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An Investigation of the Relationship between Climate Change, Water Demand and Price of Wheat and Maize Crops in Egypt

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Authors' contributions

This study was carried out in collaboration between all authors. All authors managed the literature searches, read and approved the final manuscript.

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ABSTRACT

The objective of this work was to estimated crop yield production, water demand and prices for wheat (*Triticum aestivum* vulgar. L) and maize (*zea maiz.* L), under two climate change scenarios (A1 and B1) and compare this results to the current statues. Fluxes of production, water demand and prices were evaluated in three different climatic areas (Lower, Middle and Upper Egypt) through 25 years from 1988 to 2012. Estimations for the production, water demand and prices were done for both crops at years 2025, 2050 and 2100.

Concerning the estimated yield production, obtained results presented a negative relationship between both wheat and maize yield and climate change circumstances in the studied areas. However, a positive relationship were found between water demand and prices in a side and increasing air temperature under climate change conditions on the other side. On other hand, the results lead to reduction of water use efficiency (WUE) and return of water unit at three areas. Also, the greatest shortage was indicated in estimated year 2100.

Keywords: Climate change; wheat; maize; water demand; prices; production; estimate.

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1. INTRODUCTION

The impact of climate change in many parts of the world has been explored for different crops [1-5]. It has been suggested that some effects of climate change are likely to be beneficial in some agricultural regions [6]. However, countries lying in the tropical and sub tropical regions would face callous results, whereas regions in the temperate zone would be on the beneficial side. Impact of climate change on agricultural production is related to three major specific factors: Atmospheric carbon dioxide concentration, precipitation and temperature [7]. Moreover, agriculture is the most vulnerable sector to climate change. Agriculture productivity is being affected by a number of factors of climate change including rainfall pattern, temperature hike, changes in sowing and harvesting dates, water availability, evapotranspiration and land suitability. All these factors can change yield and agricultural productivity [8].

There is growing body of evidence of climate change. The surface air temperatures are rising, precipitation altered, and frequency of severe weather events increased [9]. Climate is the major driving force of crop production and water use [10,11]. The increased air temperature and changed precipitation pattern will significantly affect crop yield and water use efficiency [12]. However, there are interactions between climatic factors and their combined impact on crop production is complicated [13-15]. Process-based models are broadly applied to investigate the potential impacts of climate variability/change on crop production [16-18] and how crop yield responds to climate change [19,20]. Simulation results under various climate patterns and regions had significant difference. By using Water Erosion Prediction Project (WEPP) model Zhang and Liu [21] predicted that the productivities and evapotranspiration of wheat and maize would noticeably increase over the Loess Plateau during 2070-2099, mainly because of the increase of precipitation. Wang et al. [22] showed that temperature increase had little impact on long-term average water balance while increase in atmospheric CO_2 concentration reduced evapotranspiration and increased deep drainage in Southeast Australia by utilizing APSIM. Chen et al. [23] reported that simulated crop water demand and potential yield was significantly decreased from 1961 to 2003 because of the declining trend in solar radiation in the North China Plain. Yang et al. [15] resulted that simulated wheat yield under full irrigation have no significant decreasing trend from 1955 to 2006. Simulated growth duration of winter wheat was significantly decreased. Simulated ET of winter wheat was significantly correlated with measured pan evaporation. Simulated ET of winter wheat decreased significantly during the 52 years, with a decrease rate of 0.813mm $year^{-1}$. Cluster analysis showed that the variations of ET were mainly determined by solar radiation, nothing to do with the changes in temperature. The results identified the change trend of field ET under historical climate change, and determined the main meteorological factors which affect ET in this oasis. These results provide a measure for water demand, crop production and irrigation management under climate change in the oasis.

Focusing on Egypt (latitudes 22º and 32ºN, and longitudes 25º and 35ºE), it reports that, Egypt is at risk because of global warming and potentially facing "catastrophic" consequences in sea level rise (SLR), water scarcity, agriculture and food insufficiency, loss of biodiversity and habitats and new pressures on human health and national economy [24].
Wheat and maize considered as the most important crops and largest cultivated areas in Egypt. So, many studies have documented the effects of climate change on wheat yield in Egypt and concluded that the yield could be reduced by an average of 30% in the Nile Delta and Valley under surface irrigation and old land [25-27]. Attaher et al. [28] indicated that, under current conditions, about 70% of the Egyptian cultivated area has an average Et_o

values more than 4mm/day. The general trend of the climate change impacts was an increase in Et_o values from North to south, this increase will be uneven between regions and seasons. The future climatic changes will increase the potential irrigation-demands by range of 6-16%, due to the increase in Et_o only by 2100s.

Moreover, Hassanein et al. [29] using climate change scenarios obtained that, wheat plants will be impaired by changes in air temperature as a function in locations. Furthermore, Plants at different stages will be affected by the increase in air temperature by 1.5ºC, starting from anthesis date, going through length of growing cycle, and ending by both of physiological maturity and harvested yield. Wheal, the increase air temperature with 3.5ºC, plants will lose ability to grow at the normal rate which will lead to significant loss in yield.

In addition, El-Marsafawy et al. [30,31] mentioned that under GCM (general circulation models) climate change scenarios, yield of maize decreased in comparison to current climate conditions at all areas under study. At the same time, water consumptive use will be increased for all varieties.

Regarding effect of climate change on prices, Jones and Thornton [32] reported that an overall reduction of only 10% in maize production to 2055, equivalent to losses of $2 billion per year, the aggregate results hide enormous variability: Areas can be identified where maize yields may change substantially. Nelson et al. [33] shown that global warming may further increase the prices of corn, wheat, and rice by at least two-thirds by 2050. Depending on the level of warming and economic and population growth, the study predicts that corn prices, adjusted for inflation, will rise by 42 to 131 percent by 2050.

When gathering the overall illustrated literatures about effect of climate change on wheat and maize under Egyptian conditions its will be found that, a not complete image was presented. Which is reflected the essential need for another studies to complete and present a clear image for the situation of wheat and maize under climate change conditions in Egypt. The aim of this study is to calculate and estimate:

a) Crop yield production,
b) Water demand,
c) Crops prices,
d) Water use efficiency and
e) The return from water unit for maize, wheat under different suggested incremental climatic change scenarios for the years 2025, 2050 and 2100.

2. MATERIALS AND METHODS

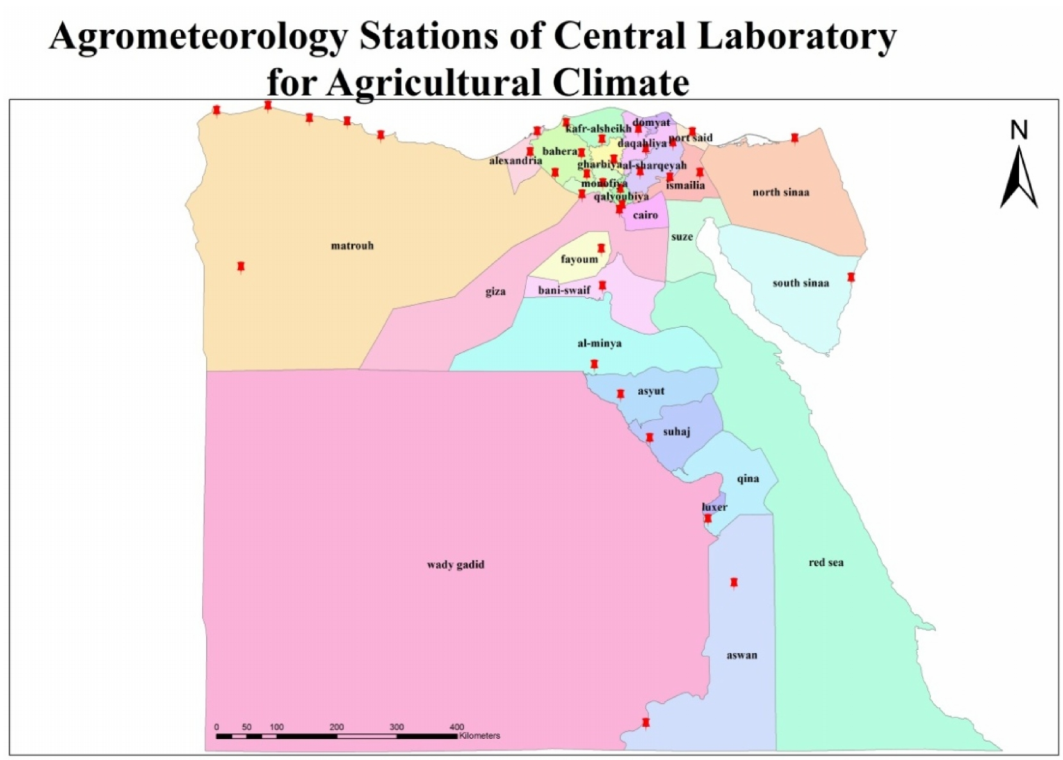
Because of the essential need for more studies to complete and present a clear image for the situation of wheat and maize under climate change conditions in Egypt. So, the main objective for this study is to estimate and calculate needed factors to complete the absent pieces the exist literatures.

To achieve this objective, there are two main components of the research: first, collect and gathering literatures related to impact of climate change on wheat and maize production, water demand, water use efficiency and prices in Egypt. Moreover, determinate the existence and absent results points related to the objective.

Second, calculated and estimated both current (the year 2012) and future (years 2025, 2050 and 2100) crops production (wheat and maize), water demand, water use efficiency, prices and the return from water unit.

2.1 Current Water Demand (Requirements)

Current Et_o (Potential evapotranspiration) for both wheat and maize was calculated depending on climatic data from 36 climate stations over Egypt. Locations of the agro-climatic stations were shown in (Map 1).



Map 1. Distribution of agro-metrological station in Egypt

The historical data cover the period from 1988th to 2012th (about 25 years). Calculation of potential evapotranspiration was made according to the following formula [34]:

$Et_o = K_P \times E_{Pan}$ mm/day

Where : Et_o = Potential evapotranspiration in mm / day

K_P (Pan coefficient) = 0.85
E_{Pan} = Pan evaporation in mm/day

The second step was to obtain values of water consumptive use (Et_{crop}) as follows [34]:

$Et_{crop} = Et_o \times K_c$ mm/day

Where: Et_o = The rate of evapotranspiration from an excessive surface of green cover of uniform height (8 to 15cm), actively growing, completely shading the ground and did not face shortage in water.

K_c = Crop coefficient (between 0.6 to 1.2).

The third step is to calculate water requirements (WR) for both Wheat and Maize as following:

$WR = Et_{crop} \times L\ \%$ mm/day

Where: L%= Leaching requirement percentage. Moreover, L % was estimated to be 1.25. Finally, calculation of open field water duty (WD) for both wheat and maize as follow:

$WD = WR \times (area/100)$

Results of the calculation for water duties for both Wheat and Maize starting from the year 1980 to 2012 were presented in (Fig. 1). Additional data about water requirements were obtained from Water Resources bulletins, Ministry of Water Resources and Irrigation. Such data were used as a reference to review obtained results from the above mentioned equation.

2.2 Estimated Water Demand (Requirements)

Several projections for the future Et_o were used to determine studied crops water demands (wheat and maize). Such literature were collected and studied.

a) The prediction that was done by Eid et al. [35] using the CROPWAT model under climate warming conditions showed increase in wheat evapotranspiration by about 10.8%, 11.4% and 10.3% and maize evapotranspiration by 7.8%, 7.8% and 8.0% at Kafr El-Sheikh (Lower Egypt), Giza (Middle Egypt) and Sohag (Upper Egypt), respectively under climate warming conditions.
Depending on this study estimated water demand for both wheat and maize in the three climatic zones were calculated and presented in (Fig. 5).
b) The projection for the future Et_o was presented by Attaher et al. [28,36] based on air temperature changes implication of IPCC's SRES scenarios using HadCM3 climate model that are described in (Table 1). It was reported that average evapotranspiration increased by per cent 3.4, 6.6 and 13.2 and 3.2, 5.2 and 6.0, respectively in 2025, 2050 and 2100.

Depending on this study estimated water demand were calculated and presented in (Fig. 6).

c) In addition, El-Marsafawy et al. [30,31] employed the DSSAT and CROPWAT simulation models to measure the adverse impacts of climate change on some maize varieties grown in Egypt, and found that climate change will lead to increase evapotranspiration (ET_{crop}) and crop water requirement in varying degree according to the agro-climatological zones in Egypt. Indicated that increasing temperature 1.5ºC increased maize water consumption around 3.5% and 8.5% with a 3.5ºC increase.

Estimated water demand for maize was calculated depending on El-Marsafawy et al. [30, 31] and presented in (Fig. 7).

Table 1. Description of IPCC special report on emissions scenarios (SRES)

Scenario	Storylines
A1	Rapid economic growth, low population growth, rapid adoption of new technologies, convergence of regions, capacity building, increased social interaction, reduced region differences in per capita income
B1	Convergent world with low population growth, transition to service and info economy, resource productivity improvements, clean technology towards global solutions

2.3 Current and Estimated Prices

a) Current prices for Wheat and maize and last five years prices were obtained from Economic Affairs Sector bulletins, Ministry of Agriculture and Land Reclamation.
b) Estimated prices for the years 2025 and 2100 were calculated using simple linear model (regression equation) employing last five years prices as inputs for the used equation.

Estimated prices for the years 2025 and 2100 as follow:

$Y = B_0 + B_1X$ where:

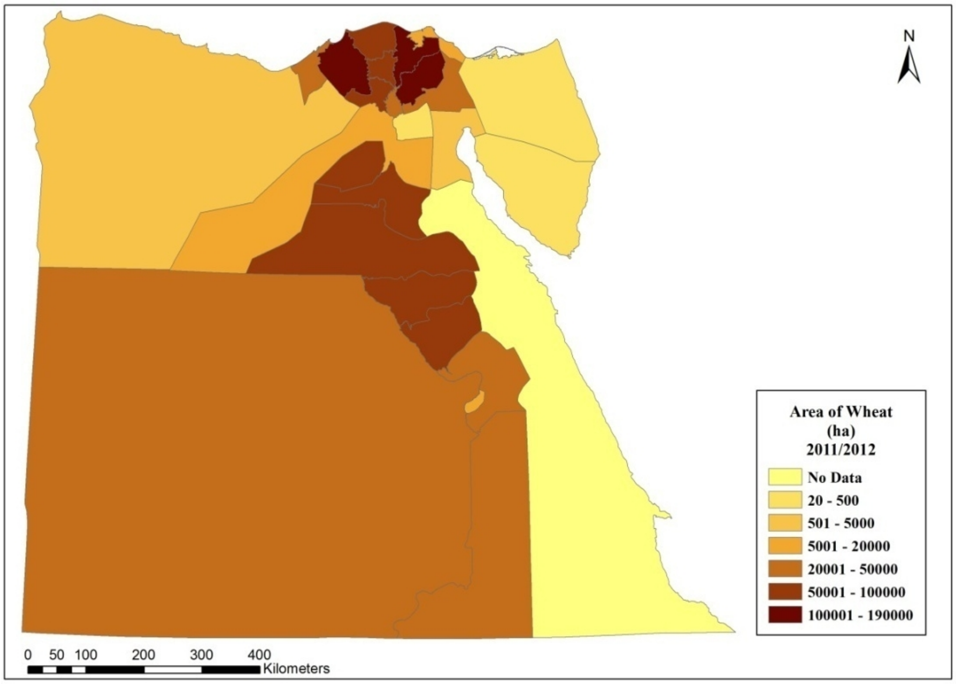
Y = estimated year,
B_1 is the slope, the change in Y over the change in X (rise over run) and calculated as follow:

$B_1 = \frac{n\sum X - \sum X \sum Y}{n\sum X^2 - (\sum X)^2}$,
B_0 is the intercept, the point where the line crosses the Y axis and calculated as follow:
$B_0 = \frac{\sum Y}{n} - B_1 \frac{\sum X}{n}$

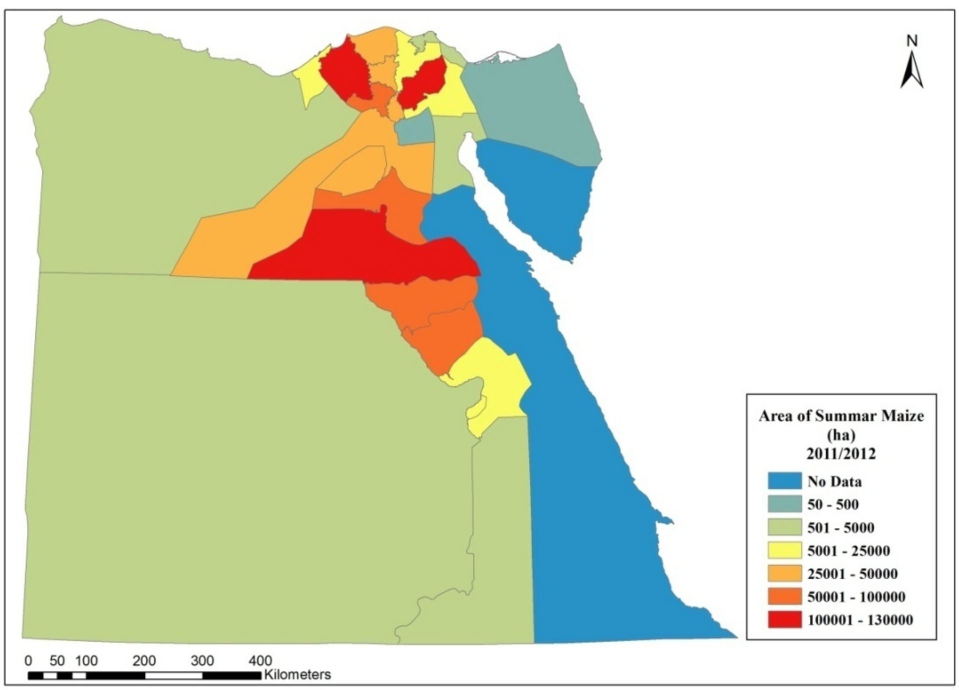
c) However, estimated prices for the year 2050 were taken from Nelson et al. [33].

2.4 Current and Estimated Crop Production

a) Data about wheat and maize production from 1988 to 2012 were obtained from Economic Affairs Sector bulletins, Ministry of Agriculture and Land Reclamation. Location of cultivated area with wheat and maize are shown in (Maps 2 and 3).
b) To estimate wheat and maize production for years 2050 and 2100, percentage of decrement in wheat and maize were obtained from Abou-Hadid [37] (for the year 2050) and Hassanien and Medany [38] (for the year 2100). Such percentages of decrement were employed to calculate the estimated production.
c) To calculate the estimated production for the year 2025 for both studied crops, simple linear model (regression equation) was used. Last five years productions (for both wheat and maize) were employed as inputs for the used equation.



Map 2. Wheat cultivated area in 2011/2012



Map 3. Maize cultivated area in 2011/2012

Estimated production for the year 2025:

$Y = B_0 + B_1X$ where:
Y = estimated year,
B_1 is the slope, the change in Y over the change in X (rise over run) and calculated as follow:
$B_1 = \frac{n\sum X - \sum X \sum Y}{n\sum X^2 - (\sum X)^2}$,
B_0 is the intercept, the point where the line crosses the Y axis and calculated as follow:
$B_0 = \frac{\sum Y}{n} - B_1 \frac{\sum X}{n}$

2.5 Water Use Efficiency

Water use efficiency (WUE) for wheat and maize were calculated for current (2012) and estimated years (2025, 2050 and 2100) according to the following equation:

$$WUE = \frac{\text{Total Crop Production } (\frac{\text{Kg}}{\text{hectare}})}{\text{Total Water Consumption } (\text{m}^3)} \quad [39]$$

2.6 Water Unit Return

Obtained data about water use efficiency and prices for both current and estimated years were employed to calculate the return from each water unit as follow:
Water unit return = WUE x Price

3. RESULTS AND DISCUSSION

3.1 Current Statement

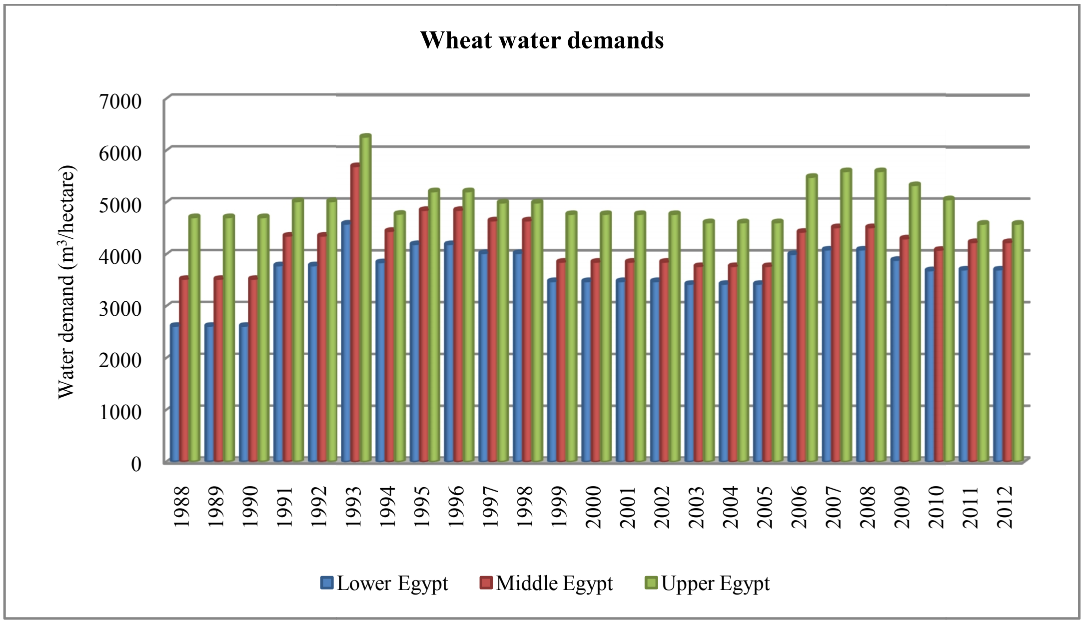
3.1.1 Water demand

General trend of the development for wheat and maize water demand (m^3/hectare) from 1988th to 2012th is illustrated in (Fig. 1). It's concluded from the mentioned data that, water demand for both studied crops was higher in Upper Egypt followed by Middle Egypt. However, Lower Egypt was always the lowest through the studied period.

When study the data carefully, it could be noted that same water demand was calculated in the first two years of the study. Starting from the year 1991 water demand was increased gradually till the year 2012. The highest water demand was found in the year 1993 for wheat. Moreover, the highest water demand for maize was found in years 1995 and 1996 for maize.

3.1.2 Cultivated area

Data illustrated in (Fig. 2) show cultivated area (thousand hectare) for wheat and maize from 1988th to 2012th. The greatest cultivated area for both studied crops was obtained at Lower Egypt and followed by Middle Egypt. However, the smallest cultivated area was found at Upper Egypt, with one exception regarding to wheat cultivated area in the year 2012. Moreover, it's concluded from the data distribution that cultivated area for both studied crops were increased in some years and decreased in other years, that reflected on the figure to be like high Columns followed by low columns.



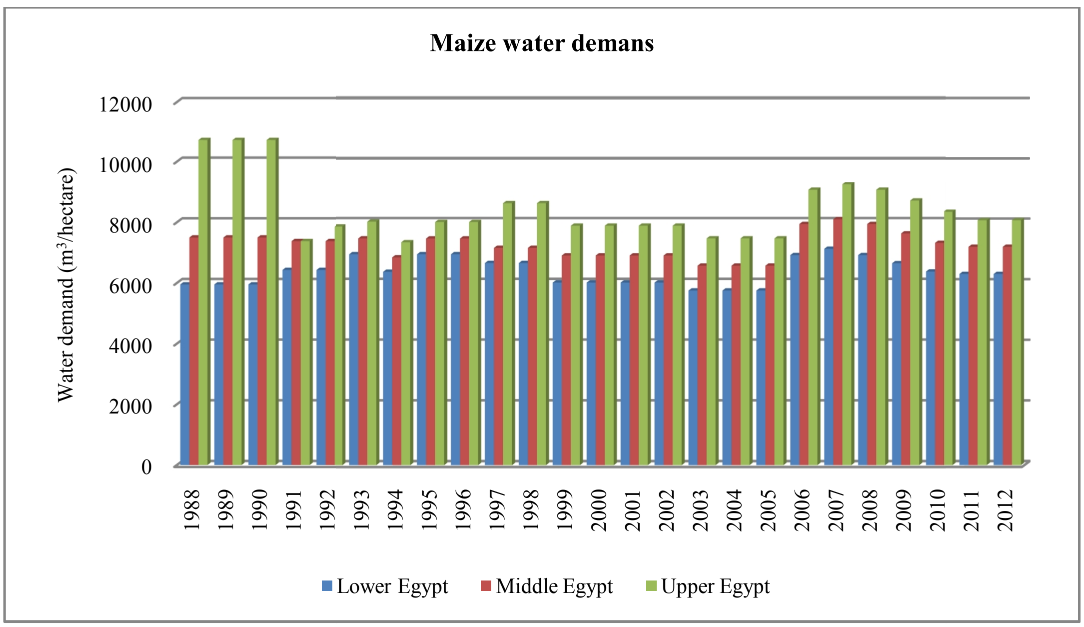
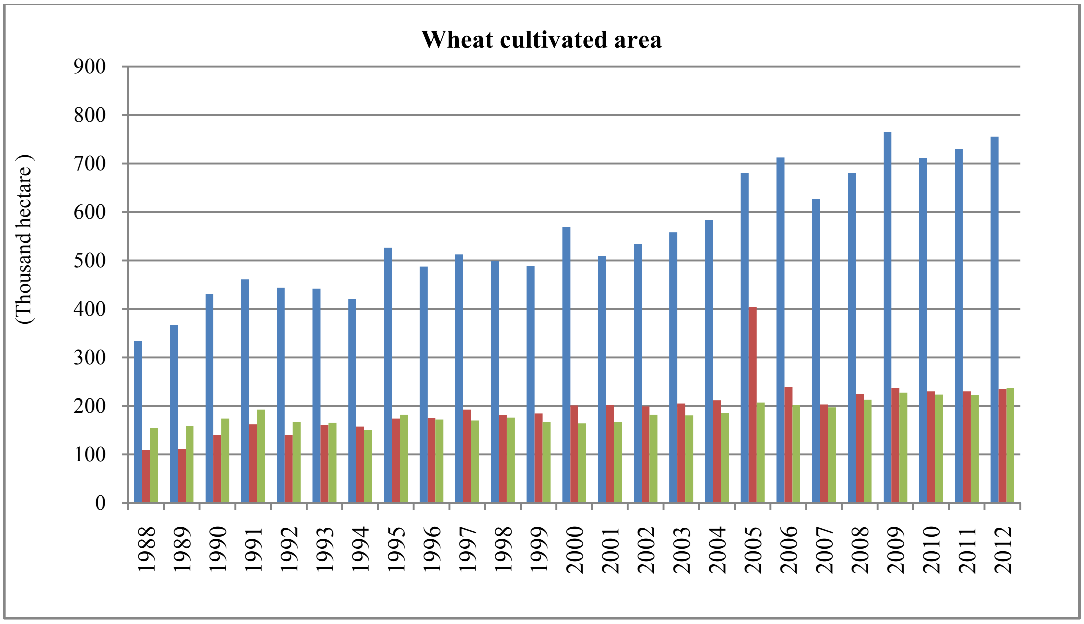


Fig. 1. Water demand for wheat and maize in lower, middle and upper Egypt from 1988 to 2012

3.1.3 Average productivity

As shown in (Fig. 3) the average productivity (ton/hectare) of wheat and maize crops was increased through the studied period from 1988th to 2012th. Inside the studied period years from 2000th to 2003th recorded the highest average productivity of wheat crop at Meddle and

Upper Egypt. However, Lower Egypt recorded the highest average in 2004th to 2007th. On other hand, the period 2004th to 2007th gave the highest average productivity of maize at Lower, Upper and Meddle Egypt, respectively.



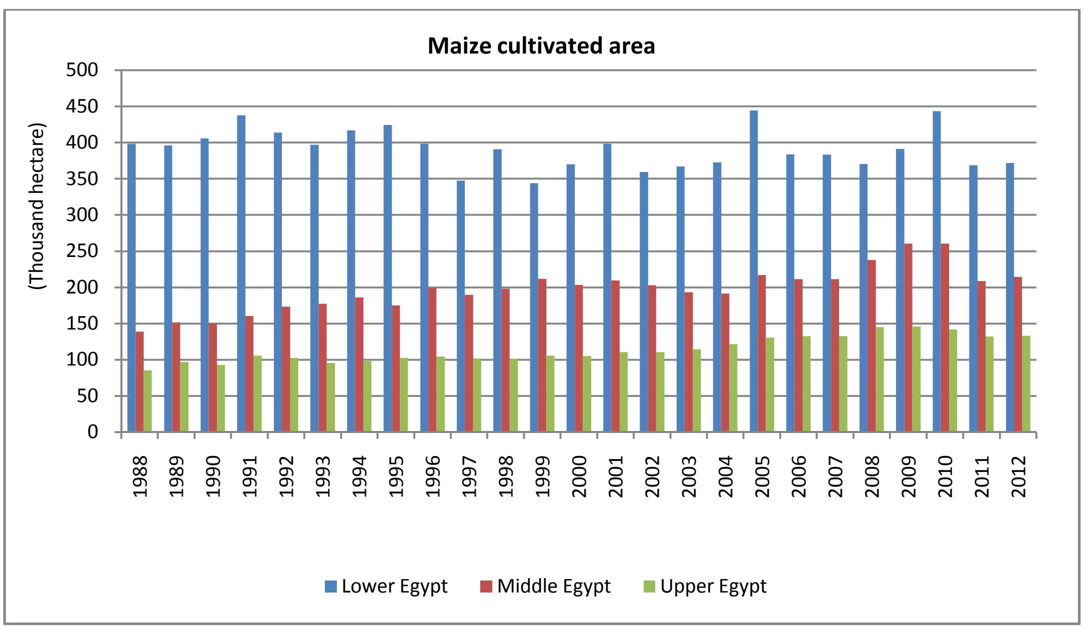
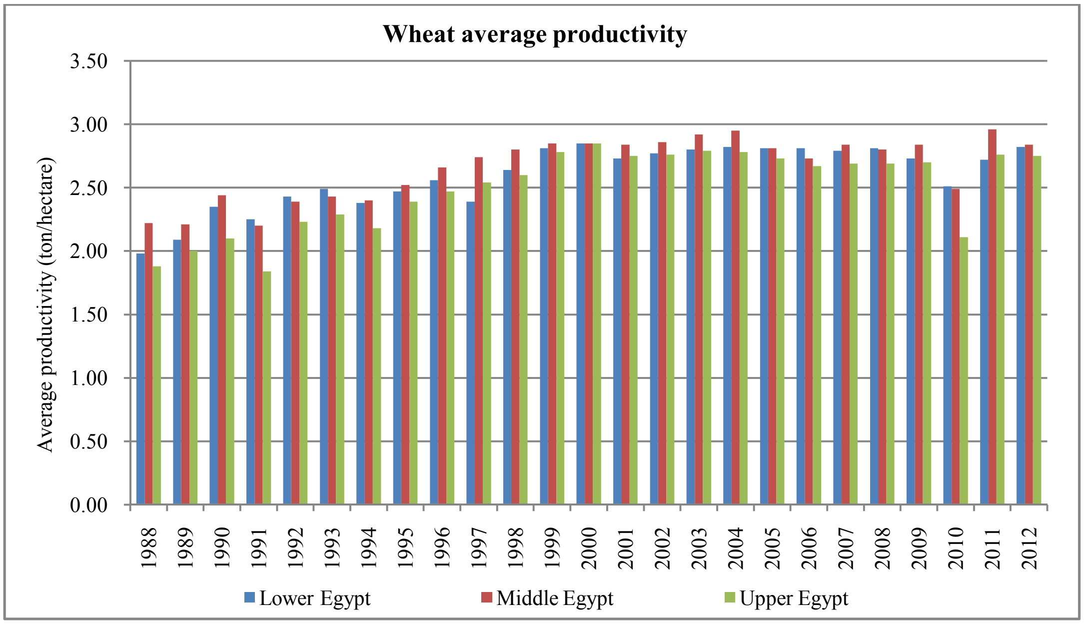


Fig. 2. Cultivated area for wheat and maize in lower, middle and upper Egypt from 1988 to 2012



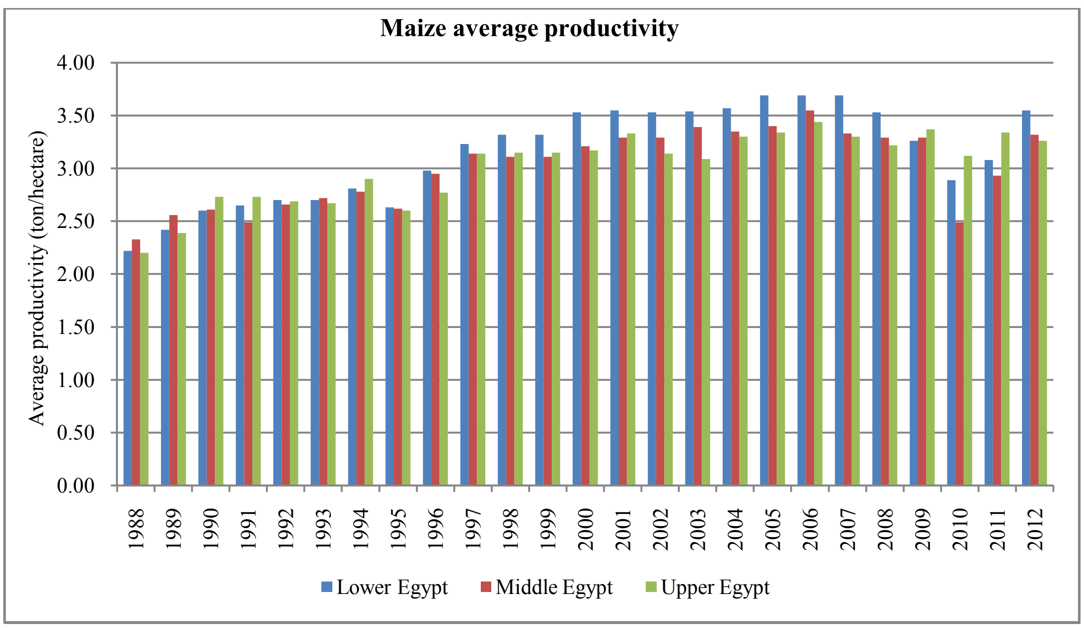
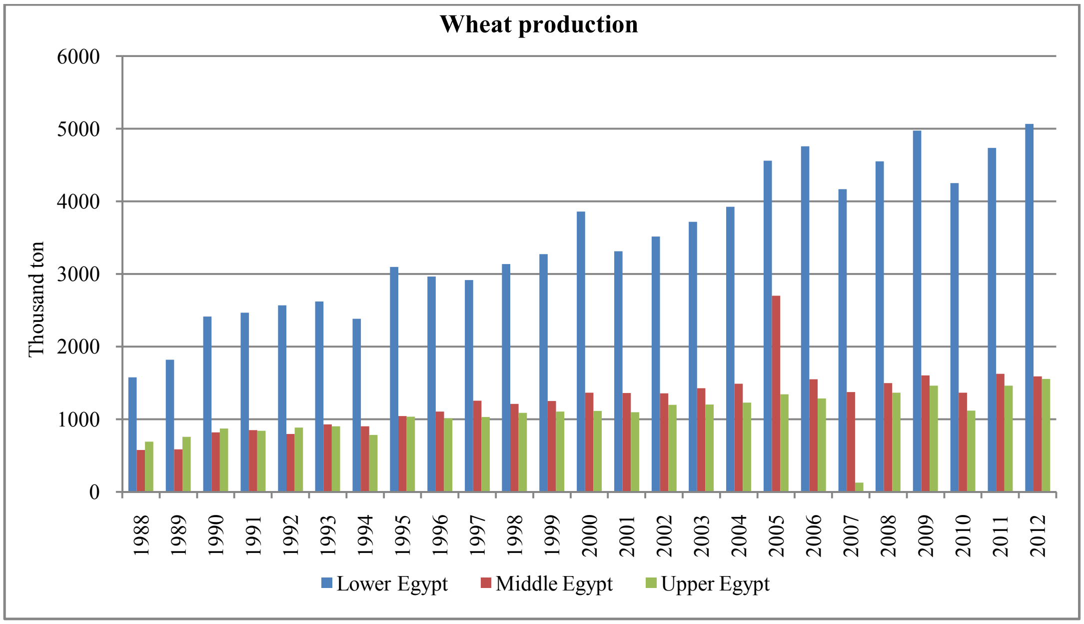


Fig. 3. Average productivity for wheat and maize in lower, middle and upper Egypt from 1988 to 2012



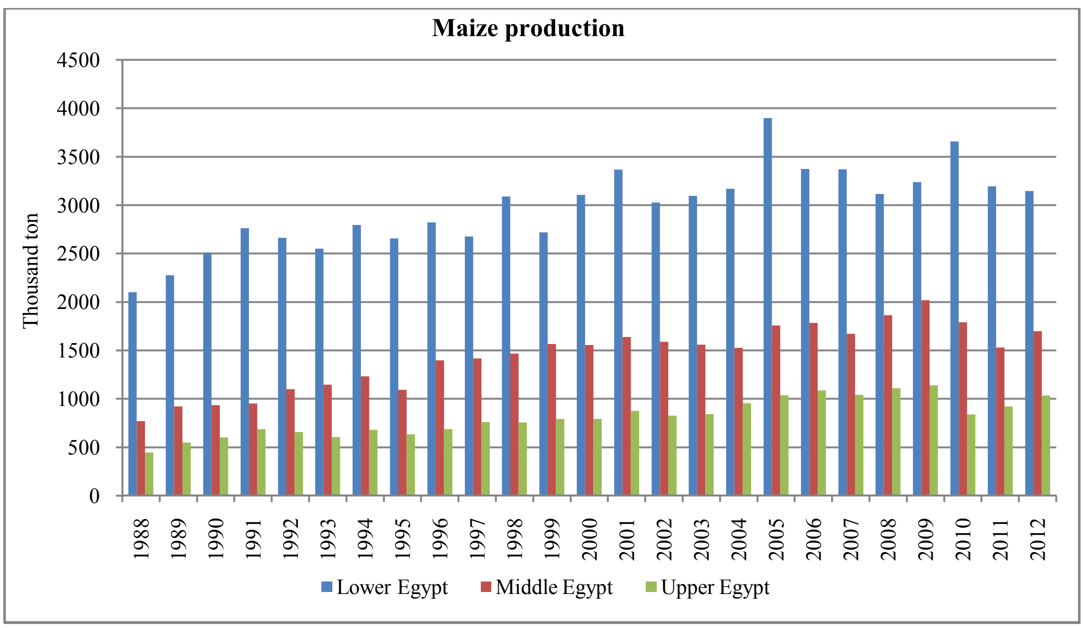


Fig. 4. Production of wheat and maize in lower, middle and upper Egypt from 1980 to 2012

3.1.4 Production

Data presented in (Fig. 4) showed the production (thousand ton) of wheat and maize from 1988th to 2012th. The obtained results reveal that the production of both crops was increased through the overall studied period at three district of Egypt. It's clear that greatest production values of wheat crop were observed in the year 2012 at Lower Egypt, in year 2005 at Middle Egypt and in years 2009, 2011 and 2012 at Upper Egypt. Moreover, the highest maize productions were found in year 2005 at Lower Egypt and in year 2009 at Middle and Upper Egypt, respectively.

3.2 Future Statement

3.2.1 Water demand

It's concluded from data in (Fig. 5) that water demand for both wheat and maize will be increased because of the projected increments in wheat and maize evapotranspiration that done by Eid et al. [35]. But, the general trend for water demand through the three studied district (Lower, Middle and Upper Egypt) will not change. In other words, the highest water demand will be estimated in Upper Egypt followed by Middle Egypt and Lower Egypt will be the lowest water demand. The only estimated change will be in the amount of needed water for both studied crop.

Moreover, same emphasize about increasing the water demand for both studied crops was obtained when calculating water demand depending on the prediction for the future evapotranspiration that done by Attaher et al. [28,36]. In addition, illustrated data in (Fig. 6) add more clarification and specific description about the predicted future water demand in specific years (2025, 2050 and 2100) for both wheat and maize using tow IPCC's SRES scenarios.

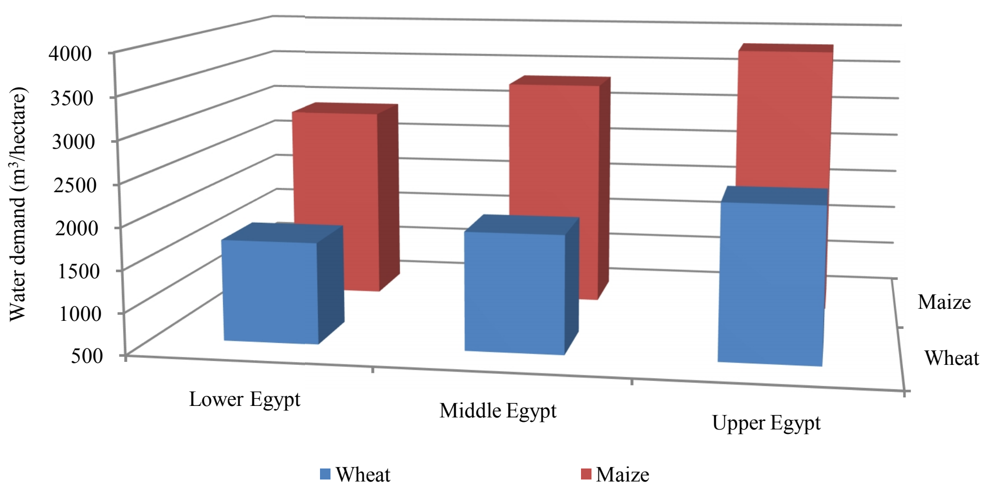


Fig. 5. Water demand for wheat and maize under lower, middle and upper Egypt conditions using CROPWAT model under climate warming conditions

Depending on the presented data in (Fig. 6) it's concluded that, the rate of increment could be continued through the above mentioned years to reach the highest water demand in the year 2100 for both wheat and maize under the circumstances of the two scenarios. Regarding to the given results by each scenario, it's obvious that the second scenario "B1" presented lower amount of water demand for both studied crops comparing to the first scenario “A1” for years 2025, 2050 and 2100 and for all studied areas (Lower, Middle and Upper Egypt).

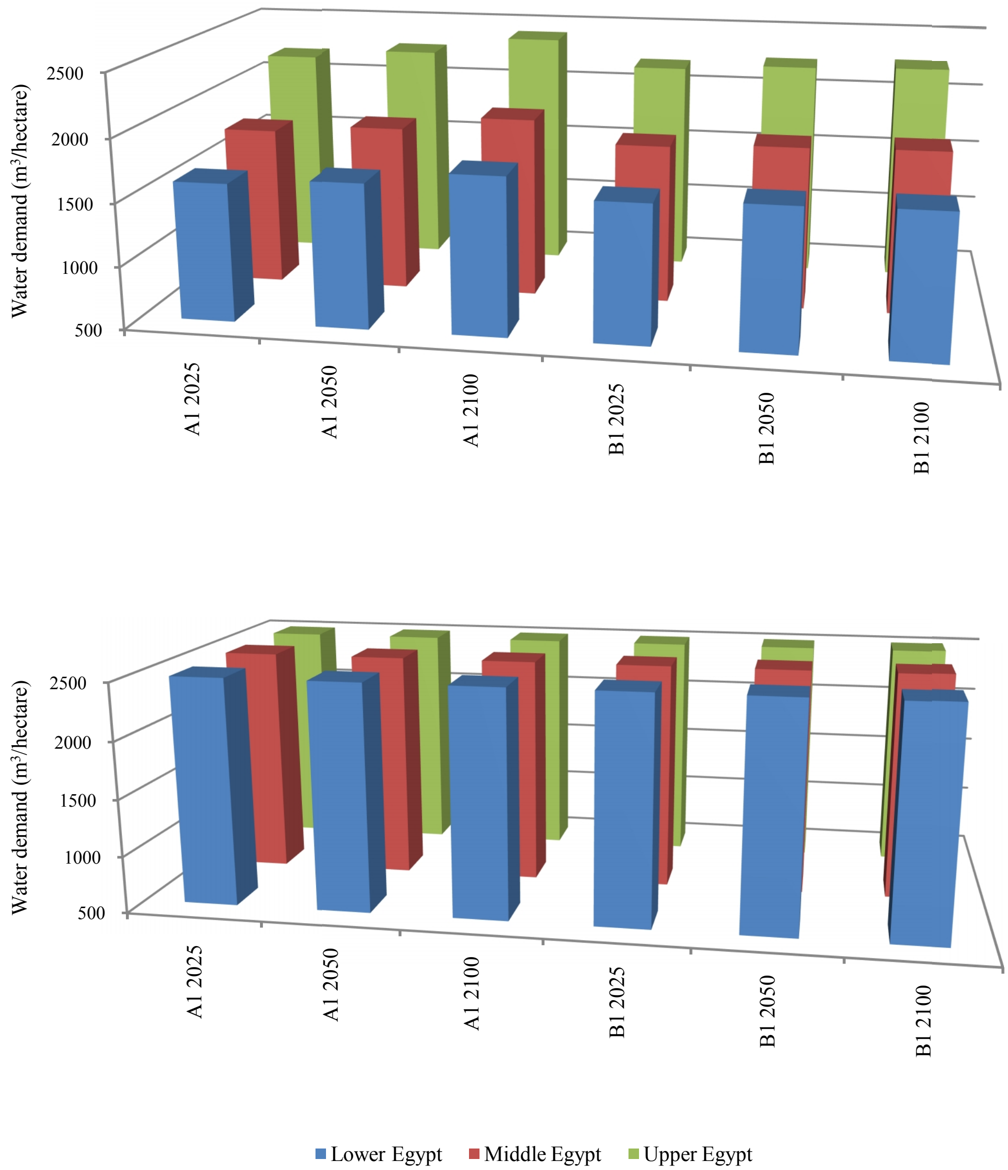


Fig. 6. Water demand for wheat and maize under A1 and B1 IPCC SRES scenarios for 2025s, 2050s and 2100s under lower, middle and upper Egypt

More emphasize about increasing the water demand for maize was found when calculating the water demand for the tow crops using the future prediction for Et_o that done by El-Marsafawy et al. [30,31] employed the DSSAT and CROPWAT simulation models. It’s concluded from (Fig. 7) that, amount of needed water for the mentioned crop will be increased and such increment will be varying regarding to the zones in Egypt (Lower, Middle and Upper). Also, the amount of increments recorded high values when the temperature arises by 3.5ºC comparing to 1.5ºC.

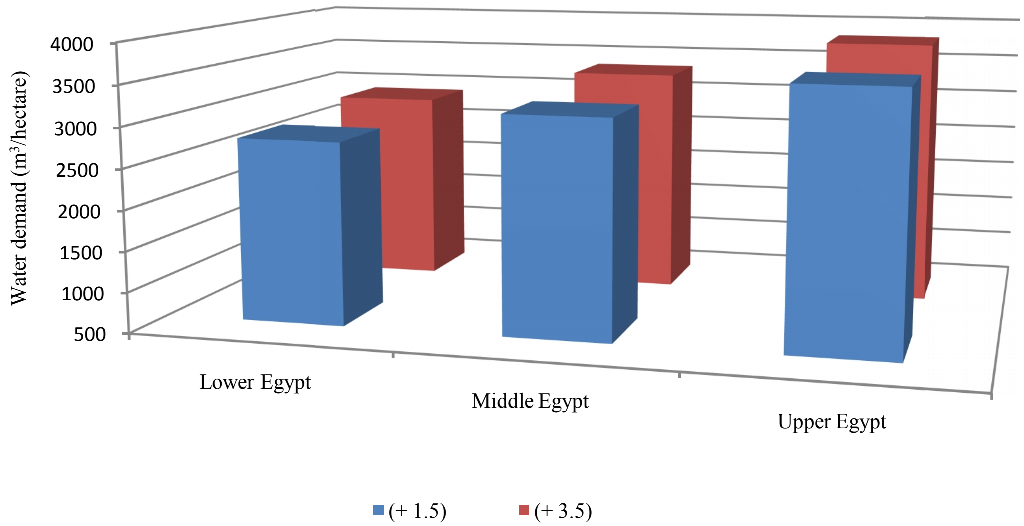


Fig. 7. Water demand for maize using DSSAT and CROPWAT simulation models under lower, middle and upper Egypt

3.2.2 Production

According to the presented data in (Figs. 8 and 9), notice a shortage in predicted production of two crops studied under two climatic change scenarios (A1 and B1) in predicted years (2025, 2050 and 2100). Furthermore, the greatest shortage observed with tested scenarios and crops in 2100, while, the lowest shortage obtained with two scenarios and crops in 2025. The measured differences were (-5.63, -5.76% and -6.3, -6.44%), (-15.0, -15.36% and -12.93, -13.24%) and (-36.0, -38.4% and -20.21, -21.34%), respectively, between current production (2012) and estimated production (2025, 2050 and 2100) for wheat and maize crops under (A1 and B1) scenarios conditions. These results are in harmony with those of Eid et al. [25], Khalil et al. [26], Ibrahim et al. [27], Abou-Hadid [37] and Hassanien and Medany [38].

3.2.3 Prices

Data in (Fig. 10) showed that estimated change in price for wheat and maize crops under both climate change scenarios (A1 and B1). The highest estimated change in price was detected with two scenarios and both crops in 2100. However, the lowest estimated change in price was recorded with A1 and B1 scenarios and wheat and maize crops. The measured differences in estimated price were about (+21.75, +29.4%), (+43.5, +58.8%) and (+87.0, +117.6%) for wheat crop and (+43.65, +53.15%), (+87.3, +106.3%) and (+174.6, +212.6%) for maize crop, between current price in 2012 and each of estimated prices in 2025, 2050 and 2100 under climate change scenarios A1 and B1, respectively. Generally, the greatest values for estimated price were detected with climate change scenario (B1) with both tested crops during 2025, 2050 and 2100 compared to climate change scenario (A1). The increasing values of estimated price might be attributed to redaction of estimated production of both growing crops under climate change conditions (increase the air temperature) which, lead to increase water demand per hectare. These finding are in accordance with those of Attaher et al. [28], Hassanein et al. [29], El-Marsafawy et al. [30,31], Nelson et al. [33] and Attaher et al. [36].

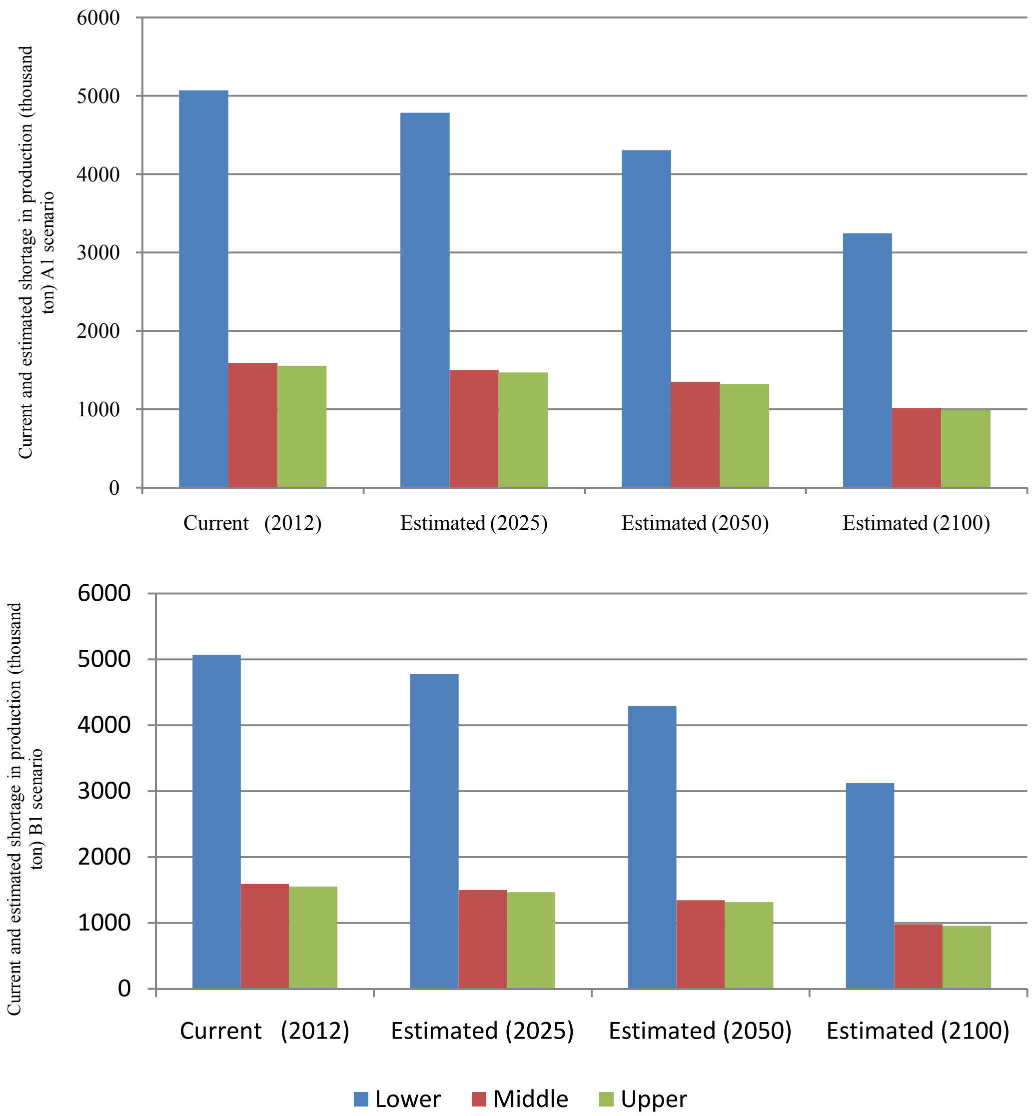


Fig. 8. Current and estimated shortage in wheat production under two climatic change scenarios (A1 and B1)

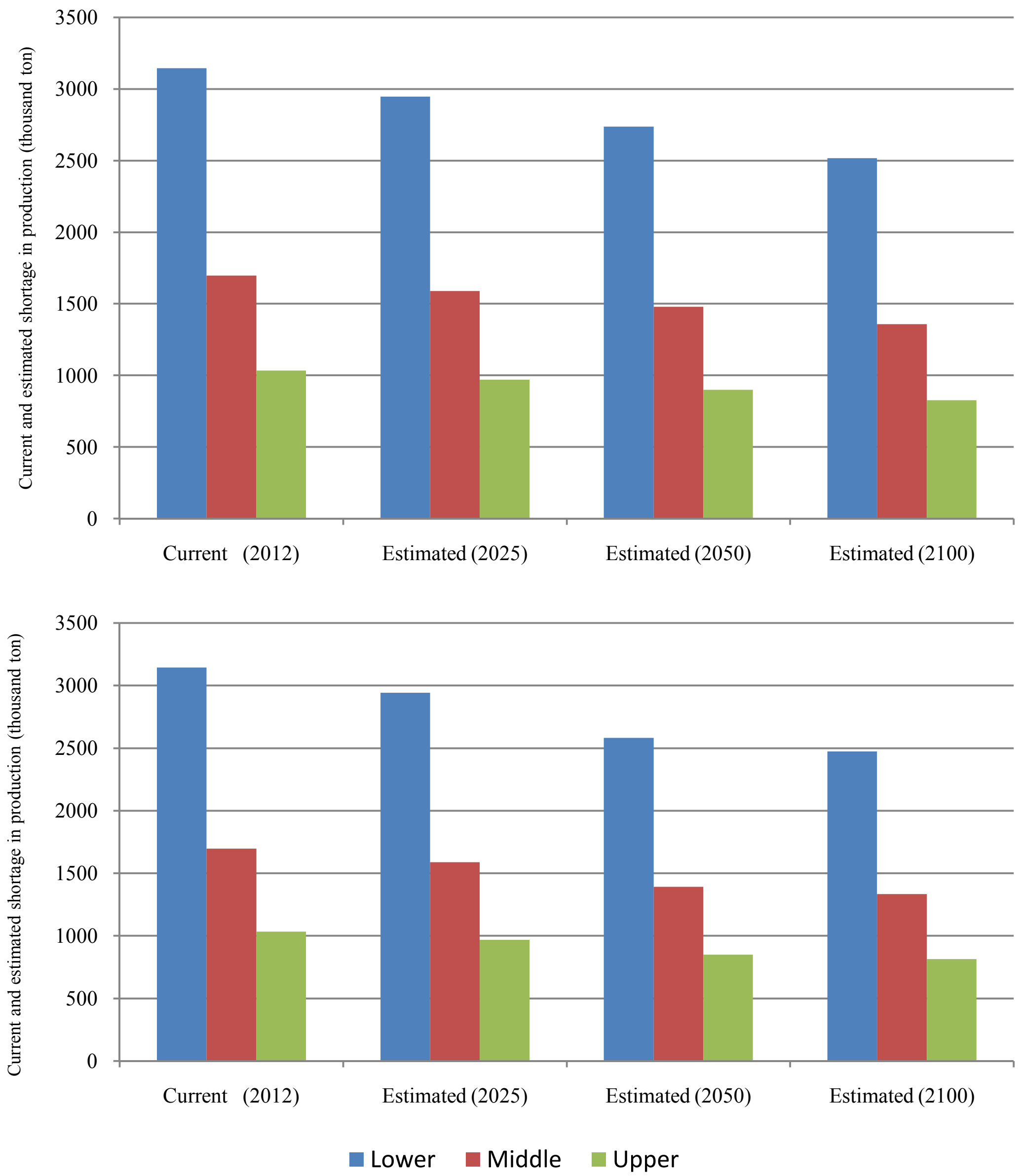


Fig. 9. Current and estimated shortage in maize production under two climatic change scenarios (A1 and B1)

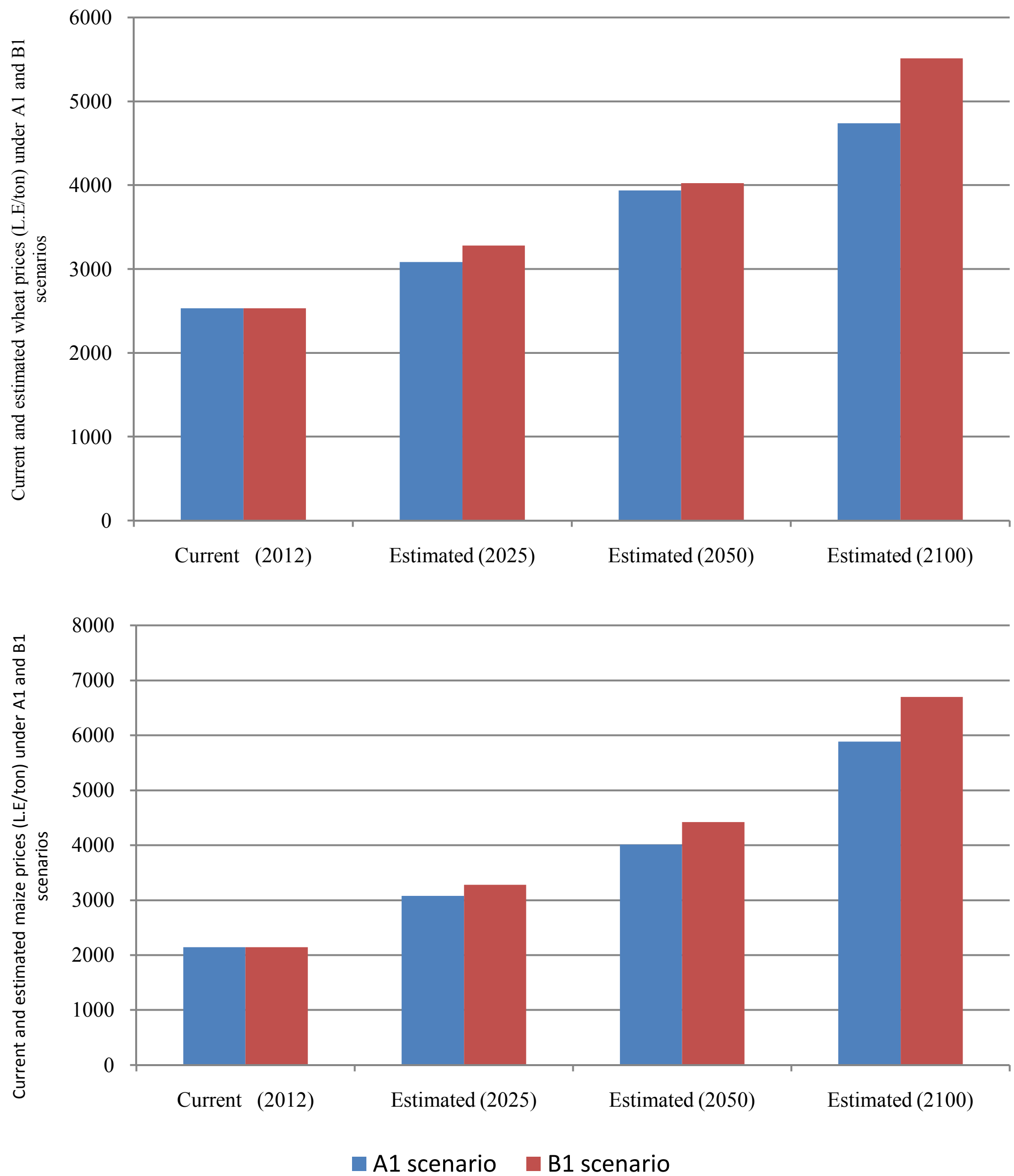


Fig. 10. Current and estimated prices for wheat and maize under two climatic change scenarios (A1 and B1)

3.2.4 Water use efficiency

Data in (Figs. 11, 12, 13 and 14) decided that water use efficiency (WUE) for both crops was affected by climatic zones. Results obtained that Lower Egypt recorded the highest values of WUE followed by Middle Egypt, when, the lowest values were recorded with Upper Egypt. This is lead to reduction of production and increasing the water demand at Upper Egypt compared with Lower Egypt. In the same time, WUE affected also by using climate change scenarios (A1 and B1). The lowest WUE values were observed during the estimated year

2100 followed by estimated year 2050 and 2025 under both scenarios A1 and B1 compared with current climate condition for two crops. These results were in agreement with those reported by Kattge and Knorr [12].

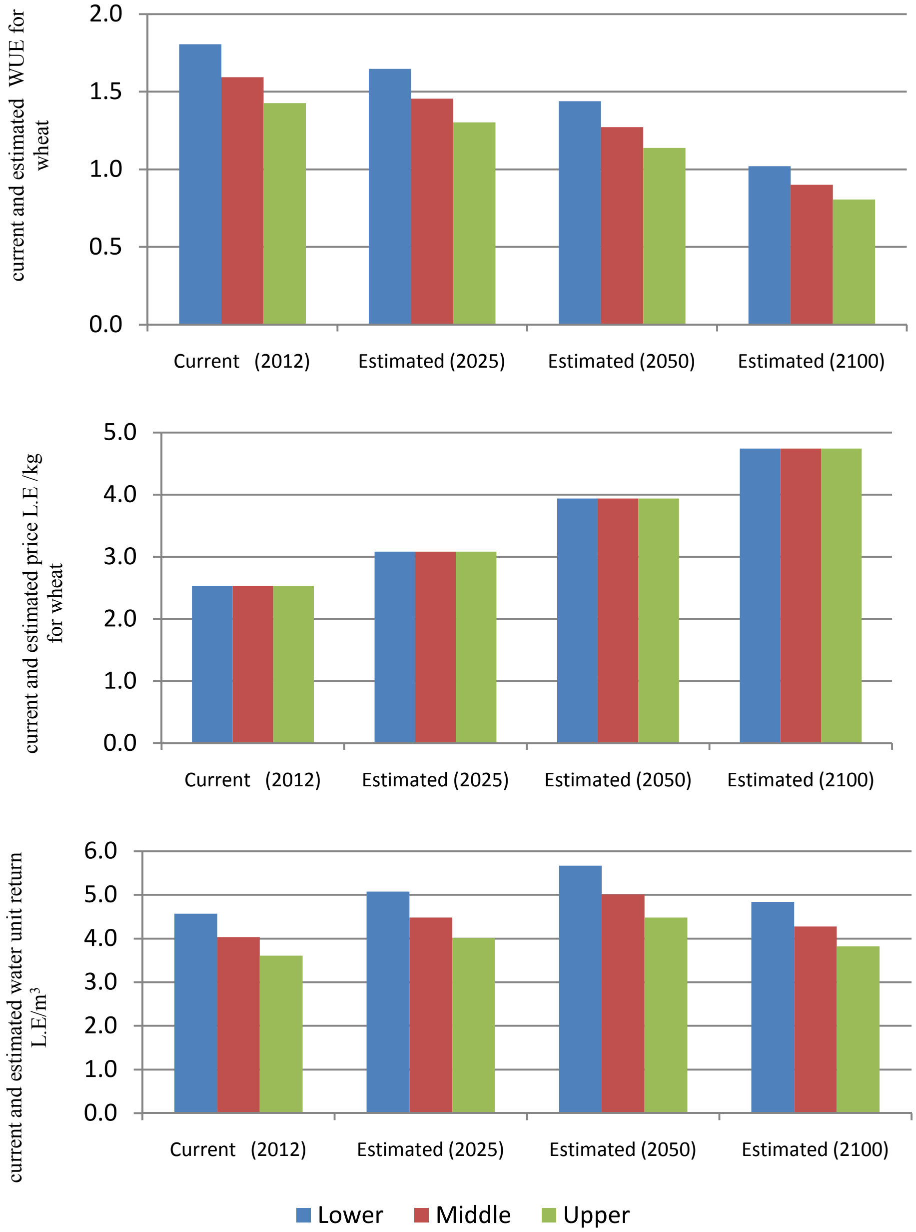


Fig. 11. Current and estimated water use efficiency, prices and water unit return for wheat under A1 climate change scenario

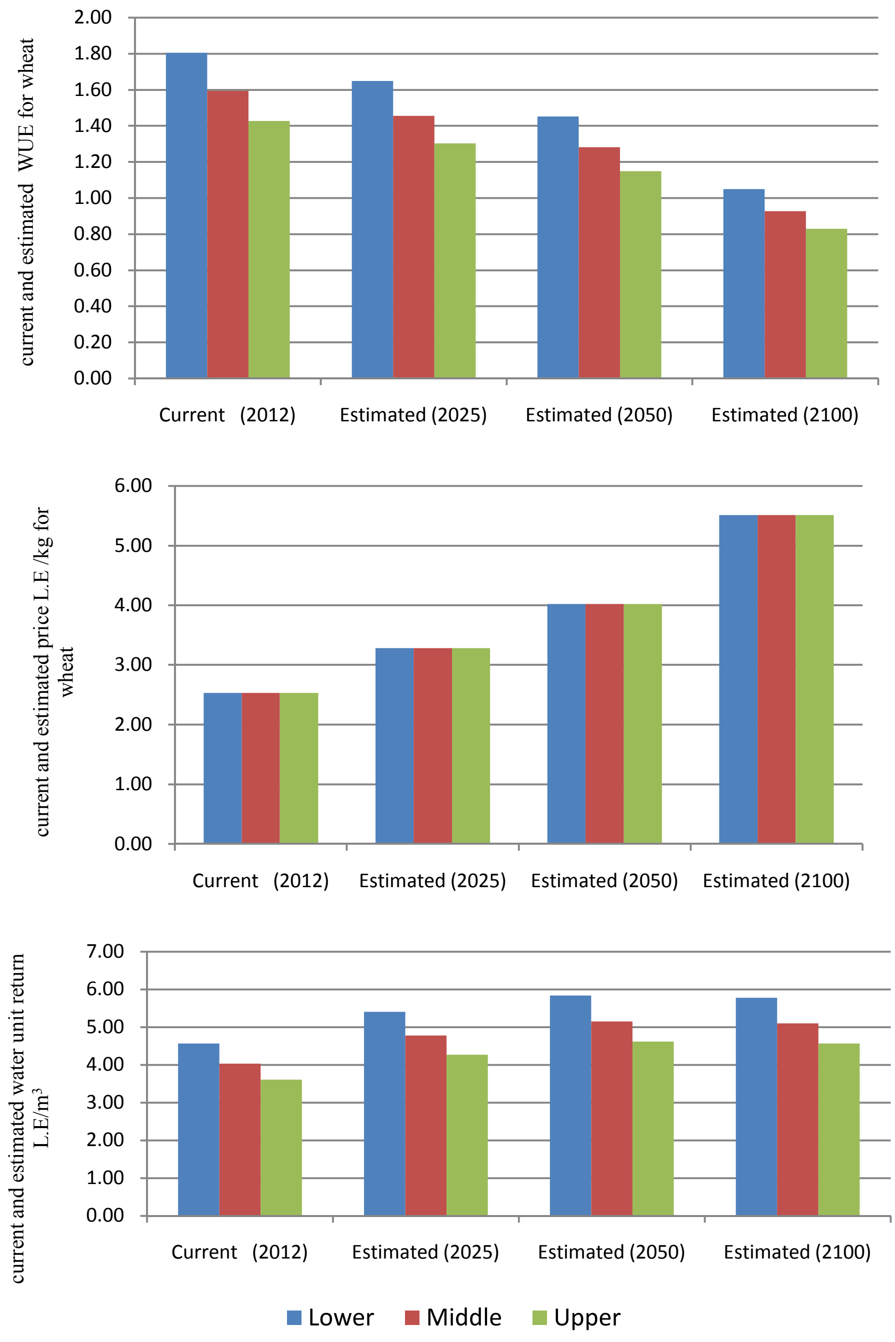


Fig. 12. Current and estimated water use efficiency, prices and water unit return for wheat under B1 climate change scenario

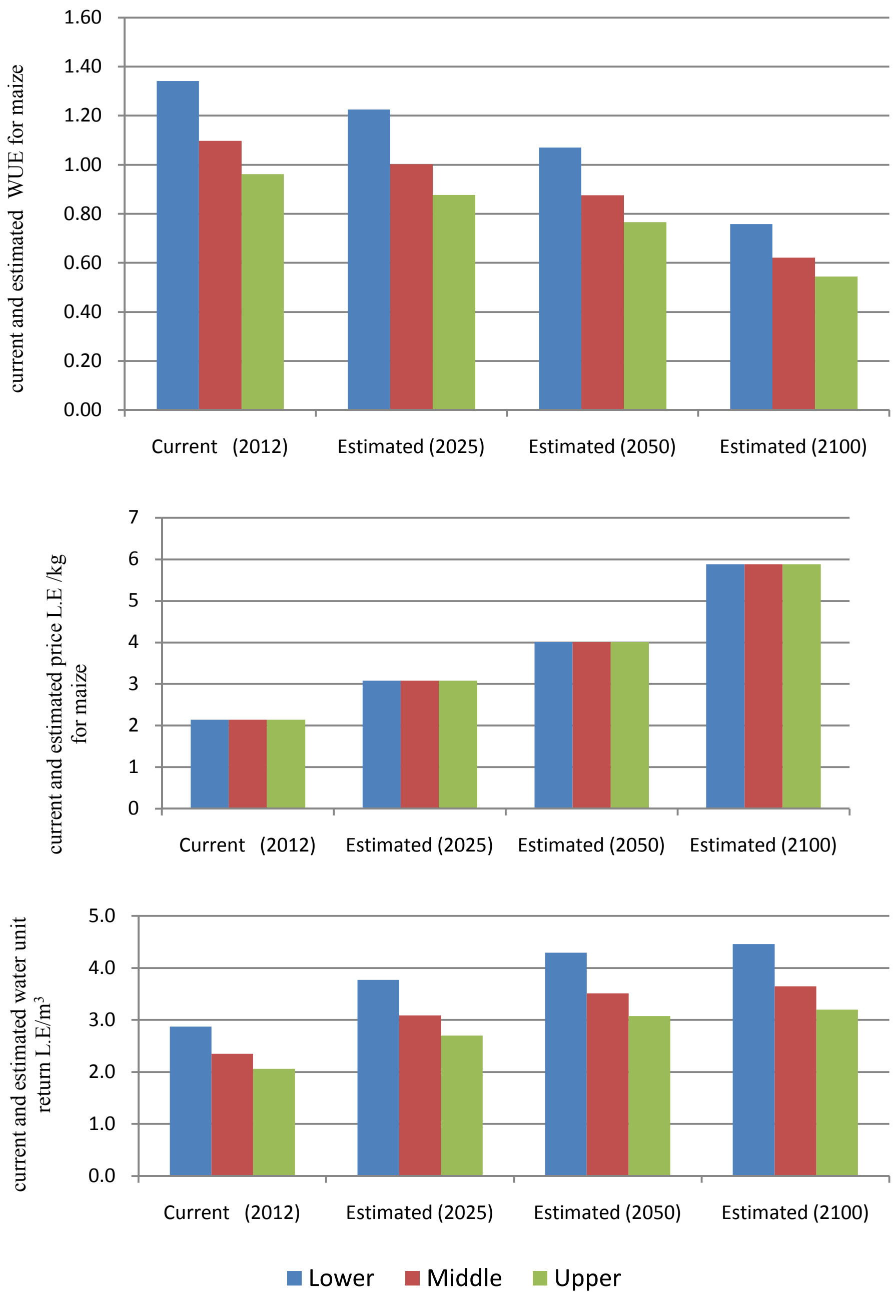


Fig. 13. Current and estimated water use efficiency, prices and water unit return for maize under A1 climate change scenario

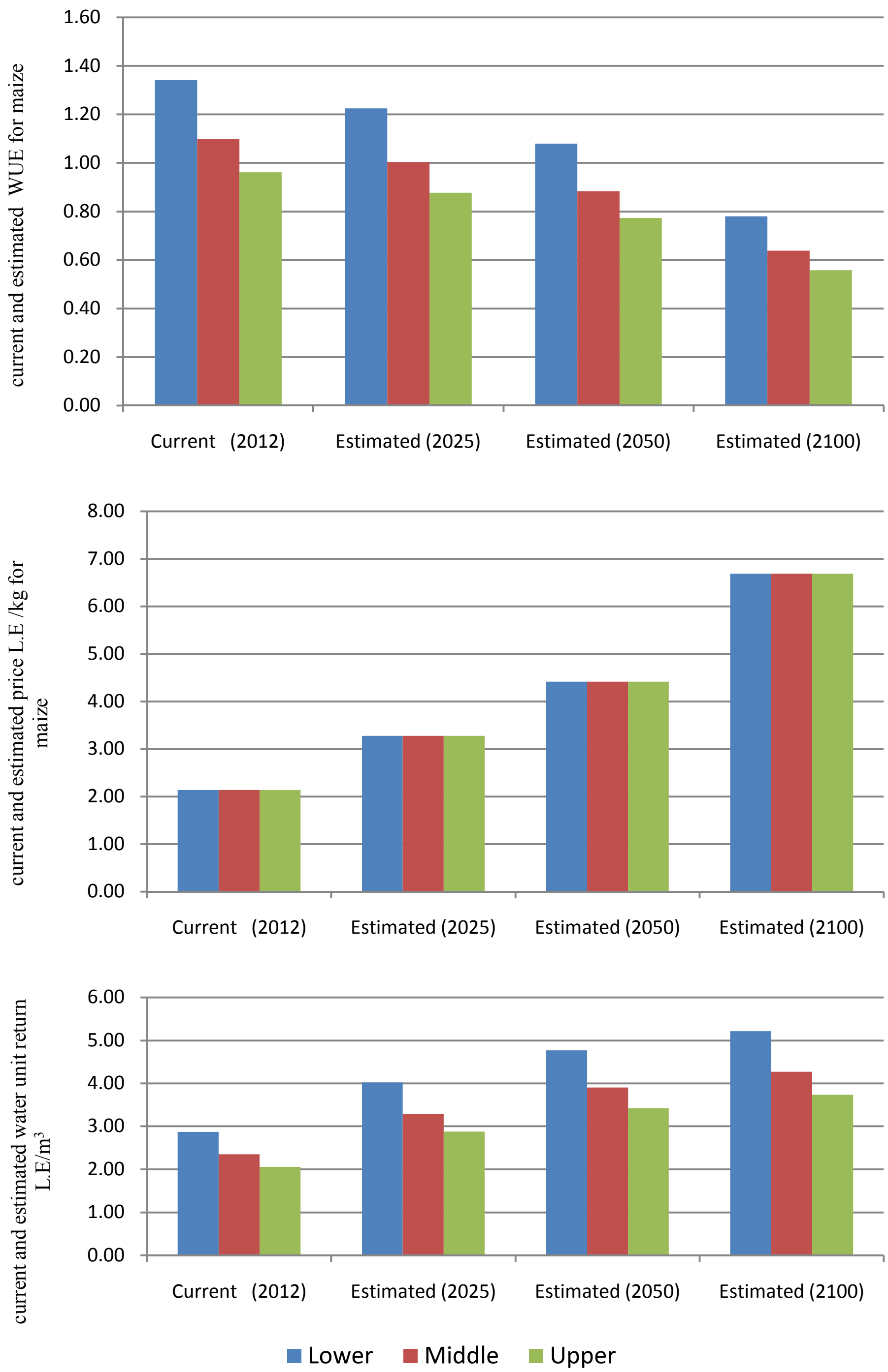


Fig. 14. Current and estimated water use efficiency, prices and water unit return for maize under B1 climate change scenario

3.2.5 Return of water unit

Furthermore, from data in (Figs. 11, 12, 13 and 14) it's noticed that the return of water unit L.E/m^3 for two tested crops was significantly affected negatively by increasing prices L.E/Kg, increasing water requirements/hectare, shortage at production/hectare and reduction of WUE, all together for both crops at three estimated years (2025, 2050 and 2100) under two climate change scenarios (A1 and B1).

On other hand, the greatest reduction values for water return were detected in Upper Egypt. When, the lowest reduction in the water unit return values obtained with Lower Egypt. This trend was true under current and estimated years under the two climate change scenarios. These finding are in agreement with those of Jones and Thornton [32] and Nelson et al. [33].

4. CONCULUSION

In this investigation its concluded from the overall analysis (however obtained from review literatures or done inside the study) that, different methods and models used to analysis effect of climate change reflected a negative effect for the future increments in air temperature on both studied crops water demand, production, prices, water use efficiency (WUE) and return of water unite.

Regarding the negative effect on water demand, analysis showed that water demand for both studied crops will be increased. Such increment will record the highest level in Upper Egypt followed by Middle Egypt and Lower Egypt, in descending order. The obtained increment on water demand will record the highest level in the year 2100 followed by the year 2050. Moreover, lowest level of increment will be found in the year 2025.

Concerning wheat and maize production and productivity, both climate change scenarios (A1 and B1) present a future decrement in wheat and maize production and productivity. The mentioned shortage in production and productivity will be sharp in Lower Egypt compared to other two districts (Middle and Upper Egypt). Moreover, level of decrement in both studied crops will be in the same range in Middle and Upper Egypt. Levels of shortage or decrements in both studied crops will be increased continuously with the time. This is mean the highest level of decrement will be found in the year 2100 followed by the year 2050. Moreover, lowest level of decrement will be found in the year 2025.

Focusing on both wheat and maize prices, both climate change scenarios A1 and B1showed that, price will continue move up in the future. Such movement will reach the highest level in the year 2100 compared to the other two estimated years 2025 and 2050. The climate change scenario B1 present higher level of prices move up compared to A1 scenario for the three estimated years 2025, 2050 and 2100.

Highlighting on water use efficiency, both used climate change scenarios showed that water use efficiency will be decreased in the future. In addition, water use efficiency will record the highest level of decrement in Upper Egypt compared to other two districts (Middle and Lower Egypt). The lowest water use efficiency estimated in the year 2100 followed by the year 2050 and finally the year 2025 compared to the current status. The mentioned decrement in water use efficiency considered as a normal results for increasing the water demand and the reduction in production and productivity for both studied crops.

About the return from the water unit, both climate change scenarios A1 and B1 showed that the money return from the water unit will be increased in the future. Highest water unit return estimated in the year 2100 followed by the year 2050 and the year 2025 in descending order compared to the current status (2012). The return from the water unit estimated to be higher in Lower Egypt than Middle Egypt. Moreover, the lowest water unit return estimated Upper Egypt. In addition, the water unit return will be increased compared to the current status (2012) to record the highest level in the year 2100.

Such increment in water unit return does not present a real value. But, this increment is a result for the reduction in both production and productivity, which will create a high demand for those crops without availability in markets to cover this demand. This unbalance between production and demand will due to this illusion in water unit return.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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