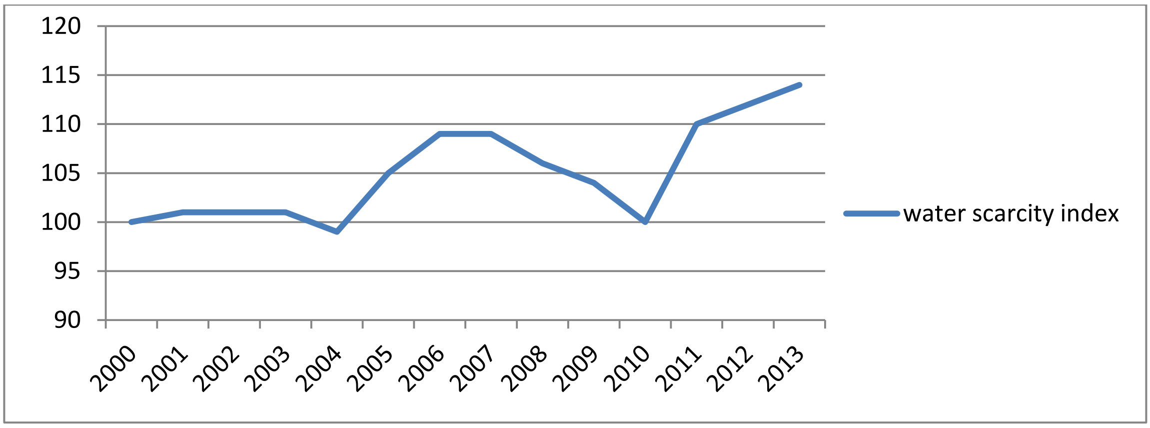

Figure 7. Water scarcity index (%) in Saudi Arabia (2000-20014). Source: Authors' calculations based on data from [11] and [12]

4. Conclusions and Policy Recommendations

Water and hence food security situation in Saudi Arabia is at risk. The country is highly dependent on non conventional water sources, with particular emphasis on desalinated water. The agricultural sector is the highest water consuming sector making the policy option of self sufficiency in food in Saudi Arabia a risky option. Based on the research results limiting the expansion of crops of high water requirements is highly recommended. In addition, investment in agriculture is recommended in countries rich in water resources with particular emphasis on comparative advantage of food crops in selected countries. Further studies, on water requirements of food crops in different regions in Saudi Arabia are highly recommended.

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