Trends of Rainfall in Different Sectors of Uttar Pradesh Under Present Scenario of Climate Change

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ABSTRACT

In the changing scenario of climate, the present study was carried out to identify the recent trends of rainfall variability in different sectors of Uttar Pradesh. Analysis of rainfall (1971-2011) was made for four sectors viz. Eastern, Western, Central and Bundelkhand region of U.P. It was found that in general, annual rainfall decreased in all sectors of U.P. but the rate of decrease of rainfall in western U.P. was faster as compared to other sectors of U.P. and was in the order of Western U.P.> Eastern U.P.> Central U.P.> Bundelkhand region. Variability of seasonal rainfall in different sectors of U.P. was also in the same order and magnitude as that of total rainfall. Average onset dates of south west monsoon in Eastern U.P. and Wentral U.P. have shifted to 19$^{th/}$and 20th June respectively, from the normal date of 15th June. Total rainfall in relation to onset of monsoon, decreased by 6%, if monsoon reaches on 19th June in Eastern U.P.(normal date of onset is 15th June) and 9.5%, if monsoon reaches on 25th June. Consequent upon length of rainy season was also decreased from normal 108 days to 99 days in Eastern U.P. whereas reduction in length of rainy season in other sectors of U.P. ranged between 12-13 days. Rainy day and rainfall intensity both reduced in all sectors of U.P. In Eastern U.P. rainfall intensity reduced from 25 mm/day (1971-1990) to 17.2 mm/day (1992-2011), i.e. 32% reduction, hence crop planning may be made accordingly in respective sectors.

Key words: *Seasonal rainfall, Rainy days, Rainy season, Yield gap,*

1. Introduction

Food security and energy security of India are crucially dependent on the timely availability of adequate amount of water and a conducive climate to the agriculture and related sectors. The rainfall received in any area is an important factor in determining the amount of water available to meet various demands, such as agriculture, horticulture, livestock, industries and domestic water supply etc. Global climate changes may influence long-term rainfall patterns impacting the availability of water, along with the risk of increasing occurrences of droughts and floods. The southwest (SW) monsoon, which brings about 80% of the total precipitation over the country, is critical for the availability of freshwater for drinking and irrigation. Changes in climate over the Indian region, particularly the SW monsoon, would have a significant impact on agricultural production, water resources management and overall economy of the country. The heavy concentration of rainfall in the monsoon months (June–September) results in scarcity of water in many parts of the country during the non-monsoon periods. Change in rainfall due to global warming or after 1990's (after industrialization) in the country, may influence the hydrological cycle and rainfall pattern. This compelled to review the demand of water hydrological design and agricultural practices. Therefore, long term trend analysis of rainfall and other weather parameters on different spatial scales will help in framing, the future scenarios for crop planning and management (Jain & Kumar 2012).

2. Data and Methodology

The districts wise rainfall data of 20 years (1992-2011) on daily basis for different sectors of U.P. was obtained from State Agriculture Department, Lucknow. Rainfall variability, characteristics of rainfall, length of rainy season, onset/withdrawal of monsoon and time series analysis of rainfall and its relation with productivity was done using step wise regression technique. District wise historical data of rice area, production and yield for period of 1992-2011 of U.P. was obtained from State Agriculture Department of Lucknow. Time series graphs were plotted for trend analysis of area, production and productivity of rice for each sectors of U.P. The data has been analyzed to evolve the rainfall based planning the farm operations, crop management and cropping system with minimum risk to utilize the rainfall efficiently for increased production.

3. Results and Discussion

3.1 Annual rainfall

Annual rainfall in Bundelkhand region was minimum (663 mm) followed by Western U.P. (750.9 mm) based on time series data (1992-2011) of average annual rainfall for different sectors of U.P. whereas eastern U.P. received highest amount of rainfall (902.3 mm) followed by central U.P. (790.2 mm) (Table 1). The variability and trend of annual rainfall for these sectors has been depicted in Fig. 2 and it was observed that annual rainfall in all sectors of U.P. decreased in recent years. The rate of decrease of rainfall in western U.P. was highest and Bundelkhand region of U.P. was lowest. The rate of decrease was in order of western U.P.> eastern U.P.> central U.P.> bundelkhand region of U.P. But if time series data is grouped into two parts, i.e. (i) 1971 to 1991 and (ii) 1992 to 2011, the recent trend of rainfall as observed from time series analysis of 1992-2011 was specific and peculiar in the sense that the rate of decrease of rainfall in Bundelkhand region of U.P. was highest instead of western U.P. as observed in combined time series analysis of 1971-2011. This shows that the western branch of the SWM after Kerala onset and western disturbances affected the south-west monsoon to the great extent in western and bundelkhand region of U.P.

Table 1: Average annual rainfall of different sectors of Uttar Pradesh

Sectors	Average annual rainfall (mm)
Eastern U.P.	902.3
Central U.P.	790.2
Western U.P.	750.9
Bundelkhand region of U.P.	663.0

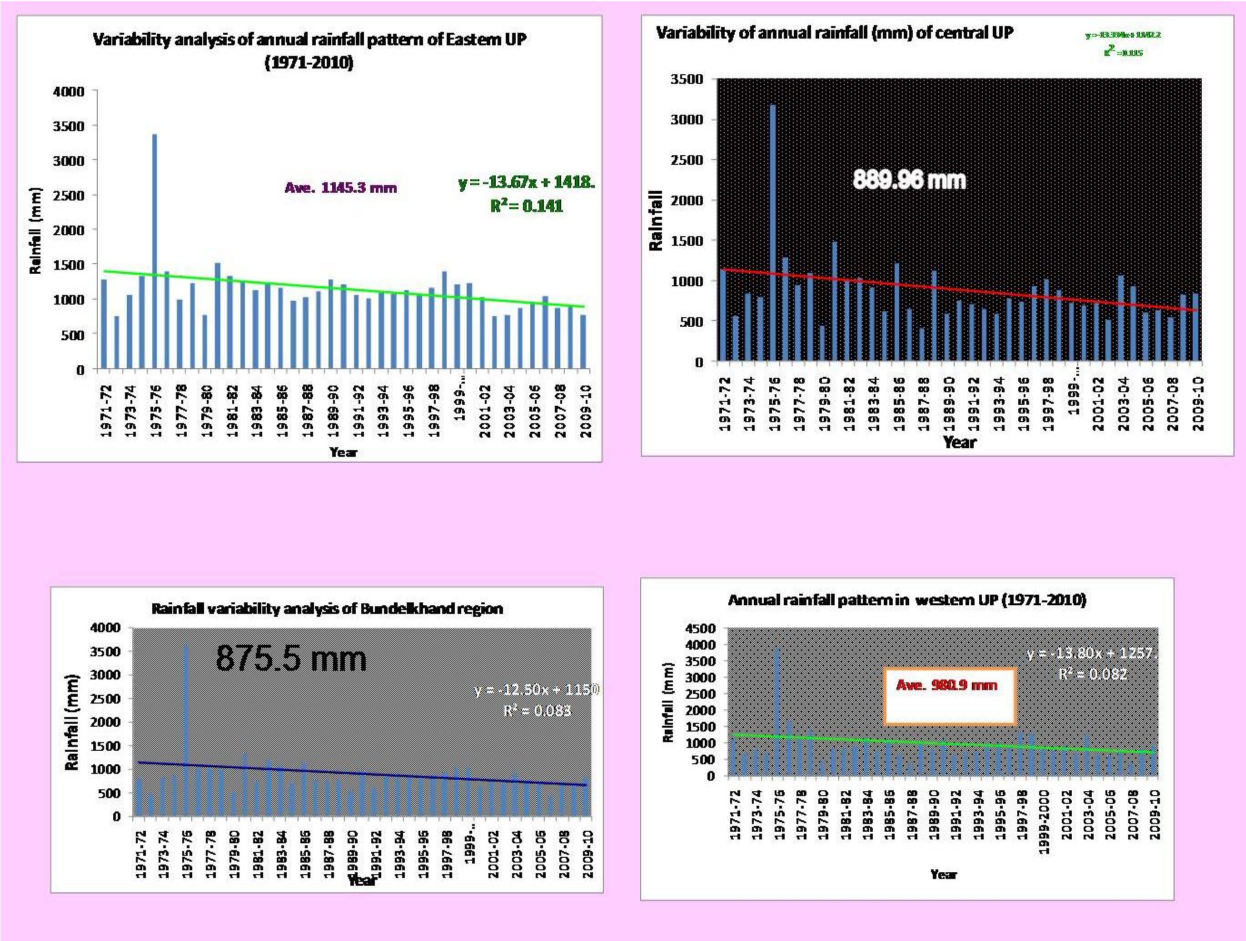

Fig. 1: Variability in annual rainfall pattern for different sectors of U.P. (1971-2010) (Rates of decrease of rainfall in different zones are in the order of Western UP>Eastern UP>Central UP> Bundelkhand region)

3.2 Seasonal rainfall

Average rainfall during south-west monsoon season in eastern U.P. was 29% followed by central U.P. (25%) and western U.P. (24%) and Bundelkhand region (22%) (Fig.2). The highest rainfall percentage, i.e. 34% was obtained in eastern U.P. during post monsoon season followed by central U.P. (26%), western U.P. (22%) while minimum rainfall during post monsoon season was received in Bundelkhand region of U.P. (22%). The lowest rainfall (16%) was received during winter season in Bundelkhand region. Highest percentage of rainfall was recorded in western U.P. (35%) followed by central U.P. (26%) and eastern U.P. (23%). The partitioning of rainfall during summer season was in order of western U.P. (30%) followed by central U.P. (28%), eastern U.P. (25%) and Bundelkhand region (17%). From the above analysis it may be revealed that due to higher rainfall percentage in western U.P. during winter season and summer season, the rabi and summer crops may be harvested at higher economics and yield hence good return.

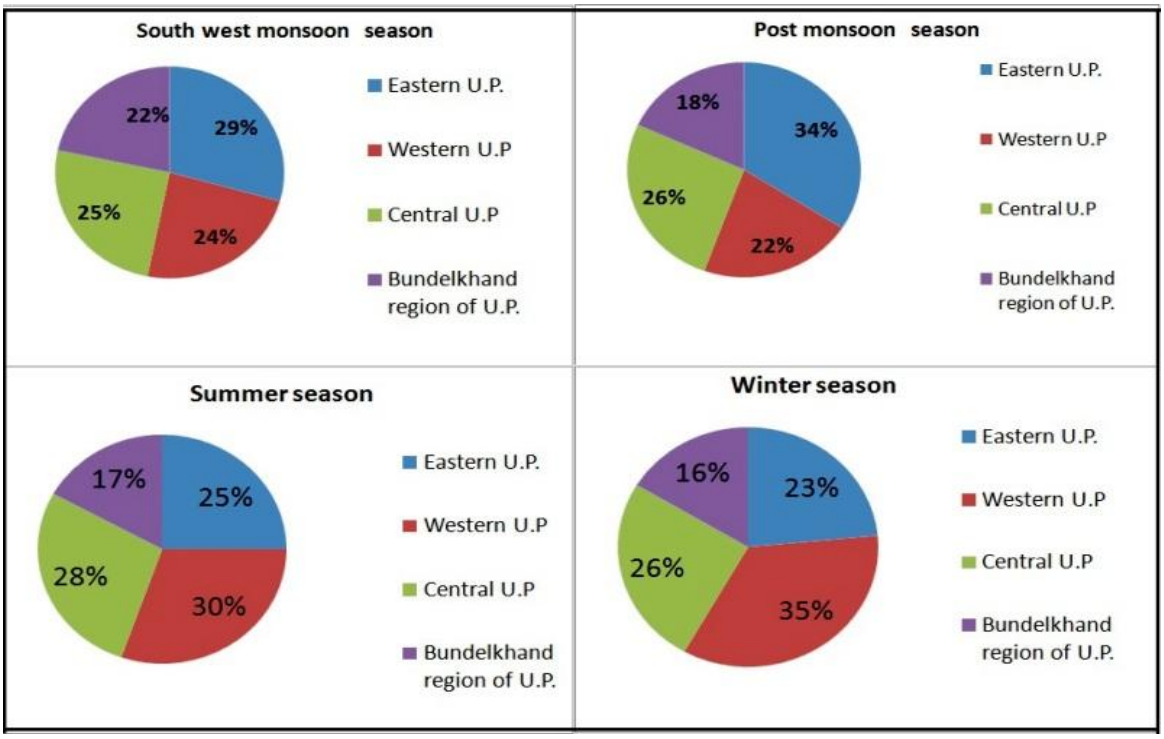

Fig. 2: Seasonal rainfall partitioning under different sectors of U.P.

3.3 Onset /withdrawal dates of monsoon and length of rainy season

Onset/withdrawal dates of monsoon and length of rainy season in different sectors of U.P. has been shown in table 2. The average onset date of south-west monsoon in eastern U.P. and central U.P. was shifted to 19 June from normal onset date followed by Bundelkhand region of U.P. (20 June) and western U.P. (21 June). Normal onset date in eastern U.P. is 15th June and that in western U.P. 17th June. The onset date in U.P. delayed 4 days from the normal. The yearly variation of onset and withdrawal dates and length of rainy season in different sectors of U.P. has been shown in table 3. It has been observed that in different years, the range of onset date of south-west monsoon in eastern U.P. and central U.P. was in between 8th to 26th June, whereas in western U.P. and Bundelkhand region, it lies between 9th to 27th June. i.e., one days ahead from eastern U.P or central U.P. This shows that monsoon covers entire U.P. within one day from east to west. Withdrawal date of south-west monsoon in different sectors of U.P. was 21st September except eastern U.P. where, average date of withdrawal was realized as 25th September against the normal date 30th September. The withdrawal of south-west monsoon shifted 5-9 days early toward rainy season. Length of rainy season was therefore, drastically reduced from normal 108 days to 99 days in eastern U.P. i.e., 9 days, whereas reduction in length of rainy season in other sectors of U.P. ranged between 12 to 13 days. This ultimately forced to reconsider the crop planning and selection of rice crop varieties of short duration as to minimize the risk losses.

Table 2: Onset and withdrawal dates and length of rainy season during south-west monsoon period (*Figures in parentheses show the normal dates/days as per IMD, Govt. of India.)

Sectors	Onset date of SWM (June)	Withdrawal date of SWM (September)	Length of rainy season of SWM (days)	Departure from normal
Eastern U.P.	19 (15)	25 (30)	99 (108)	-9
Central U.P.	19 (16)	21 (30)	95 (107)	-12
Western U.P.	21 (17)	21 (30)	93 (106)	-13
Bundelkhand region of U.P.	20 (17)	21 (30)	94 (106)	-12

Table 3: Onset and withdrawal dates of south-west monsoon in different sectors of U.P.

Years	Eastern U.P.		Central U.P.		Western U.P.		Bundelkhand region of U.P.	
	Onset date of SWM (June)	Withdrawal date of SWM (Sept.)	Onset date of SWM (June)	Withdrawal date of SWM (Sept.)	Onset date of SWM (June)	Withdrawal date of SWM (Sept.)	Onset date of SWM (June)	Withdrawal date of SWM (Sept.)
1992	21	24	23	22	27	25	25	27
1993	23	27	19	27	21	24	27	25
1994	20	20	25	19	23	18	24	16
1995	20	24	19	22	20	16	18	20
1996	20	29	20	19	24	20	18	15
1997	20	25	19	22	18	27	18	26
1998	24	27	16	25	28	26	20	26
1999	21	27	23	27	24	25	23	24
2000	15	25	16	21	16	15	12	21
2001	18	19	13	17	17	19	20	8
2002	12	25	23	20	9	20	19	20
2003	22	28	21	28	20	20	24	30
2004	15	25	19	22	20	23	15	22
2005	23	25	18	24	25	26	24	22
2006	26	26	25	16	25	12	22	17
2007	17	29	15	28	18	27	24	28
2008	8	26	14	25	11	21	11	25
2009	24	16	26	12	25	12	23	15
2010	25	22	21	22	26	27	26	23
2011	18	25	19	14	19	22	21	23
Total	392	492	382	428	418	420	407	428
Average	19	25	19	21	21	21	20	21

3.4 Rainy days and rainfall intensity in different sectors of U.P.

The rainy days and rainfall intensity of different sectors of U.P. has been shown in table 4. The number of rainy days in different sectors of U.P. ranged from 40 days in Bundelkhand region to 48 days in eastern U.P. during south-west monsoon period whereas it was almost same and ranged between 15.4 mm/day in Bundelkhand region to 17.2 mm/day in eastern U.P. Intensity of rainfall in Central U.P. was 16.4 mm/day, within 41 rainy days however, in western U.P. it was 15.6 mm/day in 45 days and in Bundelkhand region it was at par with central U.P. i.e., 41 rainy days 40 days. From the data, it was revealed that rainy days and rainfall intensity both were reduced in all sectors of U.P. In eastern U.P. rainfall intensity reduced from 25 mm/day (1971-1990) to 17.2 mm/day (1992-2011) i.e., 32% reduction was noticed. A similar trend has also been noticed during recent years (1992-2011) for number of rainy days but it was very less i.e., only 6% for eastern U.P. The similar findings have also been reported by Tripathi *et al.*, 1998.

Table 4: Rainy days and rainfall intensity during south-west monsoon under different sectors of U.P.

Sectors	**Rainy days of SWM (days)**	**Rainfall intensity of SWM (mm/day)**
Eastern U.P.	48	17.2
Central U.P.	41	16.4
Western U.P.	45	15.6
Bundelkhand region of U.P.	40	15.4

4 Yield Gap Analysis of Rainfed Rice

Yield gap of rainfed rice in different sectors of U.P. has been shown in Fig. 3 to 6. It has been observed that the maximum yield gap was found in eastern U.P. (7.3 q/ha) at 865 mm rainfall followed by central U.P. (7.1 q/ha) at 780 mm rainfall and Bundelkhand region (5.9 q/ha) at 610 mm rainfall. In western U.P., the yield gap was lowest i.e., 3.9 q/ha only at 710 mm rainfall. Maximum yield gap was observed in eastern U.P. and minimum in western U.P. Minimum yield gap in western U.P. even at low rainfall (710 mm) shows the better management of rainfall i.e., low runoff, better utilization of water use efficiency whereas highest yield gap in eastern U.P. almost twice that of western U.P. at better rainfall availability (865 mm) indicate the need of more management care to minimize the yield losses hence yield gap. Central U.P. also needs similar type of management as that of eastern U.P. to minimize the yield gap. In Bundelkhand region of U.P., rice cultivation was not popular but now a days due to better rainfall availability orientation towards rainfed rice farming are increasing

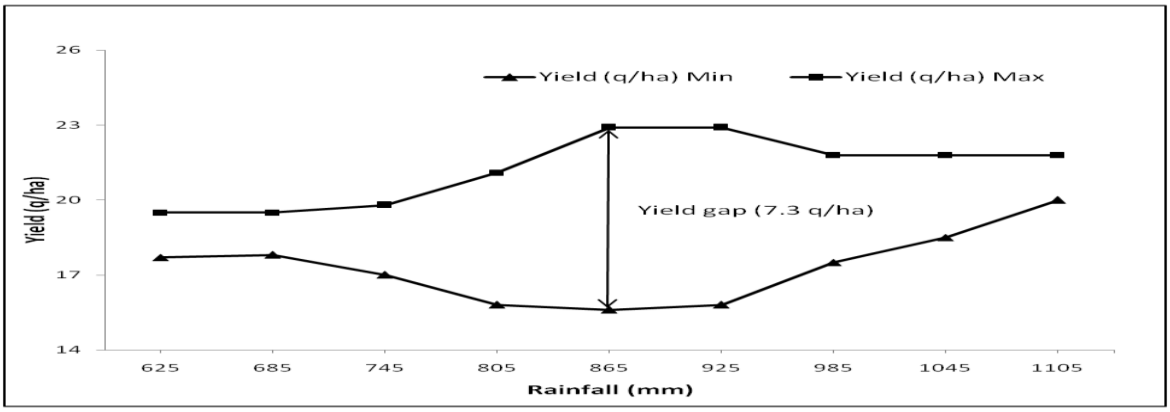

Fig. 3: Yield gap analysis of rainfed rice in western U.P under variable rainfall Condition

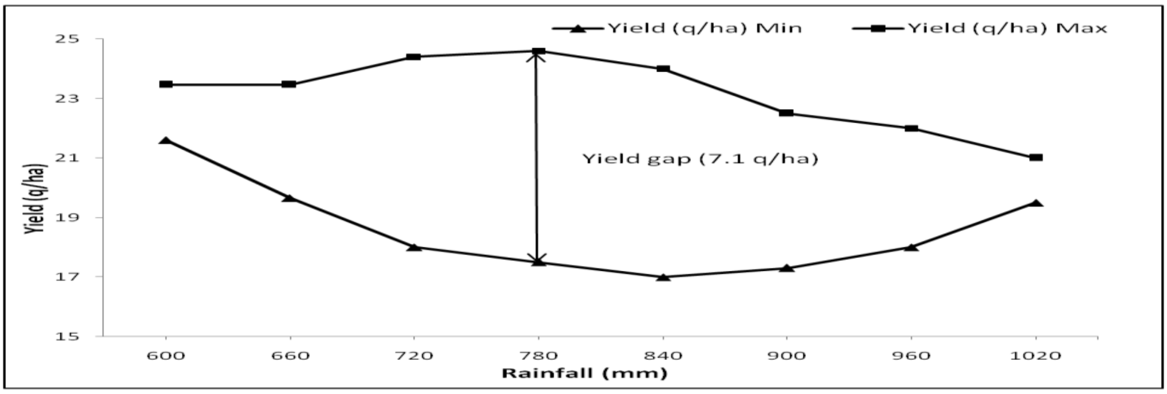

Fig. 4: Yield gap analysis of rainfed rice in Eastern U.P. under variable rainfall condition

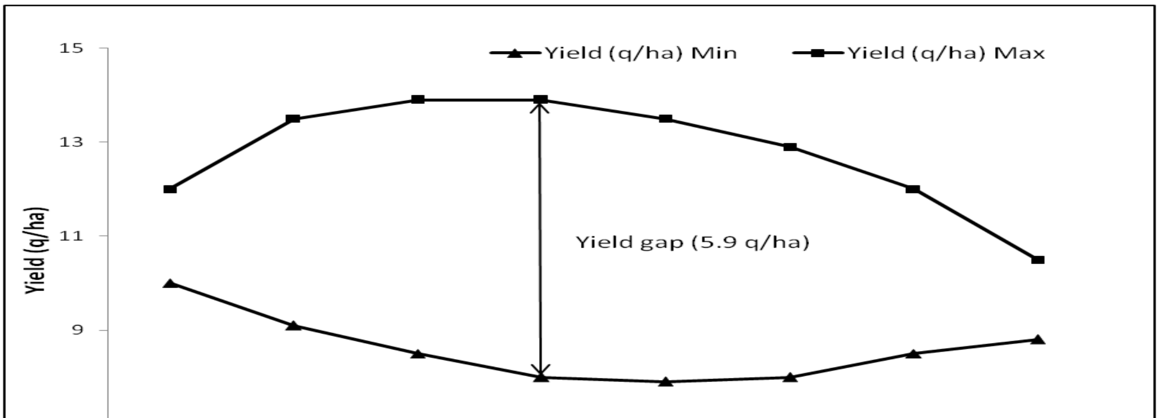

Fig. 5: Yield gap analysis of rainfed rice in central U.P. under variable rainfall condition

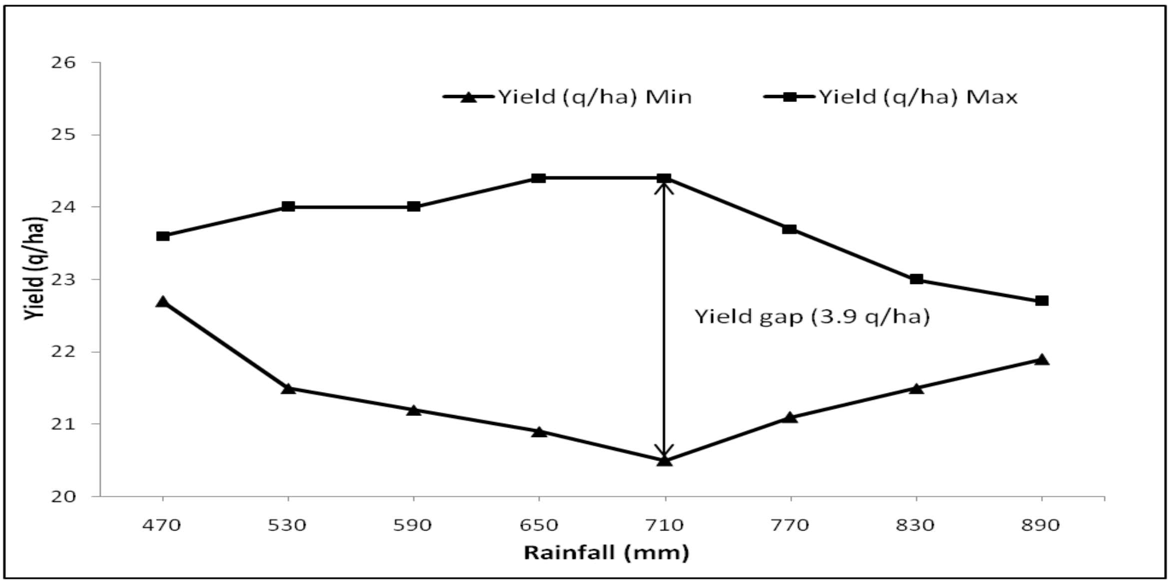

Fig. 6: Yield gap analysis of rainfed rice in Bundealkhand region under variable rainfall condition

5 Conclusions

It is concluded that the quantum of total annual rainfall decreased in all sectors of U.P. with western U.P. at faster rate as compared to other sectors. Results of decrease of seasonal rainfall in different sectors were also in same order and magnitude as that of total rainfall. It may also be concluded from this study that the total rainfall is related to the shift of onset of monsoon towards rainy season. The amount of rainfall decreased by 9.5%, if the onset of monsoon shifts from 15th June to 25th June. Crop planning is required accordingly. Length of rainy season is also reduced from normal 108 days to 99 days in U.P. Therefore, crop planning for short duration and low water requiring variety of rice in U.P. or sectors of U.P., needs to be developed.The production/productivity constraints of rice through estimation of yield gap vis-à-vis climatic constraints for different sectors of U.P. was identified and concluded accordingly. This study will render help not only to the farmers for selection of crop, cropping pattern and change required in ongoing farming operations but also for opening a window option to select the crop/variety for growth in different sectors of U.P.

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