CLIMATE CHANGE IMPACTS ON AGRICULTURAL WATER DEMAND AND RESILIENCE FOR SUSTAINABLE AGRICULTURE IN BANGLADESH

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ABSTRACT

Climate change has affected significantly the agricultural sector of Bangladesh in recent past by showing spatio-temporal variation in water availability in different areas. The objective of this study is to address the effect of rainfall variation due to climate change, its impacts on agricultural water demand and adaptations.
In this study, rainfall data of fifty years from 1963 – 2013 for four locations - Dinajpur, Bogra, Barisal and Chandpur district were used to study rainfall variation for Kharif-I (March - June), Kharif-II (June - November) and Rabi (November - March) seasons . For different geographic locations, different trend lines have been observed. Analyzed trend lines of 50 years mean rainfall show that Kharif-I is becoming wetter than Kharif-II, whereas Rabi is becoming drier. Trend line of annual average rainfall deviation is significantly increasing for Kharif-I and decreasing for Rabi. So it can be speculated that as the years increase, Kharif-I will be increased and it will become more uncertain and unpredictable. The analysis also show that average rainfall of Rabi season will be decreased in all of the study areas and it will become more certain and predictable. As potential solution to the climate change impacts on agricultural water demand in different types of climatic conditions research for nuclear agriculture and hydrology, water resource development and preparing more effective crop calendar has been recommended. It is expected that this study would provide a strong motive to encourage agriculturists, policy makers and researchers to combat adverse impacts of climate change on agriculture.

Keywords*: climate change, rabi, rainfall deviation, rainfall variation, kharif*

1. INTRODUCTION

Climate change is a significant and lasting change in statistical distribution of weather patterns over period ranging decades to millions of year. Climate change is caused by factors that indicate organic process, biotic process, variation in solar radiation received by earth, planet tectonics and volcanic eruption and human educed alteration of the natural world.

Climate is usually defined as the average weather in a place. It includes patterns of temperature, precipitation, humidity, wind and seasons. Climate patterns play fundamental role in shaping natural ecosystem and the human economics and cultures that depend on them. But the climate we have come to expect it is not what is used to be, because the past is no longer a reliable predictor of the future. According to the report preparing for a changing climate is raising level of CO_2 and other heat trapping in the atmosphere have wormed the earth.
It is causing wide ranging impacts including raising sea level, melting snow and ice, more extreme heat events, fires and droughts, rainfall and floods.

So many system are tied to climate a change in climate can affect many related aspects of where and how people, lands and animals live such as food production, availability and use of water and health risk for example a change in the usual timing of range or temperatures can affect when lands bloom and set fruit. Some short term climate variation is normal but longer term trends now indicate a changing climate. Climate is the average weather for a particular region over a long time period.

Climate change and agriculture are interrelated processes both of which take place on a global scale. Global warming is projected to have significant impacts on condition affecting agriculture including temperature, CO_2, glacial run off, precipitation and the interaction of these elements. These conditions determine the carrying capacity of the biosphere to produce enough food for the human population and domesticated animals. The overall effect of global climate changes on agriculture might help to properly anticipate and adapt framing to maximize agricultural production.

Recent studies indicate that Bangladesh is undergoing a rapid economic growth, which is mainly attributed to the manufacturing sector by setting aside the economic significance of agriculture. However, 80% of rural population in the country is heavily dependent on agriculture while rice is staple crop particularly for marginal and small farmers. Food production has been repeatedly threatened by natural disaster like flood, salinity and droughts mainly influenced by the country's unique geophysical and climate conditions. In the north, the mountainous ranging of the Tibetan Plactcau is drained through a massive river network spreading all over Bangladesh and finally ending up in the Bay of Bengal. The occurrences of extreme monsoonal periods often increase the drainage effects leading to floods mainly in the southern lowland areas.

Additionally, saline intrusions are noticed in the south downstream areas, which are attributed to the higher sea level elevation in the coast lands. On the other hand, less rainfall along with its uneven distribution and high evaporating losses in the north-west Bangladesh have caused seasonal drought events which is responsible for severe impacts on marginal farmers.

The extreme events are anticipated to get disturbed by climate change as repeatedly noted that the snow melting in the mountainous areas of the Tibetan plateau coupled with erratic and intense monsoon are expected to constitute the drive for increased flooding. Also the delayed monsoon conditions and the higher sea level intrusion are problem to lead in more frequent drought and salinity effects. The food production will inevitable incur significant losses from the extreme weather by acting threat the food security status of the country.

2. METHODOLOGY

To address the impact of climate change on agricultural sector of water demand a historical assessment of some hydro climatic attributes in the study areas to identify their irrigationship and trends was considered. Precipitation data from Bangladesh Meteorological Department (BMD) was used to explore the issue of climate change in agricultural sector.

2.1 Study area

This study was conducted on four meteorological stations in Bangladesh. Among them Dinajpur and Bogra were selected from Northern region; Barisal and Chandpur district from southern region of Bangladesh. Dinajpur lies between latitude 25.63^0 N and longitude 88.65^0 E; Bogra is between latitude 24.85^0 N and longitude 89.36^0 E; Barisal is between latitude 27.70^0 N and longitude 90.36^0 E; Chandpur is between latitude 23.21^0 N and longitude 90.36^0 E. These study area show different amount of rice production in table 1.

Table1: Yield of Aman rice in Different study Area

Study Area	Aman Rice Production Scenario (2012-13)		
	Area (Hectare)	Yield per hectare (M.Ton)	Production (M.Ton)
Dinajpur	245924	2.569	631882
Bogra	182066	2.426	448188
Barisal	123545	1.812	223867
Chandpur	47187	1.920	90938

2.2 Cropping pattern and crop calendar

Rice dominates the cropping pattern throughout Bangladesh. Rice is the principal food of our people and grown in this country from time immemorial. It contributes for about more than 80% of the total food grains produced in the country. Rice production has been broadly divided into three classes of crop season:

Kharif-I : Produce Aus rice from last week of March to mid of June mainly pre-monsoon period.
Kharif-II : Produce Aman rice from June to first week of November mainly monsoon period.
Rabi : Produce Boro rice from June to first week of November mainly monsoon period.

2.3 Rainfall pattern in Bangladesh

There are four prominent seasons in Bangladesh. Namely

- Winter (December to February)
- Pre monsoon (March to May)
- Monsoon (June to August)
- Post monsoon (September to November)

2.4 Data Collection and data range

In this study, rainfall data of four weather stations were collected from Bangladesh Meterological Department (BMD). The rainfall data is included monthly and annual rainfall for the period January 1963 to December 2013. Aman Rice production data of Kharif –II season from 2008 to 2012 were collected Bangladesh Bureau of statistics (BBS) for the selected study areas.

3. RESULT AND DISCUSSION

3.1 Trend line analysis of seasonal rainfall variation

Due to different geographic location rainfall pattern vary in different district of Bangladesh. Rainfall pattern in different crop season also vary in different location. An analysis is performed to find out the trend of 50 years (1963-2013) rainfall distribution in different study area of Bangladesh.

Kharif-I starts from last week of March to mid of June. April and may is considered as an irrigation time. Mean value of April and May is plotted in graph from the period 1963-2013.

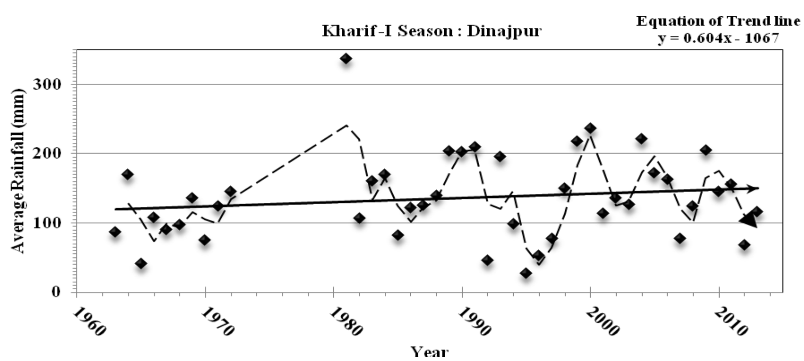

Figure 1: Average rainfall distribution over the kharif-I season in Dinajpur

Figure 1 is the Average rainfall distribution from 1963-2013 over the kharif-I season of Dinajpur district which is located at the north of Bangladesh. Average rainfall of the particular season is seen increase of the trend line.

The increase trend of rainfall distribution in Dinajpur is given by the following equation from figure1:

$$Y = 0.604x - 1067 \qquad (1)$$

Here, Y= Average Rainfall in mm and x = Time in years from 1963 to 2013

From the equation it can be calculated that in 1963, the trend line value of average rainfall in Kharif-I season in 1963 have 120 mm rainfall. Again in 2013 it was 150 mm of rainfall.

From the equation, in the year 2013, the value of Y = 0.604x – 1067 = 0.064*2013 – 1067 = 148.852 mm
From the equation, in the year 1963 the value of Y = 0.604x – 1067 = 0.064*1963 – 1067 = 118.652 mm

Therefore, over the period of 50 years, change in average rainfall has increased of trend line is
= 148.852 mm - 118.652 mm
= 30.2 mm (upward)
Or, from the equation (1), Y = 0.604 × 50years = 30.2 mm

From the others trend line equation for Bogra is 22mm, Barisal 12mm and Chandpur is 15mm increased over 50 years.

Table 2: Summery of seasonal rainfall variation in all study area resulted from trend line equations

Parameters (1963 – 2013)		Dinajpur	Bogra	Barisal	Chandpur	Overall Trend
Season: Kharif-I (last week of March - mid of June)	Equation of liner Trend	Y= 0.604x– 1067	Y= 0.439x – 742	Y = 0.239x – 319.8	Y = 0.235x – 391.4	Rainfall is increasing
	Average Shifted Value	+30	+22	+12	+15	
	Trend Gradient	(+ve) ↑	(+ve) ↑	(+ve) ↑	(+ve) ↑	
Season: Kharif-II (June - first week of November)	Equation of liner Trend	Y= 0.203x–76.88	Y= -0.088x+450.3	Y = 0.088x – 151.6	Y= - 0.157x + 624.4	Rainfall is both increasing and decreasing
	Average Shifted Value	+10	-4	+4	-8	
	Trend Gradient	(+ve) ↑	(-ve) ↓	(+ve) ↑	(-ve) ↓	
Season : Rabi (Mid November – March)	Equation of liner Trend	Y= -0.166x+341.8	Y= -0.08x+171.1	Y= -0.254x+533.4	Y= -0.051x+125.5	Rainfall is decreasing
	Average Shifted Value	-8	-4	-13	-3	
	Trend Gradient	(-ve) ↓	(-ve) ↓	(-ve) ↓	(-ve) ↓	

Table-2, It was found in season kharif-I, the average seasonal rainfall trend is increasing respectively Dinajpur +30mm, Bogra +22 mm, Barisal +12mm, Chandpur +15mm. Though Barisal and Chandpur the south zone a little of increasing it can be said it is positive for irrigation. But it is the fact this is not so effective as much as the production is required to full fill the demand of increasing population.

In the Kharif-II season shows a variety in results. Dinajpur from north and Barisal from south shows increase in average rainfall respectively +10mm and +4mm. Though +4mm is not good, it can be indicate as average trend. Bogra shows -4mm average rainfall. Though it is negative in trend it also can be said an average trend. But result from Chandpur -8mm is not well for increasing cropping condition.

It is too unsatisfactory to say that average rainfall in this season is naturally less, more over then it shows decreasing trend. Dinajpur, Bogra, Barisal and Chandpur all shows a negative trend respectively -8mm, -4mm, -13mm, -3mm. Bogra and Chandpur are near to average rainfall but Barisal and Dinajpur are in sever condition. Mainly create more pressure on water consumption from ground water. As a result ground water level is decreasing day by day.

3.2 Deviation from Average Rainfall in Rabi

Every years average rainfall deviation from fifty years average rainfall shows the decrease trend line in all over the study area. The deviation trend line analysis in Dinajpur shows in the Figure 2 represents all other study area.

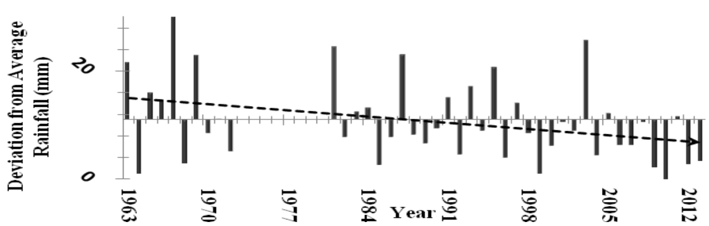

Figure 2: Average rainfall deviation of Dinajpur in Rabi season

In this figure, average rainfall from 1936 to 2013 is only 11mm in Rabi season. Plotting values of individual average rainfall (Rabi) in the graph, trend line shows much downward. So during long term from 1963 to 2013 the average rainfall is decreasing in Rabi.

3.3 Adaptation and Mitigation for sustainability

Bangladesh is a densely populated country. To meet the needs of this huge population rice production is required more and more production. This population habitation pressure is responsible for decreasing agricultural land. To mitigate this situation BADC, BRRI etc are playing important role to fight with climate as well as high future demand of rice using technology.

3.3.1 Use special hybrid for special climatic cases:

Bangladesh Rice Research Institute (BRRI) released so far 61 high yielding rice varieties including four hybrid varieties. Bangladesh Institute of Nuclear Agriculture (BINA) released 8 varieties. Some of the special popular varieties of BRRI and BINA along with their important characteristics are shown below:

- High yield rice
  - i. BRRI hybrid dhan3
    -Height: 110 cm, Grain yield: 9 t/ha. Duration: 145 days, Type: Boro
  - ii. BRRI dhan29
    -Height: 90 cm, Grain yield: 7.5 t/ha. Duration: 160 days, Type: Boro
  - iii. BRRI hybrid dhan4
    - Height: 112cm, Grain yield: 6.5 t/ha. Duration: 118 days, Type: Aman

- Submergence Tolerant Rice
  - i. BRRI dhan52
    - Height: 116cm, Grain yield: 4.5-5 t/ha. Duration: 142 days, Type: Aman
  - ii. BRRI dhan51
    - Height: 90cm, Grain yield: 4.5 t/ha. Duration: 142-154 days, Type: Aman

- Saline Tolerant Rice
  - i. BRRI dhan53
    - Height: 105cm, Grain yield: 4.5 t/ha. Duration: 125 days, Type: Aman, Saline tolerant: up to 8-10 ds/m
  - ii. BRRI dhan47
    - Height: 105cm, Grain yield: 6 t/ha. Duration: 150 days, Type: Boro, Saline tolerant: up to 12-14 ds/m

- Flash Flood Tolerant Rice in Haor Area:
  - i. BRRI dhan45
    -Height: 100 cm, Grain yield: 6.5 t/ha. Duration: 145 days, Type: Boro

- Moderately Drought Tolerant Rice
  - i. BRRI dhan42
    -Height: 105 cm, Grain yield: 3.5 t/ha. Duration: 100 days, Type: Aus

- Heat/Cold Tolerant Rice
  - i. BRRI dhan36
    -Height: 90 cm, Grain yield: 5 t/ha. Duration: 140 days, Type: Boro

There are also Short Duration Yield Rice, Late Variety Rice, Haor Suitable Rice etc to protect impact of climate change.

3.3.2 Water Reservation:

In Rabi season to fulfill high water demand and reducing ground water use water can be reserved in rainy season. The "downstream model" (figure 3) is that of a small reservoir only supplying a gravity-fed surface irrigation scheme equipped downstream, most generally for rice production during the rainy season thanks to supplemental irrigation. In many instances and for a number of reasons, not all potentially irrigable land is actually farmed. During the dry season, the reservoir level is too low and its volume too reduced to serve the irrigation scheme. In this model – made possible thanks to the increasing affordability of water-lifting devices - the water storage is used in a more productive and more equitable way, including (through some permanent wells) the groundwater recharge generated by the presence of the water body. Since water lifting is not an obstacle anymore, the reservoir banks can be utilized, preferably for high value crops and with water-saving low-pressure localized irrigation. In this model too, the flexibility in water management and reduced interdependence among irrigators are conducive to improved governance and conflict resolution over land and water rights issues, allowing both a more complete use of irrigation facilities during the rainy season and a larger number of irrigators to take advantage of the water storage during the dry season, both upstream and downstream. During the dry season, the central drain in the downstream area is actually used as a low discharge canal from where motorized and treadle pumps get the supply water.

In contrast with this, current knowledge and available technologies suggest a different development pattern like rainwater harvesting system, plastic pond, dam etc.

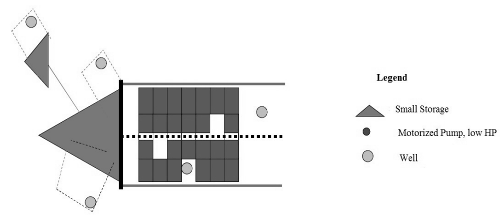

Figure 3: A divisive downstream model of small water storage system

3.3.3 Prepare more effective crop calendar:

For hybrid seed technology, Bangladesh achieved such crop can harvest in very short time. As a result it can be suggested that crop calendar can be modified in four seasons.

4. CONCLUSIONS

Rice yield depends mainly on rainfall in the context of Bangladesh. But rice production can be threatened by rise in sea level, temperature, cyclone, drought and many of natural disaster which are not considered in the present study. With respect to 50 years rainfall data analysis, Rabi season is in the most severe condition and its trend line is downward. Boro rice is one of the major food grains which contributes majority of total rice production. Mean rainfall is naturally less in this season. The irrigation process for Rabi, highly depends on underground water. With the increasing of higher population rate, demand is increasing proportionally. It is high time to be concern about food security of Bangladesh. In Kharif-I, average rainfall is increasing which is positive in sense of irrigation. In future this season has possibility to reduce additional irrigation. Kharif-II is both increasing and decreasing, but decreasing amount is not so much effective. Chandpur is a district with many rivers but its production is not satisfied in kharif-II because of natural disaster due to climate change. Dinajpur is affected with drought in several times. Water reservoir system should be applies in such case. It is a matter of concern that to ensure sustainable agriculture in Bangladesh extreme climatic behaviour tolerant seed invention, water reservation system with suitable technology and complies more effective crop calendar is necessary.

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