IMPACT OF CLIMATE CHANGE ON IRRIGATION WATER REQUIREMENTS FOR SUGAR CANE PRODUCTION IN EGYPT

H. A. Radwan*

ABSTRACT

Global climate change should pose serious impacts on water resources and agriculture in the future. The aim of this research was to calculate water requirements for sugarcane grown in 7 governorates in Egypt under current climate and under ongoing climate change scenario up to 2100. The results indicated that water requirements for sugarcane will increase by 12 %–18% compared to the current water use depending on governorate location., where the applied irrigation amount is expected to increase in all governorates under climate change water requirements due to long growing season (365 days) of sugar cane, its water requirements under climate change conditions increased by 11–19%. This study investigates the projected changes in evapotranspiration and irrigation water demand for sugar cane crop Middle and Upper Egypt. The mean air temperature as statistically downscaled and compared with the current climate, defined as the period 1971–2000. FAO-56 Penman-Monteith equation was implemented to estimate ETo by using current climatic data. Evapotranspiration is estimated based on the predicted maximum and minimum air temperature using the RCPs scenarios (RCP2.6 – RCP4.5 – RCP6.0 and RCP8.5) during three time series (2011-2040, 2041-2070 and 2071-2100). The obtained results revealed that the mean air temperatures were increased under all RCPs scenarios compared to current data. Moreover, the RCP8.5 had the highest mean air temperature compared to the other RCPs scenarios. ETo significant increased in different tested time series compared to the current ETo values. The values of irrigation water demands in long term time series (2071-2100) were higher than short term (2011-2040) or mid-term (2041-2070) with respect to the current situation.

***Senior Res., Agricultural Engineering Research Institute, Agricultural Research Center, Dokki, -Egypt**

The estimation of water requirements for sugar cane crops in different agro-climatic zone show that Upper Egypt region has the highest Cultivated area of sugar. Total water requirements (WR) for sugar cane during the growing seasons revealed that WR will increase under all scenarios in comparison with the current conditions. Total water budget in Middle and Upper Egypt. For sugar cane crop will increase under all scenarios compared with the current conditions and ranged from 4, to 4,56 billion cubic meters in or mid-term (2041-2070). Total water budget in Middle and Upper Egypt. For sugar cane crop will increase under all scenarios compared with the current conditions and ranged from 4,0 to 4,8 billion cubic meters in (2070-2100). This paper suggested a adaptation options for better water management for sugar cane crop Middle and Upper Egypt region, such as Gated pipe system consumed total water budget in Middle and Upper Egypt. For sugar cane crop will increase under all scenarios compared with the current conditions and ranged from 2.8 to 3.26 billion cubic meters in or mid-term (2041-2070) . Total water budget in Middle and Upper Egypt. For sugar cane crop will increase under all scenarios compared with the current conditions and ranged from 2.9 to 3.3 billion cubic meters in 2070-2100) compare with 4,0 billion cubic meters in flooding system now .

Keywords: *Downscale climatic data- Maximum and minimum temperature - Penman-Montheith equation- RCPs scenarios.*

INTRODUCTION

Egypt is one of developing country with a large population with large consequent food demands but limited water resources. Egypt currently faces a tight water future. water gap in Egypt will reach 21.0 billion m3 by the year 2025 Sanchez et al(2005) even in the absence of climate change with competition increasing El-Raey (1999). Agriculture the major water consumer AbouZeid (2002). Climate change will alter agricultural water use and potentially increasing demand. Effects on crop water use, have been studied, under Egyptian conditions in scattered and limited studies (El-Marsafawy, Eid (2001)and Medany(2001) IPCC (2013) investigates the projected changes in water use for a major Egyptian crop, sugar cane using the latest climate change projections. Reliable predictions of climate change impacts on water use, irrigation requirements and yields of irrigated sugarcane are necessary to plan adaptation strategies. The agricultural sector is a major freshwater consumer and around 70% of the world's freshwater withdrawal is for irrigation Scanlon et al (2007). Demand for freshwater has been increasing continuously with growing world population and economic development. It is anticipated that water withdrawal, especially for agriculture, will increase by 50% in developing countries by 2025 (base year 2000), and 18% in developed countries (UNEP 2007). WWDR (2012) has also reported that the global water consumption of agriculture is predicted to increase by 19% or to reach to 8515 km3 per year by 2025. Moreover, the water shortage is further exacerbated by the increase in variability of water distribution due to the impacts of climate change. To estimate water use by the crop, the most widely accepted model which derives evapotranspiration (ETc) for crops growing with adequate water, nutrition and free of pests and diseases, from a reference evapotranspiration (ETo) which is determined by Penman-Monteith model and crop coefficient (Kc) that are used to convert ETo to ETc for a particular stage of development (Allen et al. 1998). This is important for the sugar industry, not only for irrigation scheduling, but for increased water-use efficiency. Allen et al. (1998) reported that values of Kc for sugarcane is 0.4 and 1.25 for the initial (low canopy) and mid (full canopy) and 0.7 for the end (harvest) respectively. Confirmed the values for the initial and mid periods of development Inman-Bamber and McGlinchey (2003) but Kc = 1.25 is higher than Allen et al.'s final stage, provided water was not limiting. They found that measured ETc seldom exceeded 7 mm day-1. The challenges faced by the agricultural sector under the climate change scenarios are to provide food security for an increasing world population while protecting the environment and the functioning of its ecosystems (Rosenzweig *et al*. 2012). For countries that are highly dependent on natural resources, these challenges may be amplified by extreme events having social and economic impacts that far outweigh their apparent probabilities of occurrence (Thornton *et al.* 2009). The term crop water requirement is defined as the amount of water required to compensate the evapotranspiration loss from the cropped field (USDA Soil Conservation Service 1993) describes it as the total water needed for evapotranspiration, from planting to harvest for a given crop in a specific climate, when adequate soil water is maintained by rainfall and/or irrigation so that it does not limit plant growth and crop yield. Although the values for crop evapotranspiration and crop water requirement are identical. Crop water requirement refers to the amount of water that needs to be supplied, while crop evapotranspiration (ETc) refers to the amount of water that is lost through evapotranspiration (Allen et al. 1998). Climate change has been identified as one of the major challenges facing the world today, and there are concerted efforts at a global level to reduce the emissions of greenhouse gases (GHGs) which contribute to global warming. It has increasingly been recognized that emissions of GHGs are not only related directly to energy conversion (which no doubt is amajor contributor), but also indirectly through the consumption of goods and services. In this regard it has become widely acknowledged that sustainable consumption and production are imperative to maintain sustainable economies in the face of population growth as well as increasing living standards (Clark, 2007; Tukker *et al.,* 2007). According to Challinor *et al*. (2007), climate change is anticipated to increase temperature and vary rainfall patters. To date global mean temperatures have increased by about 0.7°C since mid-1800s although the temperature increase is not uniform (IPCC, 2007). The semi-arid regions that appear to have relatively ample water supplies for agriculture under the current climate are all most likely to be adversely affected due to an increase in water demand for irrigation projects under a warmer climate (Krol, and Bronstert, 2007). The increase in temperature due to climate change is also likely to alter the net daily evaporation which is essential in irrigation scheduling.. High net daily evaporation due to high temperatures may cause water stress in sugarcane. It is highly likely that more frequent irrigation cycles will be done to meet the demand of the crop and evaporation (Chandiposha, 2013). However, high temperatures is likely to negatively affect sprouting and emergence of sugarcane (Rasheed *et al.,* 2011). In addition, temperatures above 32°C result in short internodes, increased number of nodes, higher stalk fiber and lower sucrose (Bonnett *et al.,* 2006).Higher temperatures and changes in precipitation patterns are expected to increase irrigation water demand for crops. Based on a revised SRES A2 scenario, Fischer *et al*. (2007) estimated an increase in global irrigation water requirements of 45 percent between 2000 and 2080. Irrigation water requirements were projected to increase by around 50 percent in developing regions and 16 percent in developed regions. Knox *et al.* (2010) used the DSSAT-Canegro model to predict that expected climate change in the 2050s could increase sugarcane irrigation requirements in Swaziland by +9%, and sucrose yields by about 15%. The sugarcane crop is grown for 12 months, producing a vast quantity of cane per feddan, limiting physical access into fields. Traditional irrigation systems do not adapt to sugarcane with limited water. Against the background of the rapid decline in irrigation water potential and low water-use efficiency in the flood (conventional) method of irrigation (Hanafy *et al.* 2008). Sugar cane is one of the major strategic agricultural products in Egypt. It occupies the second status of importance after wheat. The sugar industry depends mainly on sugarcane product. In addition o its main uses in sugar production, it has several uses in producing juice, molasses and several minor products. Sugarcane is grown mainly in Upper Egypt. Its main producing governorates are: El-Minia, Sohag, Qena, Luxor, and Aswan. The total area under sugarcane in theses main producing governorates was 311000 faddan in 2011. The total production was 15398006 ton with an average productivity of 49.5 ton per faddan in the same year. Out of the total area under sugarcane, 82.5% of it was grown in Qena, Luxor and Aswan governorates. Also the same proportion of the total production was driven from these three governorates only (Ministry of Agriculture and Land Reclamation, Council of Sugar Crops (2012).Water scarcity in Egypt is a critical issue. The increasing demand for limited water resources puts pressure on the Ministry of Public Works & Water Resources to formulate policies and programs to improve water allocation. Various water users, in particular the agricultural sector. Must reconsider their requirements in order to overcome the problem of water scarcity and keep the national water balance in equilibrium. Sugar canes are a major crop in Egypt ,the present area of sugarcane (Saccarum officinarum) is about 311000 acer with a total commercial production of about 15.4 million ton/year cane or 49.51 ton/acre sucrose, Ministry of Agriculture and Land Reclamation, Council of Sugar Crops (2012)Table (1a, band c)

Table 1a: Areas and Production of Sugar Cane in the Main Producing Governorates in Egypt 2011

Governorate	Area (Faddan)	Production (Ton)	Productivity (Ton/Faddan)	% of total Area	% of total production
Menia	38757	1903162	49.11	12.5	12.4
Sohag	15663	790355	50.46	5.0	5.1
Qena	114247	5659796	49.54	36.7	36.8
Luxor	62190	3085308	49.61	20.0	20.0
Aswan	80143	3959385	49.40	25.8	25.7
Total	311000	15398006	49.51	100.0	100.0

Source: Collected and calculated from: Ministry of Agriculture and Land Reclamation, Council of Sugar Crops (2012).

Sugarcane is grown between 28°N and 24°N of the equator in Egypt. Optimum temperature for sprouting (germination) of stem cuttings is 32 to 38°C. Optimum growth is achieved with mean daily temperatures between 22 and 30°C. Minimum temperature for active growth is approximately 20°C. For ripening. A long growing season is essential for high yields. The normal length of the total growing period varies between 9 months with harvest before winter frost to 24 months in Egypt, but it is generally 15 to 16 months. Plant (first) crop is normally followed by 2 to 4 Raton crops, and in certain cases up to a maximum of 8 crops are taken, each taking about 1 year to mature. Sugarcane

Table 1b: Consumptive use and Field water requirements for major crop rotations in Middle and Upper Egypt

Crop Rotations	Consumptive use (m^3)		Field requirements (m^3)	
	M. Egypt	U. Egypt	M. Egypt	U. Egypt
Sugarcane	7170	9109	11381	14459

Source: Collected and calculated from: Ministry of Agriculture and Land Reclamation, Council of Sugar Crops (2012)

Table 1c: On-farm water requirements and yields for sugarcane by irrigation systems in Middle Upper Egypt, as an average for planting

Irrigation System	Water applied (m^3/fed.)	
	M. Egypt	U. Egypt
Traditional surface	11318	14459
Drip system	8121	8450
Gated pipes system	8474	9003

Source: Collected and calculated from: Ministry of Agriculture and Land Reclamation, Council of Sugar Crops (2012)

Does not require a special type of soil. Best soils are those that are more than 1 m deep but deep rooting to a depth of up to 5 m is possible. The soil should preferably be well-aerated and have a total available water content of 15 percent or more. When there is a groundwater table it should be more than 1.5 to 2.0 m below the surface. The optimum soil pH is about 6.5 but sugarcane will grow in soils with pH in the range of 5 to 8.5. Sugarcane is moderately sensitive to salinity and decrease in crop yield due to increasing salinity is: 0% at ECe 1.7 mmhos/cm, 10% at 3.3, 25% at 6.0, 50% at 10.4 and 100% at ECe 18.6 mmhos/cm. There are two major cultivation season for Sugar cane in Egypt: Spring cane season cultivated during February and March and Autumn plant cane season cultivate during September and October. The aim of this research was to study the effect of climate change on the water requirement for sugar cane and how to reduce the risks of climate change and ways of overcoming the risks of climate change.

MATERIAL AND METHODS

Climate change scenarios:

The IPCC (2013) released a set of climate change scenarios based on representative concentration pathways (RCPs).The RCP scenarios involve widely differing emissions pathways, reflecting differing levels of effectiveness in tackling emissions and climate change. The lowest, RCP2.6 is a very strong mitigation scenario, with CO_2 levels peaking by 2050 at ~443ppm. RCP4.5 has a continuing rise in CO_2 concentrations to the end of the century, when they reach ~538ppm. In RCP6.0, CO_2 concentrations rise more rapidly, reaching ~670ppmv by 2100. RCP8.5 continues current rapidly increasing CO_2 emission trends with CO_2 concentration reaching 936ppmv by 2100. Overall characteristics of these scenarios are given in Table 2.

Evapotranspiration calculation:

Evapotranspiration is a measure of crop water use and will be calculated, for both, current and future conditions using the Food and Agricultural Organization (FAO) Penman- Monteith (PM) procedure presented by **Smith and Pereira (1996)**. In this method, ETo is expressed as follows:

$$ET_o = \frac{0.408\Delta\,(R_n - G) + \gamma \frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34\,u_2)} \qquad (1)$$

where ETo is the daily reference evapotranspiration (mm day^{-1}), Rn is the net radiation at the crop surface (MJ m^{-2} day^{-1}), G is the soil heat flux density (MJ m^{-2} day^{-1}), T is the mean daily air temperature at 2 m height (°C), U_2 is the wind speed at 2 m height (m s^{-1}), e_s is the saturation vapor pressure (kPa), e_a is the actual vapor pressure (kPa), is the slope of vapor pressure curve (kPa °C^{-1}) and γ is the psychometric constant (kPa °C^{-1}).In application having 24-h calculation time steps, G is presumed to be 0 and e_s is computed here e^0 is the saturation vapor function and T_{max} and T_{min} are the daily maximum and minimum air temperature. The FAO Penman-Monteith equation predicts the evapotranspiration from a hypothetical grass reference surface that is 0.12 m in height having a surface resistance of 70 s m^{-1} and albedo of 0.23. The equation provides a standard to which evapotranspiration in different periods of the year or in other regions can be computed and to which the evapotranspiration from other crops can be related. Standardized equations for computing all parameters in Eq. (2) are given by **Allen *et al* (1998).** In turn the crop water requirement (WR), is calculated by multiplying the reference crop evapotranspiration, ET_o, by a crop coefficient, $K_c$following **(Allen *et al* ,1998).**

Climatic regions and data:

Egypt can be divided into several agro-climatic regions. The most important agro-climatic regions are: the Delta region, seven governorates (Kafr El-shiekh, Dakahlia, Sharqia, Ismailia, Portsaid, Suez and Cairo));the Middle Egypt region four governorates (Giza, Fayoum, Beni Suif and Menya) represented in this study by one governorate(Menya) and the Upper Egypt region represented by five governorates (Asyut, Sohag, Qena, Luxor and Aswan).Downscaled climate data for these regions were drawn from ClimaScope(http://climascope.tyndall.ac.uk/) for the concerned governorates and average data for each agro-climatic zone were computed. Data on maximum and minimum historic temperature (1971 to 2010) plus projections for different eras (2011-2040, 2041-2070 and 2071 - 2100) were assembled. Daily historical data on relative humidity, wind speed, precipitation and solar radiation were drawn from automated weather stations of the Central Laboratory for Agriculture Climate (CLAC) and data sources in the concerned governorates.

Table (2): Description of IPCC Representative Concentration Pathway (RCP) until 2100 compared to the average data from 1971 to 2000 year.

Scenario	Radioactive forcing Wm^{-2}	Atmospheric Ppm in 2100	Global Temperature Increase, °C	Pathway
RCP 2.6	3 before 2100 declining to 2.6 by 2100	490 ppm	1.5	Peak and decline
RCP 4.5	4.5 post 2100	650 ppm	2.4	Stabilization without overshoot
RCP 6	6.0 post 2100	850 ppm	4	Stabilization without overshoot
RCP 8	8.5 in 2100	1370 ppm	4.9	Rising

$$e_s = \frac{e^0(T_{max}) + e^0(T_{min})}{2} \qquad (2)$$

$$WR = [(ET_o * K_c) + LR] * 4.2 \quad \ldots\ldots\ldots (m^3 / fed/ day)$$

Where: -

WR = irrigation requirement for crop m^3/ Feddan/ day

K_c = Crop coefficient [dimensionless].

ET_o = Reference crop evapotranspiration [mm/day].

LR = Leaching requirement LR (%) (Assumed 20% of the total applied water)

4.2 is a conversion factor transforming the estimate from millimeters per day to cubic meters per Fadden per day (Fadden = 4200 m^2)

RESULTS AND DISCUSSION

Trend of annual air temperature:

Fig. (1-4) Show the projections for annual min mum and maximum air temperature for middle Egypt and upper Egypt under current (1971-2000) and future (2011-2040, 2041-2070 and 2071 - 2100) under studied scenarios. The annual maximum temperature in the middle Egypt being increase for all RCPs scenarios. The highest annual maximum air temperature values arise under RCP8.5, while the lowest arise under RCP2.6. The average annual maximum air temperature in upper Egypt is about 2°C hotter than in the middle Egypt.

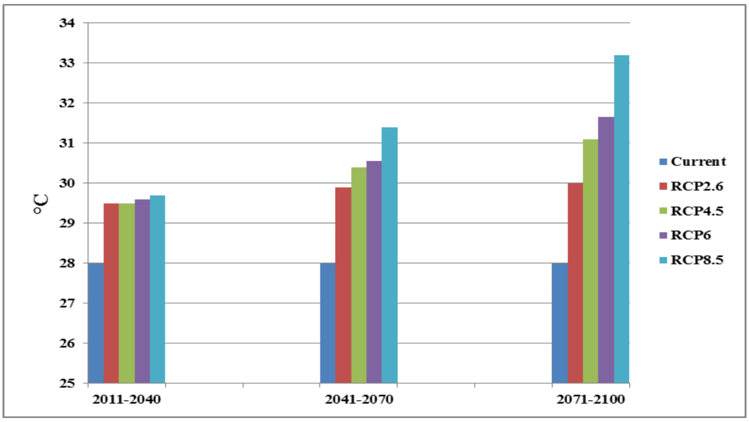

Fig 1.The average annual maximum air temperature in Middle Egypt region under current and future conditions for different RCPs scenarios.

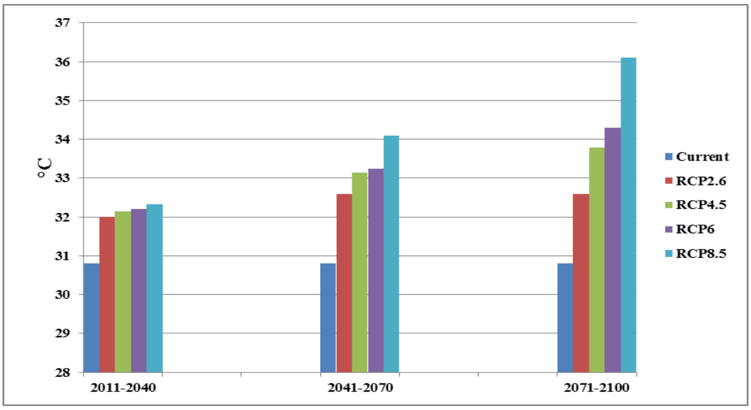

Fig 2. The average annual maximum air temperature in Upper Egypt region under current and future conditions for different RCPs scenarios

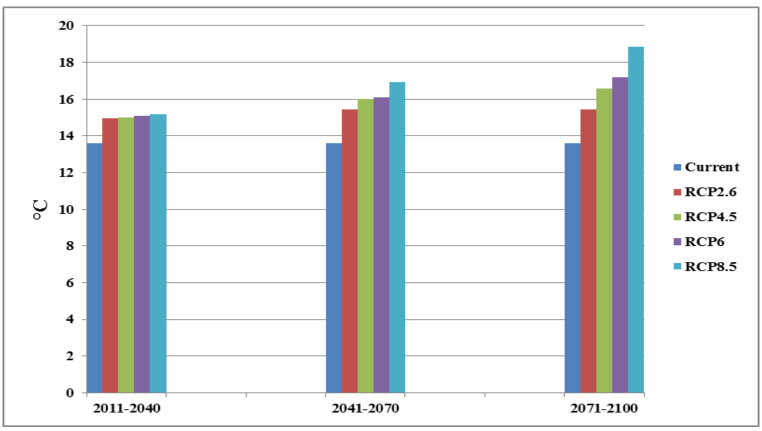

Fig 3.The average annual minimum air temperature in Middle Egypt region under current and future conditions for different RCP scenarios

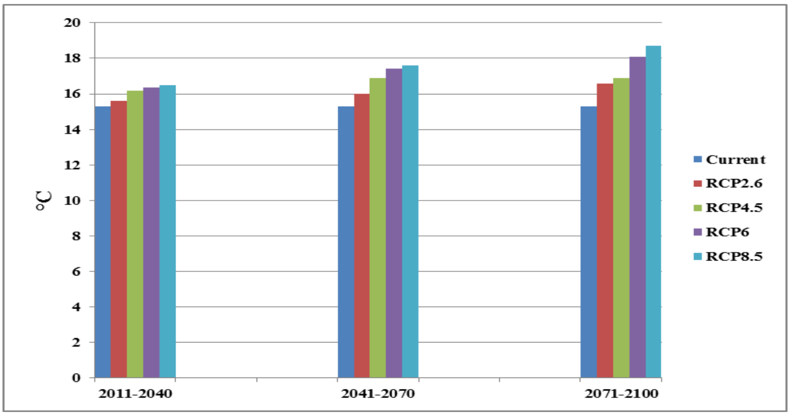

Fig 4.The average annual minimum air temperature in Upper Egypt region under current and future conditions for different RCP scenarios.

Trend of the current and future ETo:

Figs (5 – 9) illustrate the results of the ETo calculations for the Middle Egypt and upper Egypt region under studied scenarios of climate change current and future. The highest monthly ETo in the Middle Egypt under the current situation occurs during June (13.15 mm/day) under RCP8.5scenario, while the lowest ET occurs in January (2.88mm/day) under RCP2.6. scenario for Menya governorate. The highest monthly ETo in the upper Egypt governorates under the current situation occurs as follow The highest monthly ETo occurs during June (13.66 mm/day) under RCP8.5scenario, while the lowest ET occurs in January (3.02mm/day) under RCP2.6 for Sohag governorate. The highest monthly ETo occurs during June (13.89 mm/day) under RCP8.5scenario, while the lowest ET occurs in January (3.07mm/day) under RCP2.6 for Qena governorate. The highest monthly ETo occurs during June (15.17 mm/day) under RCP8.5scenario, while the lowest ET occurs in January (3.30mm/day) under RCP2.6for Luxor governorate. The highest monthly ETo occurs during June (15 mm/day) under RCP8.5scenario, while the lowest ET occurs in January (3.45mm/day) under RCP2.6 for Aswan governorate. The percentage of ETo increase ranged by 5.9 (RCP6.0 at 2011-2040) , 13.7% (RCP 6 at 2041-2070) and 20.6% (RCP 6 at 2071-2100) compared to current conditions.

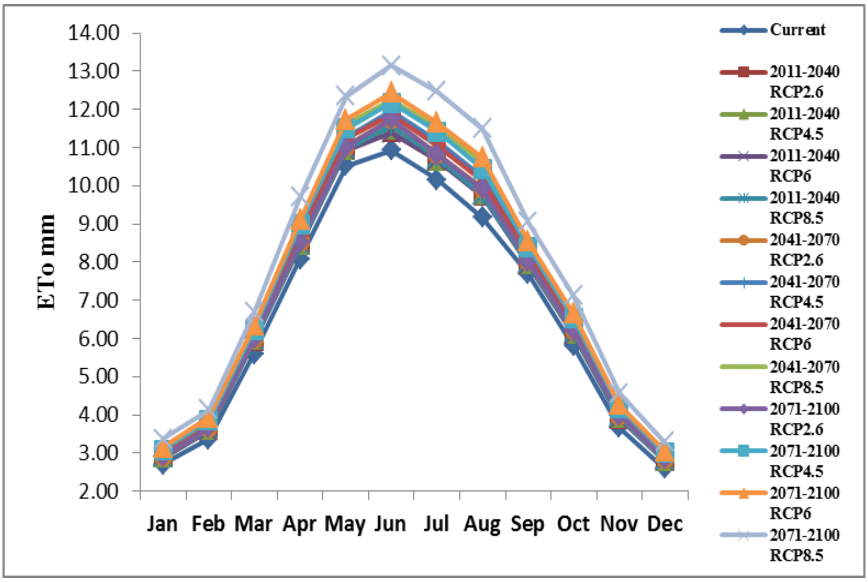

Fig 5.Average reference evapotranspiration (mm) under current and future conditions at Menya governorate Middle Egypt region

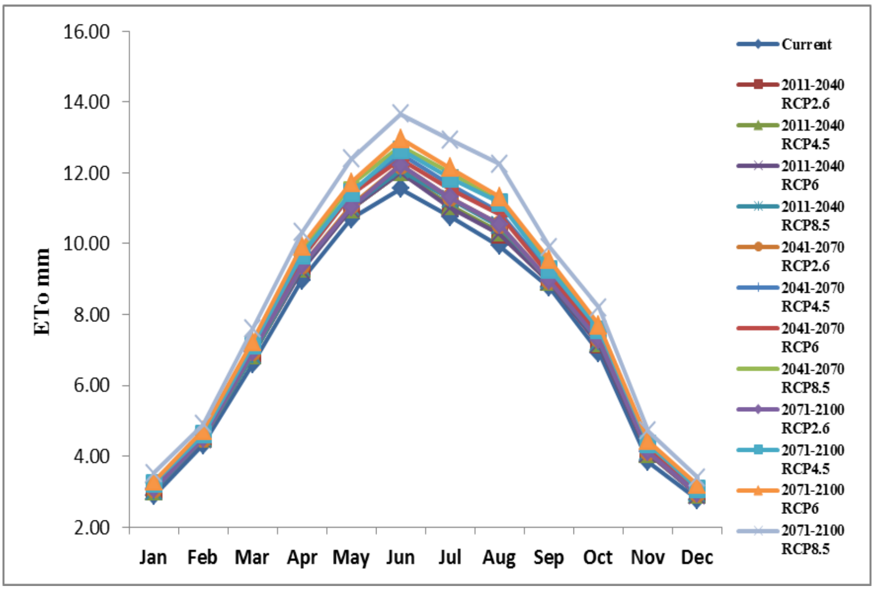

Fig 6. Average reference evapotranspiration (mm) under current and future conditions at Sohag governorate Upper Egypt region

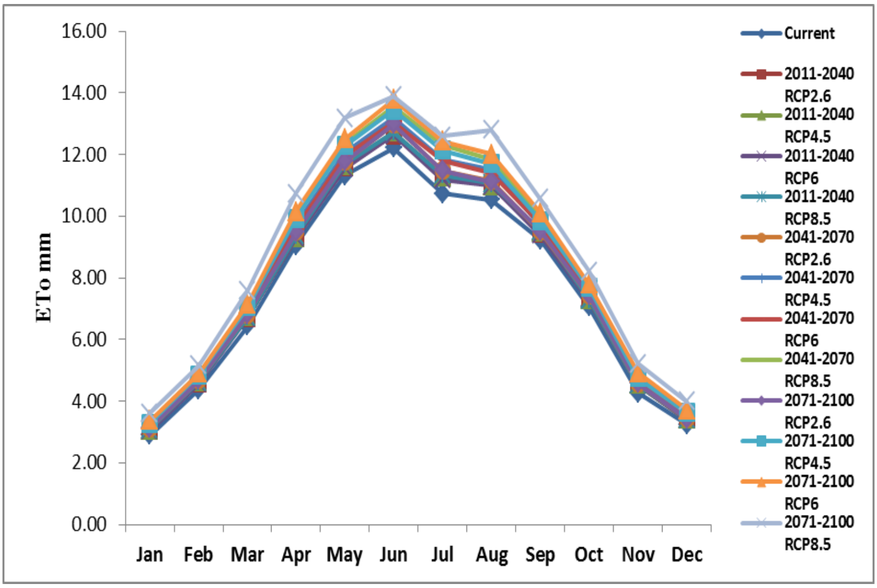

Fig 7. Average reference evapotranspiration (mm) under current and future conditions at Qena governorate Upper Egypt region

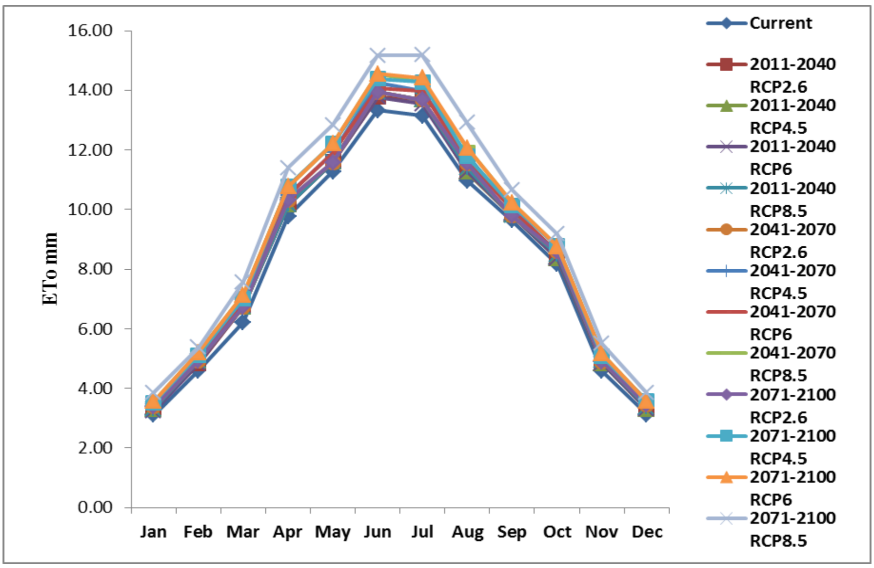

Fig 8. Average reference evapotranspiration (mm) under current and future conditions at Luxor governorate Upper Egypt region

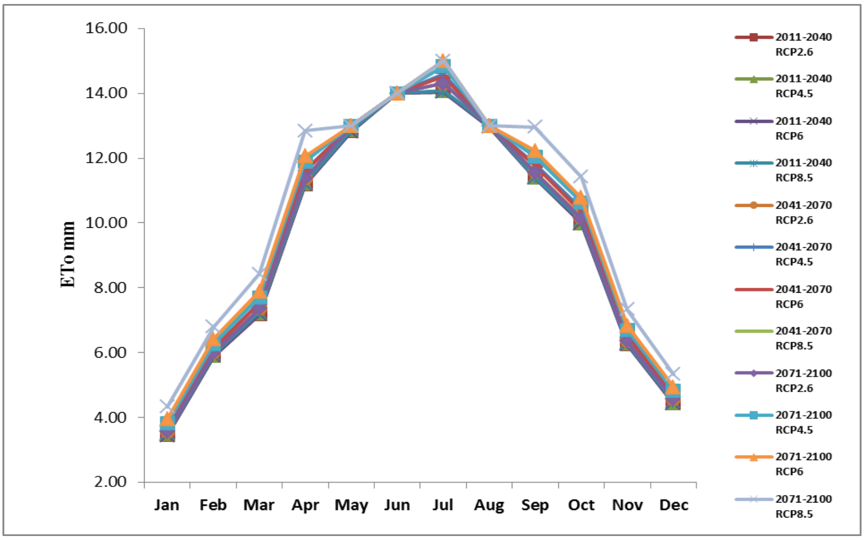

Fig 9. Average reference evapotranspiration (mm) under current and future conditions at Aswan Upper Egypt region

Water requirements:

Data in Tables (3,4) show the regional estimates of sugar cane water requirements values in the growing season (cubic meter per feddan) under current and future conditions, indicates that irrigation requirements for sugar cane would be expected to increase by a range of 8.5% to 12.5% by 2070. Data in Table 3 show the total cultivated area(feddan) with sugarcane for 2012 by cultivation growing seasons .Data in Tables 3 show the consequent total national water requirements (WR) by cultivation season using 2012 land areas 4 billion cubic meter represent 8.74 % from total water budget for agriculture indicates that total water requirements increase across all RCP scenarios the RCP2.6 scenarios with the 2070 increase by 6.5% and 12.4% for the total crop area . Who concluded that the crop-water requirements of the important strategic crops in Egypt would increase under all IPCC SRES scenarios of climate change, by a range of 6.5to 12.4 % during the 2070 water requirement reach to 4.56 billion cubic meters represent 10.18 % from total water budget . According Table 4 it can be an adaptation options for better water management for sugar cane crop in Middle and Upper Egypt region, using Gated

Table (3). Average water requirements (m^3/feddan/season) for sugar cane under current and future conditions at RCP scenarios Middle and Upper Egypt region.

region	Irrigations system	Current m^3/fed	RCP2.6	RCP4.5	RCP6	RCP8.5	RCP2.6	RCP4.5	RCP6	RCP8.5	RCP2.6	RCP4.5	RCP6	RCP8.5
Middle Egypt			2011-2040				2041-2070				2071-2100			
Menya	Flooding	11500	12066	12085	12049	12135	12257	12543	12474	12932	12245	12804	13058	13843
	Gated pipe	8214	8619	8632	8607	8668	8755	8960	8910	9237	8747	9146	9327	9888
Upper Egypt														
Sohag	Flooding	11776	12893	12895	12865	12975	13067	13388	13331	13709	13049	13530	13848	14585
	Gated pipe	8412	9209	9211	9189	9268	9334	9563	9522	9792	9321	9665	9892	10418
Qena	Flooding	12455	13294	13329	13265	13381	13553	13855	13754	14267	13543	14138	14433	15025
	Gated pipe	8897	9496	9521	9475	9558	9681	9897	9824	10191	9673	10099	10309	10732
Luxor	Flooding	12826	14276	14320	14242	14336	14390	14678	14644	15076	14390	14988	15104	15893
	Gated pipe	9162	10197	10229	10173	10240	10279	10484	10460	10769	10279	10706	10788	11352
Aswan	Flooding	13693	15478	15502	15466	15540	15696	15913	15877	16221	15692	16114	16283	16769
	Gated pipe	9781	11056	11073	11047	11100	11212	11366	11340	11587	11209	11510	11631	11978

Table (4). Average total water requirements (m^3/ season) for sugar cane under current and future at RCP scenarios Middle and Upper Egypt region

Governorate	Area (Faddan)	Current* m3/fed	future ** m3/fed	TOTAL(M^3) Flooding *	TOTAL(M^3) Flooding **	TOTAL (M^3) Gated pipe*	TOTAL (M^3) Gated pipe**
Menia	38757	11500	12932	445705500	501199506	0	0
		8214	9237	0	0	318349998	357999647
Sohag	15663	11776	13709	184453146.7	214717543.5	0	0
		8412	9792	0	0	131752247.6	153369673.9
Qena	114247	12455	14267	1422946385	1630014867	0	0
		8879	10191	0	0	1014399113	1164296333
Luxor	62109	12826	15076	796610034	936353826.2	0	0
		9162	10769	0	0	569042658	668824161.6
Aswan	79143	13693	16221	1083705099	1283816036	0	0
		9781	11587	0	0	774097683	917011454.1
Total	311100			3933420165	4566101778	2807641700	3261501270

*year2015
** year2041 -2070

pipe system consumed total water budget in Middle and Upper Egypt, will increase under all scenarios compared with the current conditions and ranged from 2.8 to 3.26 billion cubic meters in or mid-term (2041-2070) . total water budget in Middle and Upper Egypt for sugar cane crop will increase under all scenarios compared with the current conditions and ranged from 2.8 to 3.28 billion cubic meters in (2070-2100) compare with 4,14 billion cubic meters in flooding system now this will save water about 1.2 billion cubic meters represent 2.8% from total water budget .

CONCLUSIONS

Egypt is quite risky to climate change this study shows that irrigation water demands increases depending on climate change scenarios. The total amount of irrigation water demands increased by 1432 m^3 /fed represent 12 % of available fresh water and 2250 m^3 /fed represent18 % of available fresh water in Middle and Upper Egypt Governorates respectively for sugar cane crop under climate change RCP scenarios. On the other hand, water budget under climate change scenarios in the same Governorate can be reduce by water adaptation using gated pipe system.

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الملخص العربى

تأثير تغير المناخ على متطلبات مياه الري لإنتاج قصب السكر في مصر

د. حنفى عبد المنعم رضوان*

قد يكون لتغير المناخ العالمي آثار خطيرة على الموارد المائية والزراعة و الهدف من هذا البحث توقع الاحتياجات المائية لقصب السكر في محافظات انتاج قصب السكر في مصر في ظل المناخ الحالي وتحت سيناريو تغير المناخ حتى عام ٢١٠٠. وأشارت النتائج إلى أن متطلبات قصب السكر المياه سوف تزيد بنسبة ١٢- ١٨ ٪ اعتمادا على موقع المحافظة حيث من المتوقع أن تزداد الاحتياجات المائية في جميع المحافظات تحت سيناريو تغير المناخ وكمية الري بسبب موسم النموالطويل لقصب السكر ٣٦٥ يوما. وقد اعتمدت منظمة الأغذية والزراعة على معادلة بنمان-مونتيث لتقدير معامل البخر باستخدام البيانات المناخية الحالية. تم تقدير التبخر على درجة حرارة الهواء القصوى والدنيا المتوقعة باستخدام سيناريوهات عمليات التشاور الإقليمي (RCP2.6 - RCP4.5 - RCP6.0 وRCP8.5) خلال ثلاثة من السلاسل الزمنية (٢٠١١-٢٠٤٠، ٢٠٤١-٢٠٧٠ و٢٠٧١-٢١٠٠) . واوضحة النتائج أن درجات حرارة الهواء المتوسطة زادت في جميع سيناريوهات عمليات التشاور الإقليمي مقارنة البيانات الحالية. وعلاوة على ذلك، كان RCP8.5 أعلى متوسط درجة حرارة للهواء بالمقارنة مع السيناريوهات عمليات التشاور الإقليمي أخرى. زيادة معامل البخر في مختلف السلاسل الزمنية مقارنة بقيم معامل البخر الحالية. وكانت قيم الذيادة من الطلب على المياه للري في سلسلة زمنية طويلة الأجل (٢٠٧١-٢١٠٠) أعلى من المدى القصير (٢٠١١-٢٠٤٠) أو منتصف المدة (٢٠٤١-٢٠٧٠) فيما يتعلق بالوضع الحالي. تقدير الاحتياجات المائية للمحاصيل قصب السكر في مختلف المناطق المناخية الزراعية وخاصة منطقة صعيد مصرلما لديها اكبر منطقة مزروعة من قصب السكر. اوضح البحث ان مجموع الاحتياجات المائية لقصب السكر خلال موسمى الزراعة سيزيد في جميع السيناريوهات في مقارنة مع الظروف الراهنة. مجموع الموازنة المائية في مصر الوسطى وصعيد مصر لمحصول قصب السكر سوف تزيد في جميع السيناريوهات مقارنة مع الظروف الحالية وتراوحت بين ٤ إلى ٤،٥٦ مليار متر مكعب منتصف المدة (٢٠٤١-٢٠٧٠). مجموع الموازنة المائية في مصر الوسطى وصعيد مصرلمحصول قصب السكر سوف تزيد من ٤ إلى ٤,٨ مليار متر مكعب في (٢٠٧٠-٢١٠٠). ويمكن استخدام خيارات التكيف من أجل تحسين إدارة المياه لمنطقة مصرالوسطى ومنطقة مصر العليا، ونوصى باستخدام نظام نظام الأنابيب المبوبة تستهلك الموازنة المائية الإجمالية في مصرالوسطى وصعيد مصر. لمحصول قصب السكر كمية مياة اقل من اجمالى المياة تحت نظام الرى السطح الحالى وتراوحت بين ٢,٨ - ٣،٢٦ مليار متر مكعب منتصف المدة (٢٠٤١-٢٠٧٠). مجموع ميزانية المياه في مصر الوسطى وصعيد مصر. لمحصول قصب السكر سوف تراوحت بين ٢.٩ الى ٣,٣ مليار متر مكعب في (٢٠٧٠-٢١٠٠) مقارنة مع ٤ مليار متر مكعب في نظام الغمر الحالى.

*باحث أول ، معهد بحوث الهندسة الزراعية، مركز البحوث الزراعية ، الدقي.