Climate Change and Irrigation in Sudan

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Abstract
The total irrigated area in Sudan is about 1.7 Million ha. Half of it is in the great Gezira scheme, which is taken as an example to discuss the effect of climate change on irrigation. Climate change is a reality. The increase in global temperature as a direct result of the increase in CO$_2$ is evident. The increase in temperature leads to a 5% increase in crop water requirements which amounts to 800 million m$^3$ in Gezira scheme. Which reduce the area irrigated by 100 thousand ha,. Less clear is the manifestation of climate change in terms of rainfall. It is physically proved that there is an increase in water vapor content in the atmosphere, leading to an increase in energy of the atmosphere. The more energetic atmosphere tends to shed this extra energy in the form of more frequent and more intense tropical cycles. Four scenarios of possible climate change effects on Gezira scheme were discussed which are late rains, early cessation of rains, heavy rainfall and flooding and drought.

Keywords: Irrigation, Climate Change, Gezira, Water vapour, Crop water requirements.

Introduction
Climate change is a reality. It is manifested in a steady increase of global air temperature as a result of the increase in carbon dioxide (CO$_2$) concentration in the atmosphere (IPCC 2007). What is not definite is its manifestation in the rainfall. It may lead to drought in some parts of the globe and at the same time, it may lead to heavy rainfall and flooding in other parts. However, due to the increase in temperature of the atmosphere and hence an increase of water vapor content the atmosphere will have more energy which has to be shed in the form of more hurricanes, typhoons, tropical cyclones accompanied by heavy intense rainfall and very high wind speeds. The secretary General of the World Meteorological Organization (WMO) reported evidence of climate change in 2013. He reported (WMO, 2013) that the World has experienced heavier precipitation, more intense heat, more hurricanes and typhoons, extreme cold in Europe and the United States, floods in India, Nepal, northern China and a major drought in southern China and Brazil. He continued to say that the temperature for 2012 was 0.5°C above the 1961-1990 average and 0.03°C higher than the 2001-2010 average, which was already the warmest on record, thirteen of the 14 warmest years on record, occurred in the 21$^{st}$ century. In addition, each of the last three decades has been warmer than the last.

The increase in temperature is a direct result of increase in Green House Gases, mainly carbon dioxide (CO$_2$). Inspite of World efforts to reach an international agreement to reduce (CO$_2$) emission, the concentration of (CO$_2$) in the atmosphere

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has increased from 1.3 cent per year between 1970 and 200 to 2.2 per cent per year between 2000 and 2010 (WMO, 2013).

**Irrigated Areas in Sudan**

The total irrigated area in Sudan is about 1.7 million ha. The bulk of those areas lie in the Dry climatic zone with an annual rainfall of about 300-350 mm during a short rainy season July-September. (Adam, 2005)

The Gezira Scheme alone has 50% of the total area. About 20% of the irrigated areas cover Rahad Scheme (0.12 million ha), New Halfa (0.16 million ha), Suki (0.04 million ha). The rest of the irrigated areas lie along the White Nile Private and Public pump Schemes, Blue Nile pump Schemes, small pump Schemes in North and River Nile States, which lie in the Desert zone.

The total area of these pump Schemes is 0.4 million in addition there are the Sugar Companies: Kenana, White Nile and Sudan Sugar Company. The latter has four factories: Gunneid, Sennar, Assalya and New Halfa. The total area of the Sugar estates is about 0.16 million ha. (Yagoub Abu Shara, 2012)

**Effect of Increase in Temperature on Irrigation Requirements**

An increase of 2°C in mean temperature in Sudan was observed comparing the 1981-2010 Normals with the 1941-1970 Normals (SMA, 2011). This increase in mean air temperature leads to a 5% increase in Reference Evapotranspiration which results in a 5% increase in Crop Water Requirements. This is equivalent to 700 million m³ per year of Irrigation Water Requirements. In addition to an increase of 5% in evaporation from dams which is amounts to 100 million m³ per year.

The total of 800 million m³ per year lost as a result of a temperature increase of 2°C is equivalent to a loss of 100,000 ha in area of winter crops (about 10% area of Gezira Scheme). This is based on the fact that winter crops in Gezira scheme consumes about 8,000 m³ per ha per season (Adam, 2005).

**Scenarios of Climate Change:**

Four scenarios of climate change are going to be considered: Dry rainy season, Intense and heavy rainfall, late start of the rains and early cessation of the rains.

1. **Drought:** In years of drought, the irrigated Schemes provide a food security at least partially. If all the irrigated areas minus the Sugar areas are grown with Sorghum, they provide a partial food security. For example 1.5 million ha with a yield of two tons of Dura per ha, gives three million tons. For a population of 30 million Sudanese, this provides 100 kg per person.

2. **Heavy Rainfall and Flooding:** In an extremely wet season with heavy rainfall and flooding, agricultural production will be negatively affected. Sowing and weeding will be disrupted. Young plants will be drowned. In such seasons the animal production will flourish. There would be rich range, ample drinking water. This requires well proposed water harvesting programs e.g. Hafiers, small dams etc. Export of animal should cater for importing human food.

3. **Late Start of the Rains:** The late start of the rains means a dry July. This leads to a delay of the sowing of Dura beyond the recommended sowing date of 15 July. The first water given to fill the cracks and provide adequate soil
moisture for sowing will have to be provided by irrigation. This means pumping for Rahad Scheme. It also means filling the canals in Gezira Scheme with maximum discharge of more than 30 million m$^3$ per day. In July, Blue Nile water has a silt concentration of 20,000 parts per million. This means 600,000 tons of silt per day. If 35% of this is precipitated in the minor canal of Gezira Scheme, the depth of silt will be about 20 cm in two weeks time. Sowing is delayed and yield will be low. This silt deposited has to be cleared when the minor canals are wet. This destroys the shape of the minors thus affecting their efficiency in providing water for the crops.

4. Early Cessation of the Rains: The early cessation of the rains means a dry September. This comes at a time when the summer crops Sorghum, Groundnuts and Medium staple Cotton reach their maximum water requirement. The total water requirements when September is dry exceeds the design capacity of the Main Canal (31.5 million m$^3$ per day).

In such seasons, the discharge may reach 35 million cubic metres per day. This leads to siltation even in the main canal. The main canal was designed as a "Canal in Regime": non- silting and non- scouring if the discharge is 31.5 million m$^3$ per day. Actually, the old Gezira main canal has been free of siltation from 1925 up to the intensification and diversification in 1965. During these 40 years, the discharge never exceeded the design capacity of 16 million m$^3$ per day.

A dry September means higher sunshine, higher solar radiation, higher temperature and lower relative humidity, which are reflected in higher evapotranspiration and hence higher crop water requirements. This leads to needed discharge which far exceed the design capacity of the main canal.

Conclusions

The evidence for climate change is now very clear. The increase of temperature as a result of increase in Carbon Dioxide (CO$_2$) concentration in the atmosphere is beyond any doubt as it obeys the non-negotiable laws of physics. The increase in energy of the atmosphere resulting from the increase in the water vapor content is also a physical reality. The atmosphere is shedding this surplus energy in the form of more violent and more frequent tropical storms (Hurricanes, Typhoons, Cyclones) accompanied by high wind speeds and flooding.

However, what is not well defined is where floods and droughts will geographically be distributed. This requires further complex scientific research under the IPCC and WMO Umbrellas.

References