International Journal of Inclusive Development
Citation: 5(2): 53-58, December 2019
DOI: 10.30954/2454-4132.2.2019.3

Crop Planning under Changing Climate Scenario

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Received: 14 Jul., 2019 **Revised:** 17 Oct., 2019 **Accepted:** 20 Nov., 2019

ABSTRACT

Climate change is very likely to affect food security at the global, regional, and local level. An attempt has been made to study the impact of climate change on crop production and productivity of different crops in Banka district of Bihar state by observing some local condition and by using some data available from district agriculture department. Climate change can disrupt food availability, reduce access to food, and affect food quality and impact the production and quality of vegetables and legumes. Nutritionally important vegetables and legumes can be particularly sensitive to temperature increases and more vulnerable to heat stress than staple or cereal crops. By observing the last five years rainfall data, it was observed that the annual average rainfall of the district was 1182.1mm, 822.2mm, 1031.8mm, 910.3mm and 816.07 mm against the average normal rainfall i.e. 1156.3 in the year 2014, 2015, 2016, 2017 and 2018 respectively. In the year 2014, a negative deviation found (-2%), afterward, 29%, 11%, 21% and 29% deviation observed in the rest of the years respectively which indicates the more uncertainty of monsoon rainfall. By observing the 19 years rainfall data, it is clearly shown that the annual rainfall trend for the district are coming out to be significant at five percent level of significance and showing a decreasing trend of annual rainfall. The main reason behind this changing rainfall pattern was climate change. So, main emphasis should be given on the farming according to weather condition of those particular areas or region.

Keywords: Impact, Climate Change, Crop and Livestock, Rainfall, Crop planning

Agriculture is an important sector of the Indian economy and climate change leads to projected increases in temperatures, changes in precipitation patterns and climate extremes (e.g., heat waves); pests and diseases;atmospheric carbon dioxide and ground-level ozone concentrations; the nutritional quality of some foods and changes in sea level and reductions in water availability may all result in reduced agricultural productivity. Increases in the frequency and severity extreme weather events can also interrupt food delivery, and resulting spikes in food prices after extreme events are expected to be more frequent in the future. Rain is a major component of the water cycle and is responsible for depositing most of the fresh water on the Earth. It provides suitable conditions for many types of ecosystems, as well as water for hydroelectric power plants and crop irrigation. Banka is one amongst the rainfed areas of Bihar and less rainfall along with drought situation frequently found in last few years due to climate change. Because of climatic variation the farming communities of the district shows more interest on drought resistant varieties for growing crop in less water.

MATERIALS AND METHODS

The present study is confined to Banka district is located in between latitude 24.7757° N and longitude 86.8220° E at an altitude of 85-247 meters above Sea level (MSL) having annual average rainfall of 1200 mm and area 3,019 km².Much of the information about the rainfall climatology of any region is mostly based on its availability and distribution. Crop planning strategies have been developed by using crop and weather data of the district. Rainfall data was analysed for a period of nineteen years(2000 to 2018) by using linear regression equation. Crop data was collected from the District Agriculture Office, Banka and conducted a comparative study between the year 2015-16 and 2018-19.

Climatic Profile of Banka, Bihar

Different Agroclimatic Zone of Bihar: Based on soil characterization, rainfall, temperature and terrain, four main agro-climatic zones in Bihar have been identified. These are: Zone-I, North Alluvial Plain, Zone- II, north East Alluvial Plain, Zone-III A South East Alluvial Plain and Zone-III B, South West Alluvial Plain, each with its own unique prospects. Agro climatic zone I and II is located south of the river Ganges whereas the Zone III is located south of the river Ganges. The name of the districts under each agro-climatic zone are given in table 1.0.Banka district comes under zone III A which is basically drought prone area. Zone wise agro-climatic situation of Bihar plains enunciates that agro-climatic zone II records the highest rainfall followed by zone I and zone III receive the least rainfall. Rainfall during the monsoon varies from the lowest in zone III to the highest in zone II and a moderate rainfall in zone I.

The cold weather commences early in November and comes to an end in the February. The days are bright and warm and the sun is not too hot. As soon as the sun sets the temperature falls and the heat of the day yields a sharp bracing cold. The mean temperature varies from 10 ˚C to 18 ˚C. January is the coldest month in Bihar. Light fog occurs occasionally during daytime especially in the month of January. Sometimes Bihar gets light winter showers in December-January. The hot weather sets in the end of March and lasts until the middle of June. The highest temperature is often registered in May, which is the hottest month in the state. The hot winds (loo) of Bihar plains blow during April and May with an average velocity of 8–16 km/hour. This hot wind greatly affects human comfort during this season. Soon after Mid-June the monsoon season commences and continues till the end of September, the beginning of this season occurs when a storm from the Bay of Bengal passes over Bihar.

Table 1: Districts under each Agro-Climatic Zone

Sl. No.	Agro-climatic zone	Districts
1	Agro- climatic zone I (Northern West)	West Champaran, East Champaran, Siwan, Saran, Sitamarhi, Sheohar, Muzaffarpur, Vaishali, Madhubani, Darbhanga, Samastipur, Gopalganj, Begusarai
2	Agro-climatic Zone II (Northern East)	Purnea, Katihar, Saharsa, Supaul, Madhepura, Khagaria, Araria, Kishanganj.
3	Agro-climatic zone IIIA (Southern East)	Sheikhpura, Munger, Jamui, Lakhisarai, Bhagalpur & Banka.
4	Agro-climatic zone IIIB (Southern West)	Rohtas, Bhojpur, Buxar, Bhabhua, Arwal, Patna, Nalanda, Nawada, Jehanabad, Aurangabad, Gaya.

The district of Banka has 60% of area under hilly zone. Hilly areas possess a good rainfall as compared to the plain regions of the district. The Climate of this district is characterized by a hot Summer and a pleasant Winter Season. March to June comprises the summer months while the cold season lasts from November to February. Monsoon sets sometimes in the part of June and the rains continue till September, October being a transitional month. The district also received some winter rains. The south west monsoon generally breaks in during the second half of June. The bulk of the rainfall occurs in July and August. The average annual rain fall is 1150 mm almost uniformly throughout the district.

RESULTS AND DISCUSSION

Influencing factors for Climate Change

There are various causes of change which can be brought about by a variety of factors. These include natural external factors, such as changes in solar

emission or slow changes in the earth's orbit; or natural internal processes of the climate or earth system such as volcanic activity; or, as has occurred recently, human-induced (anthropogenic) factors. Climate may change in a single region or across the whole planet. In the past the conversion of most of the temperate forest zones into agricultural land changed the ecology and the local climate. After the Industrial Revolution, industrialization, urbanization and population growth have caused the spread of enormous pollutants effecting the deliberate modification of the climate. Combustion of a great amount of fossil fuels has caused an increase in the concentration of greenhouse gases resulting in global warming and climate change. This has altered the wind, cloud and precipitation pattern. The land use has also an effect on the climate such as deforestation, agricultural work and urbanization.

Constraints in Agricultural Production

Water and food security are the key challenges under climate change as both are highly vulnerable to continuously changing climatic patterns. Agriculture in Banka District is mainly depending upon the monsoon rainfall but unusual rainfall patterns observed in recent year due to climate changes as a result of which the districtis frequently suffering from drought situation. There are several key challenges related with policy and strategy making that have to be confronted. Some of the important challenges are as follows:

- Collection of information and data and their sharing among people related with climate change and its impact on water resources. It is necessary because water resource management requires, systematic and well-planned actions based on accurate scientific data.
- Majority of the block have varying hydrological conditions, therefore adaptation of the same policies and strategies by each block is not possible. The policies and the action plan will be different for each location based on its hydrological conditions.
- Climate change has increased the frequency and intensity of the natural calamities and now it has become necessary to invest in the study of these natural calamities and their future impacts and prepare a comprehensive plan to minimize their impact on countries.

To minimize the impact of climate change on water resources it is necessary to understand and evaluate the vulnerability of water resources to global warming impacts. After understanding these impacts only policies and strategies should be formed and implemented.

Rainfall pattern of Banka District in past five years

For rainfall trend analysis, data from the year of 2014 to 2018 was taken in Banka district. By using the rainfall data collected from District Agriculture Office, Banka we analysed the rainfall trend of a particular district and plotted in a graph from which the increasing and decreasing trend of rainfall can be detected. It is clearly shown that the annual rainfall trend for Banka district during past five years are coming out to be non-significant (Fig. 1). A negative deviation of -2 was observed in the year 2014 but positive value was found in rest of the years.

Mean Annual Rainfall and its deviation from Normal Rainfall are shown below in Table 2.

Table 2: Mean Annual Rainfall and its deviation from Normal Rainfall for Banka District

Years	Normal Rainfall	Mean Annual Rainfall	Deviation from Normal (%)
2014	1156.3	1182.1	-2%
2015	1156.3	822.2	29%
2016	1156.3	1031.8	11%
2017	1156.3	910.3	21%
2018	1156.3	816.07	29%

By observing the rainfall data, we found that the annual average rainfall of the district was 1182.1mm, 822.2mm, 1031.8mm, 910.3mm and 816.07mm against the average normal rainfall i.e. 1156.3 in the year 2014, 2015, 2016, 2017 and 2018 respectively. Also, a positive deviation was found in all the years except 2014 (shown negative deviation of -2%) which indicates that the rainfall amount is going to be decreasing year by year and the main reason behind this is Climate Change. It is very challenging task for all agriculturist to grow crop under changing climate scenario.

Rainfall trend analysis for a period of 19 years

For trend analysis, the annual rainfall data of the Banka district are available from 2000 to 2018 as shown in Fig. 1. From the graph, it is clearly shown that the annual rainfall trend for the district are coming out to be significant at five percent level of significance and showing a decreasing trend of annual rainfall. The time trend equations of annual rainfall are shown below in Table 3.

Table 3: Time trend equation of annual rainfall for Banka district

Districts	Period	Equation	R^2
Banka	2000-2018	y = -30.047x + 1363.5	0.5107*

**-significance at 5 % level and **- significance at 1 % level.*

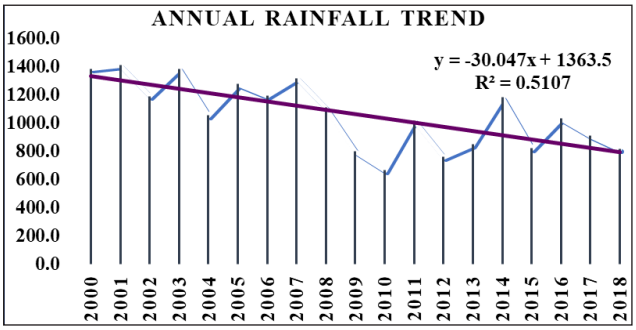

Fig. 1: Graphical representation of Annual Rainfall trend for Banka district

Impact of Climate Change on Crop

For any particular crop, the effect of increased temperature will depend on the crop's optimal temperature for growth and reproduction. In some areas, warming may benefit the types of crops that are typically planted there, or allow farmers to shift to crops that are currently grown in warmer areas. Conversely, if the higher temperature exceeds a crop's optimum temperature, yields will decline. if temperature exceeds a crop's optimal level, if sufficient water and nutrients are not available, yield increases may be reduced or reversed. More extreme temperature and precipitation can prevent crops from growing. Extreme events, especially floods and droughts, can harm crops and reduce yields. Dealing with drought could become a challenge in areas where rising summer temperatures cause soils to become drier. Although increased irrigation might be possible in some places, in other places water supplies may also be reduced, leaving less water available for irrigation when more is needed. Many weeds, pests, and fungi thrive under warmer temperatures and wetter climates or hot weather condition. He ranges and distribution of weeds and pests are likely to increase with climate change. Precipitation, especially rain, has a dramatic effect on agriculture. All plants need at least some water to survive, therefore rain (being the most effective means of watering) is important to agriculture. While a regular rain pattern is usually vital to healthy plants, too much or too little rainfall can be harmful, even devastating to crops. Drought can kill crops and increase erosion, while overly wet weather can cause harmful fungus growth. Plants need varying amounts of rainfall to survive. For example, certain cacti require small amounts of water, while tropical plants may need up to hundreds of inches of rain per year to survive.

In areas with wet and dry seasons, soil nutrients diminish and erosion increases during the wet season. Animals have adaptation and survival strategies for the wetter regime. The previous dry season leads to food shortages into the wet season, as the crops have yet to mature. Developing countries have noted that their populations show seasonal weight fluctuations due to food shortages seen before the first harvest, which occurs late in the wet season. Rain may be harvested through the use of rainwater tanks; treated to potable use or for non-potable use indoors or for irrigation. Excessive rain during short periods of time can cause flash floods.

From a local investigation in Banka Block we found that during this year no of days with heat wave (>=42^{o}C) was 2 to 3 times more than the previous years and also from last three years the district experiencing drought situation because of below normal rainfall with uneven distribution. This situation is mainly arising due to climate change which destroyed the agriculture of Banka in the last three years. Changes in agriculture status of Banka district of Bihar are mention in Table 3. There is a comparison of relative changes in cropping areas from the year 2015-16 to 2018-19 under different crops like Rice, Wheat, Maize, *Arhar*, Gram and Oil seeds like *Rai*/Mustard for both *Kharif* and Rabi season are shown in the table 4.

Table 4: Changes in agriculture status of Banka district of Bihar

Particulars	2015-16	2018-19	Relative change (%)
Area covered by different crops (Hectare)			
Kharif			
Paddy	104794	95231	5 %
Maize	**6790**	**12464**	**29 %**
Arhar	2200	1754	11 %
Rabi			
Wheat	45152	29801	20 %
Maize	4040	2284	28 %
Gram	4505	4431	1 %
Rai/Mustard	2291	1623	17 %

Source: *Krishi Vigyan Kendra, Banka (2015-16) and District Agriculture Office, Banka (2018-19).*

From the above table it was revealed that there was a relative change of 5% in paddy, -29% in *Kharif* Maize and 28% in *Rabi* Maize, 11% in Arhar, 20% in Wheat, 1% in Gram and 17% in *Rai*/Mustard cultivation found during the year. The main reason behind the decrease in cultivated areas under Paddy crop and increased under *Kharif* Maize was below normal rainfall during monsoon season which didn't allow to cultivate paddy in some area. But in case of Rabi Maize, there was a decrease in cultivated areas found because of deficient post monsoon Rainfall during Rabi season. The graphical representation of relative changes in different cropped area during these 4 to 5 years.

Crop planning under changing climate scenario

- Gates (1988) experienced that the world is sufficient to convince people that even a temporary change of climate can have profound impact on agricultural production and on the use of energy and water resources.
- There are some recommendations suggested for the region have been made to increase the production and productivity of rice and other crops in per unit area per unit time.
- About approximate 80 per cent of the total average annual rainfall concentrated in the south west monsoon and received during a short span of two to three months between June to September.
- Despite advance technology, still monsoonal rains influence the food grain production to a considerable extent. *Kharif* food grain production is adversely affected due to monsoon break or failure.
- The crops already sown with the advent of monsoon are also adversely affected due to dry spells, which result in soil moisture stress. The onset and withdrawal of monsoon influence the crop growing season and selection of crops to a large extent.
- Rainfall received during summer (March-May) season can be utilized for summer ploughing to make the land ready for final field preparation for rice crop.
- Harvesting and storage of excess rainfall received during period of south west monsoon season can be used in drought and dry spell situations as per intensity and frequency from year to year and good crop can be harvested.
- If there is well distributed rainfall in sufficient quantity then this stored water can be utilized to grow second crop in *rabi* season.

Water conservation is one of the oldest activities practiced by old civilization to fulfils the required demand for water for irrigated agriculture and domestic needs in the arid and semi-arid regions. In ancient times the recharge movement initiated by the local communities was aided and supported by emperors. The approaches that support farming communities to self-mobilize and self-organize for participatory learning and action could lead farmers to enhance their uptake of better technologies and improved use of farm-level resources in the wake of increased climate change and variability (Mapfumo *et al.* 2013).

A comparative study of changes in Cropping pattern/system of Banka District

The existing cropping pattern of the district was analysed by discussing with local people during feedback programme and the suggestion given by Krishi Vigyan Kendra by analysing local climatic condition. Here a comparative study of different cropping pattern/system adopted by local people of the district are given in Table 5. Farmers can improve their cultivation practices by using mulching technique in Vegetable production, by

applying NADEP compost and waste decomposer in crop fields.

Table 5: Cropping pattern/system adopted by farmers in Banka district

Existing		Suggested
Rice-Wheat	Rice –Rai – Moong	Rice (Short duration)- Arhar / Pulse
Rice - Linseed	Tomato / Pea	Arhar + Maize + Cowpea
Rice – Gram / Lentil	Brinjal- Spinach	
Rice – Maize	Cauliflower	
Rice – Gram+ Rai	Spongegourd – Potato- Moong	
Rice –Wheat+ Rai	Okra	

CONCLUSION

Looking into the challenges in rainfed crop cultivation in Banka district of Bihar that our future agricultural planning must be taken into account of this rainfall. Short duration but high yielding varieties need to be developed in this region because as since last two to three years the district is suffering from Drought situation due to unusual monsoon behaviour and uneven distribution of rainfall. To cope with this climatic condition, we need to adjust our cropping pattern and cropping system accordingly. From this study, we concluded that day-by-day water get scared and with continuing this trend we will suffer a severe water scarcity condition. So, to avoid such situations we should apply some technologies that helps in rain water harvesting and ground water recharging. Erratic climatic conditions and their variability with time play an important role in the crop production and overall yield. Most of the crop failures worldwide are associated with either a lack or excess of rainfall. Precise climate forecasting can reduce the risks of crop failure and also help in the pre and post decision making processes for better agricultural yield. Further the nature of the forecasting also influences the ability of farmers to respond like farmers are more concerned about within-season characteristics of rainfall rather than the amount of total seasonal rainfall. The value of forecasts diminishes if information is received after the number of pre-planting decisions are made, therefore the forecasting should be in time and specific.

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