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Impact of Climate Variability on Irrigation Water Needs and Irrigation Schedules of Maize and Cucumber in Aba, Abia State

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Abstract

In an attempt to address the discrepancies in the food production and population growth rates in Nigeria, this study estimated the irrigation water requirements of maize and cucumber in Aba, Abia State. Meteorological parameters (rainfall, minimum and maximum temperature, relative humidity, wind speed, sunshine hours) were collected from NiMet Abuja for 20 years (2000 to 2020). CROPWAT version 8.0 was applied to determine the Crop ETo and irrigation schedule of maize and cucumber. The hypothesis: Impact of climate variability does not influence irrigation of maize and cucumber was tested using Pearson correlation coefficient. The result shows that during the early and late planting season of maize, the crop water used are 338.6mm and 276.6mm, effective rainfall 478.8mm and 782.8mm and the total rainfall 740.0mm and 1028.6mm. For cucumber, the water used by the crop is 334.9mm and 285.8mm, and effective rainfall 332.6mm and 663.9mm. There was no irrigation schedule for maize and cucumber during the early and late plating seasons. It shows that water requirement for maize and cucumber was enough during the seasons. The highest crop ETo and temperature was in the month of March (4.57mm/day) and January (33.7°C). The study also reveals that the impact of climate change on irrigation water need at 0.05 significant level is IR=192.811-0.089(TR). The result shows a negative slope (-0.089), which means a negative relationship between Irrigation required and total rainfall over the 20 years period. This indicates that as rainfall increases, irrigation required decreases. The study therefore, suggests that maize and cucumber should be planted in Aba all year round; since there is enough rainfall for the crop.

Keyword: Agriculture, Climate change, Food security, Rainfall, Aba

Introduction

Climate change has become a universal concern and a threat to achieving sustainable development of agriculture (Felix *et al.,* 2016). Climate change affects agricultural production and food security through increasing temperatures, changing rainfall patterns, and greater frequency and intensity of extreme weather events (Durodola, 2019). Due to climate change, extreme events such as droughts and flooding are taking an increasing toll in developing countries (WMO, 2020). The projections show that every 1°C increase in temperature impacts food production in Asia, the United States, and Africa (Mechiche-Alami and Abdi, 2020). The UN report outlined the significant drivers of the recent rise in hunger and food insecurity: conflict, climate variability and extremes, economic slowdowns, and downturns exacerbated by the COVID-19 pandemic (FAO, 2018). The UN noted that between 720 million and 811 million people in the world faced hunger in 2020, 70 million or more in 2020 than in 2019, and some regions are more affected than others (FAO, 2021). In Africa, 21% experienced hunger in 2020 more than double the proportion of any other region (FAO, 2021). In Nigeria, Olomola and Nwafor (2018) noted that the population growth rate of Nigeria is about 3.2%, while the food production rate is about 2% annually. Food production has not been stable with its population growth. In an attempt to address the discrepancies in the food production and population growth rates, successive Nigeria governments have come up with policies and programs, among them are: Operation Feed the Nation (OFN) in 1976, Root and Tuber Expansion Programme (RTEP) in 2001, National Programme for Food Security (NPFS) in 2008, and Vision 2020. These policies and programs were designed to increase food production and address the challenges that farmers faced, but, there is increased hunger, malnutrition, diseases, and death in Nigeria.

The deteriorating agricultural productivity in Nigeria is a burden and a real challenge for the government with a population of approximately 180 million people to feed. The effect of low farm yields is exacerbated by more frequent extreme weather events (Vogel *et al.,* 2019). Studies have shown that climate variability and extremes are the drivers behind the recent rise in global hunger (FAO, 2021). Increasing climate extremes and variability are affecting all dimensions of food security and nutrition (Holleman *et al.,* 2020). Maize and cucumber were considered for the study because of their economic and nutritional benefits above other crops within the region. Maize is useful as food, feed, construction material, fuel, medicine, and decoration (Ranum *et al.,* 2014; Kanengoni *et al.,* 2015; Adejumo and Adebiyi, 2020). Maize serves as a raw material for the production of starch, gluten, oil, flour, alcohol, and lignocellulose for further processing into a whole range of products and by-products (Runyang *et al.,* 2021). Cucumber promotes hydration, aids weight loss, antioxidant-rich, diabetes management, and rich in vitamins **(**Chakraborty and Rayalu, 2021**).** Notwithstanding their importance, these crops are still in low productivity because of several factors, but rainfall is observed to be the principal yield limiting factor (Ayotamuno *et al.,* 2007; Fahad *et al.,* 2017; Tandzi and Mutengwa 2020). But each year, maize and cucumber production varies due to unpredictable climate and other factors. The variation of rainfall cause changes in the amount of available water in the soil which leads to fluctuation in the annual maize and cucumber production (FAO, 2013). An abnormal rise in daytime temperature may give rise to crop water requirements at a particular phase and also cause early completion of a growth phase. In this era of climate change, irrigation is paramount to increasing food security. Olayide *et al.* (2016) noted that irrigation had a positive and significant impact on agriculture in Nigeria. The determination of crop water requirement would help in designing appropriate irrigation, which should lead to improvement in the yields and incomes of farmers, and positive impact on soil, groundwater, and climate; hence the need for CROPWAT 8.0 software to create modelling information like crop water requirement, irrigation schedules, actual water used by the crop, climate data, crop data, and soil data to assess reference evaporation under different management conditions. This study, therefore, did a critical analysis of the optimal water needs of maize and cucumber in Aba to address the deficit in its supply occasioned by climate variability and to ensure regular availability of fresh maize and cucumber in Aba both in the rainy and dry season.

Materials and Methods

Study Area

Aba is in Abia State, Southeast part of Nigeria. Its geographical coordinates are 5°7.0′ North, 7°22.0′ East, known as Japan of Africa and Southeast because of its commercial purpose in Nigeria. It has two Local Government Areas (LGAs); Aba North and Aba South, with a population of 534,265 (NPC, 2006) and 72km^2 landmass, and elevation of 205m. According to the Koppen-Geiger classification, the climate of Aba is considered Tropical (AM), rainfall significant most months of the year, and average annual temperature of about 30°C. Farming is an occupation of the people of Aba because of the rich soil and flat landform. Okoro *et al.* (2017) noted maize and cassava asthe major crops grown in Aba.

Methods

Monthly minimum and maximum temperature, relative humidity, sunshine duration, wind speed, and rainfall were obtained from Nigerian Meteorology Agency (NiMet) Abuja from 2000 to 2020. The experimental work was carried out on a farm at Aba, at latitude 5.11623 and longitude 7.38075 using the Meteobot App which provides data from the experimental farm using the Global Positioning System (GPS) such as the amount of rainfall the soil receives, air temperature, and soil temperature at different depths. Maize and cucumber were planted on 12th March 2020 and harvested on 17th July 2020 and 24th June 2020 respectively (early planting season), and on 22nd July 2020 and harvested on 23rd November and 3rd November 2020, in that order (late planting season). The stage length, rooting depth of each crop, and other data such as crop coefficients at various stages, yield response, and critical depletion factors were collected from the FAO table. The CROPWAT 8.0 version calculates the reference crop evapotranspiration (ETo), and crop water requirements (CWR/ETc) using the available metrological parameters. The software use daily meteorological data to estimate evapotranspiration. The rainfall data is required to calculate the irrigation water requirement (IWR) and the soil-water-balance model. In developing the irrigation schedule, an interactive procedure was followed with different timing and application options. The hypothesis: the Impact of climate variability does not influence irrigation of maize and cucumber was tested using the Pearson correlation coefficient expressed thus;

$$r = \frac{\sum XY - \sum X \sum Y}{\sqrt{(n\sum X^2 - (\sum X)^2)(n\sum Y^2 - (\sum Y)^2)}} \quad \dots\dots \quad (1)$$

Results and Discussion

Results

The result in Table 4 shows that from 2000 to 2020 the average annual minimum temperature was 23.4°C, while maximum temperature as 30.8C. The temperature was higher in the months of December, January, and February and lowest in the months of June, July, and August. The mean rainfall is 2003.5mm in the month of July and August recorded the highest mean monthly rainfall of 332.8mm and 291.3mm, while December, January, and February recorded the lowest mean monthly rainfall of 24.6mm, 50.2mm, and 55.4mm respectively. The wind speed varies from 6.9km/hr to 4.9km/hr with a mean value of 6km/hr. Relative humidity was recorded as the highest in the months of July and September and lowest in January. The solar radiation average was 19.6MJ/m^2/day, while the crop ETo was higher in the month of March and February and lowest in the months of July and August. Table 5 shows the irrigation water requirements of maize for early planting season. The Effective rainfall was higher than the Crop evapotranspiration throughout the entire growth stages in the early planting season, but at the initial stages and early development stage, the crop evapotranspiration was higher than effective rainfall. It indicates that 60.0mm/dec amount of water is required to meet the crop water demand. Table 6 shows the irrigation water requirement of maize for the late planting season. The total crop evapotranspiration (ETc) was 281.0 mm/dec, effective rainfall (ER) 581.6, while Irrigation required was 0.0mm/dec. The effective (ER) was higher than crop ETc during the growth period. Therefore, the ER was enough to meet the water demand during the entire growth stage. Table 7 shows the irrigation water requirement of cucumber for the early planting season. The total crop evapotranspiration (ETc) was 337.2mm/dec, effective rainfall (ER) 394.8, while Irrigation required was 0.0mm/dec. The ER was higher than ETc during the growth period, indicating that cucumber met its water requirements. Table 8 shows the irrigation water requirement of cucumber for the late planting season. The total crop evapotranspiration was more than ETc during the growth period. Therefore, the ER was enough to meet the water demand during the entire growth stage. Table 9 shows the irrigation schedule of maize for the early planting season. The total rainfall during the entire cropping season was 740.0mm, moisture depletion pattern during the irrigation schedule 40%, actual water used by the crop 338.6 mm, effective rainfall 478.8mm, and net irrigation 0.0mm. Though at the initial stages and early development stage, the crop evapotranspiration was higher than effective rainfall; there was no irrigation schedule for the maize. Table 10 shows the irrigation schedule of maize for the planting season. The total rainfall during the entire cropping season was 1028.6 mm, moisture depletion pattern during the irrigation schedule 62%, the actual water used by the crop 279.6mm, effective rainfall 782.8mm, and N]net irrigation 0.0mm. The crop met its irrigation water required during the entire late planting season. Table 11 shows the irrigation schedule of cucumbers for the early planting season. The total rainfall during the entire cropping season was 540.0 mm, moisture depletion pattern during the irrigation schedule 100%, actual water used by the crop 334.9mm, effective rainfall 332.6mm, and net irrigation 0.0mm. The crop met its irrigation water requirement during the entire growing period. Table 12 shows the irrigation schedule of cucumber for the late planting season. The total rainfall during the entire cropping season was 949.7mm, moisture depletion pattern during the irrigation schedule 100%, actual water used by the crop 285.8mm, effective rainfall 663.9mm, and net irrigation 0.0mm. The crop met its irrigation water requirement during the entire growing period.

H_o: The impact of climate change does not influence the irrigation of maize and cucumber

Table 13 shows the result of the impact of climate change on irrigation water needs, standard deviation at 0.05 level of significance (α). The relationship between irrigation required for the production of maize and cucumber, which are dependent variables, and the total rainfall, which is an independent variable is given by *IR* = 192.811 – 0.089*(TR)*. Where IR is irrigation required, while TR is the total rainfall. The result shows a negative slope (-0.089).This implies a negative relationship between Irrigation required and total rainfall over the 20 year period, which indicates as rainfall increases, irrigation required decreases.

Discussion

Within the Southeast Nigeria, studies like Okoro *et al*. (2019), Ajiere *et al*. (2019), Ajiere and Nwagbara (2018), Eteng and Nwagbara (2014), and Chukwu (1999), have assessed the irrigation water needs of crops and the effect of climate change on some of the crops, the studies suggest that supplement irrigation may be required during the late planting season at the flowering and maturity stages. In Port Harcourt, Udom and Kamalu (2019) noted that the total crop water requirement of maize during the growing season was 456.9mm, ETo 4.22mm, and 3.91mm using the Blaney-Criddle and Pan Evaporation data. The peak period of water used by the crop was 5.66mm per day and during yield formation 6.31mm per day. The values were higher than the result of this study. Considering the climate variability within the regions, Olapido (2010) indicated that climate change will continue to increase rainfall variability, with an increase in precipitation by approximately 5-20% and consequent flooding, in some humid areas of the forest region and savanna areas in Southern Nigeria. Enete (2014) further explained that the durations and intensities of rainfall have increased, creating large runoffs and flooding in many places in Nigeria. Therefore, rainfall variation is likely to continue to increase in Southern regions of Nigeria (Akande *et al*., 2017; Ebele and Emodi, 2016). These support the findings of this study, since rainfall had a significant impact on the irrigation water needs of crops. The study also agrees with Olayide *et al*. (2016) who noted the need to minimize the impact of climate-induced production risk using irrigation in Nigeria. Studies have also shown that an increase in temperature and a decrease in precipitation is the main feature of climate change. The findings of Ajiere *et al*. (2019) show an increase in temperature and a decrease in rainfall as farmers in some parts of Nigeria depend on precipitation for their agricultural practice. The increase in temperature has an impact on maize and cucumber growth at different stages and water consumption patterns, as well as the quantity of irrigation water that crops may require to grow well (Saadi *et al*., 2015; Wang *et al*., 2016).

Conclusion

In Nigeria, the current state of irrigation development has not been fully explored. This study established that with or without irrigation, farmers can produce maize and cucumber all year round, thereby increasing food security in Aba, Abia State. This study suggests that the relationship between irrigation required for the production of maize and cucumber are dependent variables i.e temperature and the total amount of rainfall in a year. Therefore, maize and cucumber can grow in Aba without irrigation for the early and late planting season. Farmers are therefore, encouraged to continuously grow these crops within Aba because of the availability of rainfall. The results of this study will serve as a basis for assessing the irrigation water need of crops in Aba, Abia State.

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Table 1: Crop Data (Maize)

	Initial	Deve	Mid	Late	Total
Crop coefficient	0.70	-	1.20	0.65	
Rooting depth (m)	0.20	-	0.70		
Depletion level	0.40	-	0.50	0.50	
Yield Rep Factor	0.40	1.10	0.80	0.40	1.05
Kc Value	1.20	0.6	0.35		
Length Stages (days)	25	50	40	35	150
Max. crop height	2m				

Source: Harare, 2002

Table 2: Crop Data (Cucumber)

	Initial	Deve	Mid	Late	Total
Crop coefficient	0.6	-	1.00	0.75	
Rooting depth (m)	0.70	-	1.2		
Depletion level	0.50	-	0.50	0.50	
Yield Rep Factor	0.40	1.10	0.80	0.40	1.05
Kc Value	1.20	0.6	0.35		
Length Stages (days)	20	30	40	15	105
Max. crop height	0.3m				

Source: Harare, 2002

Table 3: Soil Information

Total available soil moisture	140.0 mm/m
Maximum rain infiltration rate	40 mm/day
Maximum rooting depth	900 Centimeters
Initial soil moisture depletion (as % TAM)	0 %
Initial available soil moisture	140.0 mm/m

Source: Harare, 2002

Table 4: Average meteorological parameters from 2000 – 2020 for Aba, Abia State

Month	Min Temp (°C)	Max Temp (°C)	Wind Speed (Km/hr)	RH (%)	Sunshine Hours (hr/day)	Rainfall (mm)	Solar Radiation (MJ/m^2/day)	ET$_o$ (mm/day)	ET$_o$ (mm/month)
Jan	22.9	33.7	5.7	63	9.6	50.2	22.4	4.20	123.69
Feb	24.3	33.4	6.4	69	8.9	55.4	22.5	4.46	119.0
Mar	25	32.1	6.7	73	8.4	101.3	22.5	4.57	139.5
Apr	24.7	31.3	6.4	76	8	118.0	21.7	4.43	153.6
May	24	29.9	5.9	80	7.3	116.5	20.0	4.03	141.98
Jun	22.9	28.5	6.1	86	5.7	227.8	17.1	3.44	134.4
Jul	22.4	28.4	6.6	87	4.5	332.8	15.5	3.13	133.61
Aug	22.3	28.6	6.9	86	4	291.3	15.4	3.12	140.74
Sept	22.6	29	5.8	87	5	289.9	17.0	3.42	136.5
Oct	23	30.4	5.1	84	6.5	236.4	18.9	3.77	141.67
Nov	23.4	31.6	4.9	78	8.3	119.3	20.6	4.02	125.7
Dec	23.3	32.9	5.1	65	9.6	24.6	21.9	4.08	110.67
Mean	**23.4**	**30.8**	**06**	**78**	**7.2**	**2003.5**	**19.6**	**3.89**	**133.42**

Table 5: Irrigation Water Requirement of maize for early planting season from 2000 – 2020

ETo & Rain Station: Aba — Crop: Maize

Planting Date: 12th March — Harvest Date: 14th July

Month	Decade	Stage	Kc coefficient	ETc mm/day	ETc mm/dec	Effective Rain (mm/dec)	Irrigation Required (mm/dec)
March	2	Initial	1.20	4.93	49.3	26.4	22.9
March	3	Initial	1.20	4.91	49.1	30.2	18.9
April	1	Deve	1.08	4.84	48.4	30.2	18.2
April	2	Deve	0.86	3.83	38.3	31.2	7.0
April	3	Deve	0.65	2.78	27.8	34.4	0.0
May	1	Mid	0.46	1.92	19.2	37.8	0.0
May	2	Mid	0.44	1.77	17.7	40.8	0.0
May	3	Mid	0.44	1.85	18.5	43.3	0.0
June	1	Mid	0.44	1.60	16.0	46.0	0.0
June	2	Late	0.43	1.49	14.9	48.6	0.0
June	3	Late	0.41	1.35	13.5	49.9	0.0
July	1	Late	0.38	1.21	12.1	51.5	0.0
July	2	Late	0.35	1.11	11.1	21.2	0.0
					339.8	**491.4**	**60.0**

Table 6: Irrigation Water Requirement of maize for late planting season from 2000 – 2020

ETo & Rain Station: Aba — Crop: Maize

Planting Date:22nd July — Harvest Date: 23rd November

Month	Decade	Stage	Kc coefficient	ETc mm/day	ETc mm/dec	Effective Rain (mm/dec)	Irrigation Required (mm/dec)
July	3	Initial	1.20	3.75	37.5	47.7	0.0
August	1	Initial	1.20	3.75	37.5	51.6	0.0
August	2	Deve	1.08	3.38	33.8	51.3	0.0
August	3	Deve	0.86	2.77	27.7	51.3	0.0
Sept	1	Deve	0.64	2.12	21.2	51.5	0.0
Sept	2	Mid	0.47	1.61	16.1	51.6	0.0
Sept	3	Mid	0.46	1.61	16.1	50.7	0.0
Oct	1	Mid	0.46	1.67	1.67	51.1	0.0
Oct	2	Mid	0.46	1.72	17.2	51.0	0.0
Oct	3	Mid	0.45	1.72	17.2	44.7	0.0
Nov	1	Late	0.41	1.62	16.2	38.4	0.0
Nov	2	Late	0.38	1.52	15.2	33.2	0.0
Nov	3	Late	0.35	1.43	14.3	7.4	0.0
					281.0	**581.6**	**0.0**

Table 7: Irrigation Water Requirement of Cucumber for early planting season from 2000 – 2020

ETo & Rain Station: Aba — Crop: Cucumber

Planting Date: 12th March — Harvest Date: 24th June

Month	Decade	Stage	Kc coefficient	ETc mm/day	ETc mm/dec	Effective Rain (mm/dec)	Irrigation Required (mm/dec)
March	2	Initial	0.60	2.74	27.4	26.4	0.0
March	3	Initial	0.60	2.71	27.1	30.2	0.0
April	1	Deve	0.66	2.94	29.4	30.2	0.0
April	2	Deve	0.76	3.37	33.7	31.2	0.0
April	3	Deve	0.86	3.71	37.1	34.4	0.0
May	1	Mid	0.91	3.79	37.9	37.8	0.0
May	2	Mid	0.91	3.67	36.7	40.8	0.0
May	3	Mid	0.91	3.49	34.9	43.3	0.0
June	1	Late	0.91	3.30	33.0	46.0	0.0
June	2	Late	0.80	2.75	27.5	48.6	0.0
June	3	Late	0.68	2.28	22.8	28.0	0.0
					337.2	**394.8**	**0.0**

Table 8: Irrigation Water Requirement of Cucumber for late planting season from 2000 – 2020

ETo & Rain Station: Aba — Crop: Cucumber

Planting Date: 22nd July — Harvesting Date: 3rd November

Month	Decade	Stage	Kc coefficient	ETc mm/day	ETc mm/dec	Effective Rain (mm/dec)	Irrigation Required (mm/dec)
July	3	Initial	0.60	1.88	18.8	47.7	0.0
August	1	Initial	0.60	1.87	18.7	51.6	0.0
August	2	Deve	0.66	2.05	20.5	51.3	0.0
August	3	Deve	0.77	2.48	24.8	51.3	0.0
Sept	1	Mid	0.88	2.92	29.2	51.5	0.0
Sept	2	Mid	0.92	3.14	31.4	51.6	0.0
Sept	3	Mid	0.92	3.25	32.5	50.7	0.0
Oct	1	Mid	0.92	3.35	33.5	51.1	0.0
Oct	2	Late	0.92	3.45	34.5	51.0	0.0
Oct	3	Late	0.80	3.09	30.9	44.7	0.0
Nov	1	Late	0.69	2.71	27.1	11.5	0.0
					288.6	**514.1**	**0.0**

Table 9: Irrigation Schedule of Maize for early planting season 2000 – 2020

ETo Station: Aba — Crop: Maize — Planting date: 12th March

Rain station: Aba — Soil type: Loamy — Harvest date: 14th July

Irrigation schedule: Timing: Irrigate at critical depletion

Daily soil moisture balance: Refill soil to field capacity

Field efficiency: 70%

Date	*Day*	*Stage*	*Rain (mm)*	*Ks fract.*	*Eta %*	*Depl %*	*Net Irr*	*Deficit mm*	*Loss mm*	*Gr. Irr mm*	*Flow l/s/ha*
14th July	*End*	*End*	*0.0*	*1.00*	*0*	*40*					

Totals

Total gross irrigation	*0.00 mm*	*Total rainfall*	*740.0 mm*
Total net irrigation	*0.00 mm*	*Effective rainfall*	*478.8 mm*
Total irrigation losses	*0.00 mm*	*Total rain loss*	*261 mm*
Actual water used by crop	*338.6 mm*	*Moist deficit at harvest*	*63.5 mm*
Potential water used by crop	*338.6 mm*	*Actual irrigation requirement*	*-535.0 mm*
Efficiency irrigation schedule	*%*	*Efficiency rain*	*87.7%*

Table 10: Irrigation Schedule of Maize for late planting season 2000 - 2020

ETo Station: Aba | *Crop: Maize* | *Planting date: 22nd July*
Rain station: Aba | *Soil type: Loamy* | *Harvest date: 23rd November*
Irrigation schedule: *Timing: Irrigate at critical depletion*
Daily soil moisture balance: *Refill soil to field capacity*
Field efficiency: 70%

Date	Day	Stage	Rain (mm)	Ks fract.	Eta %	Depl %	Net Irr	Deficit mm	Loss mm	Gr. Irr mm	Flow I/s/ha
23rd Nov	***End***	***End***	***0.0***	***1.00***	***0***	***62***					

Totals

Total gross irrigation	*0.00 mm*	*Total rainfall*	*1028.6 mm*
Total net irrigation	*0.00 mm*	*Effective rainf all*	*782.8 mm*
Total irrigation losses	*0.00 mm*	*Total rain loss*	*245.9 mm*
Actual water used by crop	*279.6 mm*	*Moist deficit at harvest*	*86.4 mm*
Potential water used by crop	*279.6 mm*	*Actual irrigation requirement*	*-772.9 mm*
Efficiency irrigation schedule	*%*	*Efficiency rain*	*92.6%*

Table 11: Irrigation Schedule of cucumber for early planting season 2000 - 2020

ETo Station: Aba | *Crop: Cucumber* | *Planting date: 12th March*
Rain station: Aba | *Soil type: Loamy* | *Harvest date: 24th June*
Irrigation schedule: *Timing: Irrigate at critical depletion*
Daily soil moisture balance: *Refill soil to field capacity*
Field efficiency: 70%

Date	Day	Stage	Rain (mm)	Ks fract.	Eta %	Depl %	Net Irr	Deficit mm	Loss mm	Gr. Irr mm	Flow I/s/ha
24th June	***End***	***End***	***0.0***	***1.00***	***100***	***1***					

Totals

Total gross irrigation	*0.0 mm*	*Total rainfall*	*540.0 mm*
Total net irrigation	*0.0 mm*	*Effective rainfall*	*332.6 mm*
Total irrigation losses	*0.00 mm*	*Total rain loss*	*207.4 mm*
Actual water used by crop	*334.9 mm*	*Moist deficit at harvest*	*2.3 mm*
Potential water used by crop	*334.9 mm*	*Actual irrigation requirement*	*2.3 mm*
Efficiency irrigation schedule	*100%*	*Efficiency rain*	*61.6%*

Table 12: Irrigation Schedule of cucumber for late planting season 2000 - 2020

ETo Station: Aba | *Crop: Cucumber* | *Planting date: 22nd July*
Rain station: Aba | *Soil type: Loamy* | *Harvest date: 3rd November*
Irrigation schedule: *Timing: Irrigate at critical depletion*
Daily soil moisture balance: *Refill soil to field capacity*
Field efficiency: 70%

Date	Day	Stage	Rain (mm)	Ks fract.	Eta %	Depl %	Net Irr	Deficit mm	Loss mm	Gr. Irr mm	Flow I/s/ha
3rd Nov	***End***	***End***	***0.0***	***1.00***	***100***	***0***					

Totals

Total gross irrigation	*0.0 mm*	*Total rainfall*	*949.7 mm*
Total net irrigation	*0.0 mm*	*Effective rainfall*	*663.9 mm*
Total irrigation losses	*0.00 mm*	*Total rain loss*	*285.8 mm*
Actual water used by crop	*285.8 mm*	*Moist deficit at harvest*	*0.00 mm*
Potential water used by crop	*285.8 mm*	*Actual irrigation requirement*	*0.00 mm*
Efficiency irrigation schedule	*100%*	*Efficiency rain*	*30.1%*

Table 13: Impact of climate change on Irrigation water need of maize and cucumber

Variables	Mean ± SD	Regression Model	F_{cal}	t_{cal}	p-value	Remark
Irrigation Required	138.69± 34.69	$= 192.811 - 0.089(\quad)$	1.202	-1.096	0.315	NS
Total rainfall	605.85±158.64					