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TRENDS IN FOODGRAINS PRODUCTION IN INDIA: ANALYSIS OF INDIA VIS-À-VIS NORTH INDIA

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Abstract

The trends projections in the yields of four food crops two each in Kharif and Rabi seasons has been assessed for India as well as North India by employing purposive sampling methods for collecting time series data for sixteen years (1998-2014). The results specify that the yield of Kharif crops is lower in North India, and that of Rabi crop is higher, when compared to All India. The inferences further added that the yield of Kharif crops shows a deceleration in growth in yield of Kharif crops (Maize and Rice), but the yield difference in both crops seems widening decades by decades till the year 2100 favouring the yields in All India. Furthermore, similar trends are noticeable in the expected yields of Rabi crops (Wheat and Gram) from the 2040 onwards to 2100 in both North India and All India yields. Nonetheless, the yield difference in case of Wheat crop expected to in favour of North India, while that of Gram crop tilting towards all India. The findings advocate that the slowing down of the growth rates of selected food crops may be speeded up to maintain the self-sufficiency in the production of food grains and to feed the increasing population, and which can be effectively done by the use and adoption of new climate-responsive technology in farming. The Northern region of India, known as bowl of wheat for the India, requires more focus for augmenting the production of Maize, Rice and Gram crops in the same tune as it is excelling in the production of wheat since last six decades. The study further, suggests that in light of the increasing mean temperature and lesser mean rainfall due to climate change in North India as compared to India, the extra effort may be required to not only to enhance the yield of the food crops but also to remains at the same levels.
Keywords: Climate change, Kharif season, Rabi season, Food crops, Trend.

Introduction

Agricultural development has been proved as the most powerful tools to eradicate extreme poverty, enhance wellbeing, shared prosperity and to feed about 10 billion people by the year 2050. The world collectively has been making progress towards improved food security and nutrition, which is evident from the substantial increases in per capita food supplies to a large chunk of the population across the world especially in developing countries. Agriculture is key to the economic growth of nations as it contributed one-third of the global GDP. Growth in the agriculture sector is two to four times more effective in raising incomes among the poorest compared to other sectors and found that 65 per cent of poor working adults made a living through agriculture (World Bank, 2020). The progress in agriculture in the world has not only slowed down but also seems uneven, and many countries failed to make significant progress in their food supplies since mid-nineties (Bruinsma, 2003) which can cause severe repercussions as the demand for food is expected to increase by 1.4 per cent per annum (Singh, 2006). World Bank (2020) reveals that the agriculture-driven growth, poverty reduction, and food security are at risk owing to the process of climate change which is already impacting crop yields, especially in most food-insecure parts of the world. Agriculture, forestry and land-use change are responsible for 25 per cent of greenhouse gas emissions. The climate change shocks, like pests, infectious diseases etc. are hindering the food production, thereby disturbing the food supply chains besides reducing the availability & access of nutritive and affordable food.

Globally, numerous researches have investigated the impact of climate change on the agriculture sector, especially on the production of food crops. IPCC (2014) in its report Fifth assessment report for the period 1985-2010 related to the interaction of natural and human commotion termed it '*decisive*' for climate change in future. Research on agriculture reflects both pessimism and optimism for food production, given the climate change process. Environment Protection Agency (1994) forecasted that the global wheat, maize, and soybeans yield would decline in the range of 16-33 per cent, 20-31 per cent, and 7-16 per cent respectively. Reily *et al.* (1994) estimated the damage would be in the range of $116 billion (1989 prices) to $248 billion. Fischer *et al.* (2002) estimated for 117 developing countries indicate that in 39 countries with a population of 2.5 billion (in 2080) would gain by 5 per cent or more in agricultural production, 29 countries with a population of 1.1 billion would experience no change, 49 countries with a population of 4.2 billion would experience losses of 5 per cent or more, causing aggregate output net loss of about 89 million metric tons of cereals for developing countries. Rosenzweig and Parry (1994) forecasted reduction in growth rate agricultural production from 1.2 per cent to 1.8 per cent in the years 1980-2000, whereas estimated with no change in carbon dioxide emission a 2 increase in temperature could reduce the rice output to 5 percent per hectare (Lal *et al.*, 1998). IPCC (2007) predicted that crop productivity, in the event of 1 to 3 0C temperature, could increase by 5 to 20 per cent in North America and 30 per cent in East Asia and decline by 50 per cent in Africa, 30 per cent in South Asia, and the same will for developed countries the yield will decline by 9 per cent, for Africa by 17 per cent and for Latin America by 13 per cent (Cline, 2007).

The agriculture sector in India, too coping the dangerous effects of climate change reflected in a number of studies have full of pessimism as well as optimism. Sinha and Swaminathan (1991) revealed that a 2 ^{0}C increase in mean temperature could decrease rice yield by 0.75 tonnes per hectare and a 1 ^{0}C temperature in winter temperature leads to 10 per cent reduction in wheat production in Punjab, Haryana and Uttar Pradesh whereas a reduction of 30-35 per cent in rice yields is expected for India (Kumar & Parikh, 1998). Mendelson *et al.* (2001) applied their crop model on India for 2080 for 20 years period (1966-86) and forecasts a reduction in agricultural output without carbon fertilization by 60.9 percent for Northeast region, 57.9 per cent for Northwest region, 31.3 per cent for Southeast region and 36.8 per cent for Southwest region. Mor (2017a) predicted that the value of wheat output would fall by 8.31 per cent, 6.6 per cent and 12.85 per cent by the year 2020, 2060 and 2100 respectively and increase in 1^{0}C temperature (without an increase in rainfall) is more adverse than the increase in 2^{0}C temperature when accompanied by a 10 mm increase in rainfall in the production of food crops (Mor 2017b) and the yield of the wheat crop is expected to go down in the farms in the plains by 10.11 per cent, while set to increase in the farms in the hills by 6.70 per cent, respectively by 2100 Mor [2017c]. Furthermore, that the rainfall in summer found very handy in boosting the production of both wheat and paddy crop (Mor & Madan, 2016) and increase in mean annual temperature is found associated with the reduction in the wheat yield (Mor *et al.*, 2018).

Agriculture still continues to be the backbone of the Indian economy as it provides employment to 58 per cent of the total workforce and contributed 16.5 per cent in GVA. The total foodgrains production is estimated to be 291.95 million tons in 2019-20 as compared to 208.60 tonnes in 2006-07(Govt. of India, 2020, 2007). Indian agriculture passed through the wave of the green revolution, technology improvement, and agricultural infrastructural development during plans, and public investment in agriculture allied activities to garner maximum growth in the agriculture sector. Owing to some spectacular development and innovative techniques in this phase of input-intensification, the production yield of rice and wheat crops, has increased by 4.48 per cent and 5.33 per cent respectively, in the early 1980s. However, the growth momentum came stagnation and a steady reduction in crop yields despite the agrarian income rises due to agriculture & allied activities. To feed and to employ 1.37 billion population, an upward agriculture output trend to match raising population trend is need to maintained. In this backdrop, the present study is an attempt to estimate the trend projections of food crops in India as well as in its Northern region. The selected food crops pertain to Kharif season (Maize and Rice) and Rabi season (Wheat and Gram) and the forecasting will be made of the selected crops till the year 2100AD. The present study proposes to test the following two hypotheses:

H_{01}: The trend forecast for Kharif crops in Northern India and All India don't differ; and

H_{02}: Northern India and All India have same trend projections in the yield of Rabi Cops.

The paper unfolds as follows. Section 2 deals with the material & methods employed in the course of the study. Section 3 deliberates the analysis and interpretation followed by Section 4, which is devoted to the main findings and policy implications of the study

Material and Methods

The section deal with the marital & method used in the study. Section 2.1 pinpoints the analytically tools employed in the study, Section 2.3 discusses the data and sampling procedures adopted the treatment of data, and Section 2.3 deals with the specification of variables used in course of the trend analysis.

Analytical Tools

The study, with a view to fulfil its objectives used the simple linear regression model for the estimation of trend, as detailed below:

$$Y_i = \alpha + \beta * \text{Time} + \varepsilon_\tau \qquad ...(1)$$

Where Y_i = crop yield

β = Slope Coefficient

The slope coefficient in the Equation (1) measures the rate of change in the dependant variable each year, besides indicating the long-term trend behaviour of variables during the selected time period.

Database and sampling

The study employs crop production data of India as well as its Northern region on selected four crops, i.e., Maize and Rice in Kharif season and Wheat and Gram in Rabi season for sixteen years (1998 to 2014). The data pertains to 118 districts one each from 118 agroclimatic zones across 25 states of India and 35 districts one each from 35 agroclimatic zones across seven northern states- Jammu & Kashmir, Himachal Pradesh, Punjab, Haryana, Rajasthan, Uttarakhand and Uttar Pradesh. India is delineated into total 127 agroclimatic zones based on a comprehensive research review of each state. While delineating zonal boundaries the physiographic divisions of each of the state, its rainfall pattern, soil type, availability of irrigation water, existing cropping pattern and administrative units have been considered in such a manner that there are fewer variations on the parameters within a zone (IMD, 1979). Sample units are selected to take account of all geographical and climatic disparity present in the population. Seasonal agriculture output data has been collected at the district level for four food crops- maize, rice, wheat and gram. Quantitative data for two Kharif crops-maize and rice collected over four hot, humid and wet months June to September whereas, for Rabi crops- wheat and gram collected over five cold to hot, less humid and wet months extended from October to February.

Description of Variables used in the study

Numerous variables have been used in the study for the analysis of the trend of Kharif and Rabi crops in India and are described as under:

(i) Climate variables

- **Temperature:** Temperature is measured in degree Celsius (^{o}C). The average temperature for both Rabi crop and Kharif crop season has been used in the trend analysis.
- **Rainfall:** Rainfall is measured in millimetres (mm) and average rainfall in both Kharif and Rabi season crops has been estimated and utilised.

(ii) Crop variables:

- **Kharif Season:** The yield of two crops selected, i.e., Rice and Maize, is measured in quintals per hectares.
- **Rabi Season:** The hectare production of Wheat and Gram is also measured in quintals per hectares.

Results and Discussion

In this section, the key sample statistics as well as trend analysis of both Kharif and Rabi crops will be discussed. The Section 3.1 highlights the sample statistics, while Section 3.2 presents the trends in the production of both Kharif and Rabi crops in light the process of climate change.

3.1 Key sample statistics

Table 1: Mean temperature and mean rainfall sample statistics.

Season	Descriptive statistics	Northern India	All India	Northern India	All India
	Mean temperature (degree Celsius)			Mean rainfall (mm)	
Kharif season	Mean	*33.85*	*32.17*	*156.7*	*233.24*
	Std. Deviation	(3.81)	(3.1)	(134.80)	(172.31)
	Maximum	(42.70)	(42.7)	(1364.20)	(1670.33)
	Minimum	(19.27)	(18.68)	(6.59)	(4.77)
	Observation	528	1888	528	1888
Rabi season	Mean	24.33	27.75	24.31	29.64
	Std. Deviation	(04.87)	(4.03)	(47.61)	(33.87)
	Maximum	(32.69)	(34.83)	(399.93)	(399.93)
	Minimum	(03.72)	(3.72)	(0.08)	(0.00)
	Observation	528	1888	528	1888

Source : IMD Pune (2016).

Table 1 shows the mean temperature and mean rainfall in India as well as in its Northern part in both Kharif and Rabi seasons. The table reveals Northern part of India, with a mean temperature (33.85), is hotter than India with mean temperature of 32.17 ºC in Kharif season. On the contrary, in Rabi season the Northern part of India is cooler than India, with mean temperature of 24.33ºC and 27.75ºC) respectively. In terms of mean rainfall in both Kharif and Rabi seasons, North India receives less rainfall, i.e., 156.7mm and 24.31mm when compared to whole India mean rainfall, i.e., 233.24mm and 29.64mm in both Kharafi and Rabi seasons, respectively.

Table 2: Sample Statistics of production yield of food crops. (Quintal per hectare)

Descriptive Statistics	Kharif Season		Rabi Season	
	Maize Yield	Rice Yield	Wheat Yield	Gram Yield
Northern region				
Mean	15.37	16.40	25.64	8.75
Std. Deviation	(10.11)	(10.98)	(10.94)	(2.81)
Maximum	(60.00)	(42.69)	(54.73)	(20.00)
Minimum	(0.48)	(0.00)	(1.52)	(0.74)
N	480	528	512	400
All India				
Mean	18.6	18.42	19.73	8.08
Std. Deviation	(13.16)	(10.64)	(9.83)	(3.68)
Maximum	(256.78)	(98.68)	(54.72)	(36.45)
Minimum	(0.07)	(0.02)	(0.63)	(0.74)
N	1600	1808	1467	1545

Source: Directorate of Economics and Statistics, Ministry of Agriculture and Farmer welfare, Government of India (1998-2014).

Table 2 explains that the production yield of Kharif crops, i.e., Maize and Rice, is higher in India when compared to North India and vice-versa with the yield of Rabi crops like Wheat and Gram. The production yield of the Maize crop is 15.37 Quintal per hectare in North India as compared to the All India average of 18.6 quintals per hectare. Similarly, the all India production yield of Rice crop is 18.42 quintal per hectare considerably higher than that of north India, i.e., 16.40 quintal per hectare. On the other side, the wheat crop in North India is 25.64 quintal per hectare substantially higher than that of all India average of 19.73 quintals per hectare. In the same line, the yield of gram crop production in Northern India is marginally higher (8.75 quintal per hectare) than that of all India average of 8.08 quintal per hectare.

Therefore, it can be inferred that mean temperature is considerably higher in Northern India when compared to All India in the duration of Kharif crop and vice-versa in Rabi season. In the other hand, the mean rainfall in All India is considerably higher than that of North India in the duration of both the studies crops, i.e., wheat and gram. Further, the analysis reflects that the production yield of Kharif crops is much lower in North India when compared to All India averages and vice versa in the case of Rabi crops. The above analyses suggest that higher temperature cause lower production of Kharif crops in North India, whereas the same is associated with a higher yield of Rabi crops when compared to all India yields of both crops. However, the mean rainfall in North India in both Kharif and Rabi seasons is less than that of India.

3.2 Analysis of trends in the foodgrain production

This section examines the trends of food grains production in the Northern part of India via-a vis India by considering data for the sixteen years (1998-2014). The trend behaviour of selected food crops has been estimated by taking into consideration the trend in climatic variables, crop production yields in Northern India as well as All India.

3.2.1 Analysis of trend behaviour of Kharif crops

Table 3: Trend analysis of Kharif crops yields in Northern India vis-a vis India.

Region	Crops	Trend Coefficient	t statistics	F statistics
North Region	Maize	0.43 (0.67)	0.19 (0.67)	0.19
	Rice	0.22	2.16 (0.03)	4.68 (0.03)
All India	Maize	0.42	5.93 (0.00)	35.22 (0.00)
	Rice	0.34	6.23 (0.00)	38.85 (0.00)

Source: Own.
Note: Figures in the parenthesis represent p values.

The perusal of table 3 describes shows that the trends coefficient of sampled Kharif crops turned out to be positive both for North India as well as All India levels. Further analysis of the table reflects that trend co-efficient for maize yield is positive for both North India as well as all India, but it is significant for all India and insignificant in the North Region of India. The non-significant trend coefficient of Maize crop in North India maybe because it is grown on a comparatively lesser area when compared to All India average. However, in the case of rice crop, the trend coefficients for both All India and North India found to be statistically significant.

3.2.2 Analysis of trend behaviour of Rabi crops

Table 4 presents the trends in the production of sampled Rabi crops, i.e., Wheat and Gram yield in Northern India as well as All India. The table reveals a positive slope coefficient for both the selected crops yields—the occurrence of a positive and statistically significant trend in wheat yields in Northern India vis-à-vis All India. The positive and significant trend exists in case of Wheat yield across the North region (0.314) is close to All India (0.354) pointing to the highest contribution of the Northern region in wheat production. Further, the trend in the production yield of Gram crop is positive though statistically insignificant for the North region (0.058) while the same is significant for All India (0.129).

Table 4: Trend analysis of Rabi crops yields in Northern India vis-a vis India

Region	Crops	Trend Coefficient	t statistics	F statistics
North Region	Wheat	0.314	3.029 (.003)	9.176 (.003)
	Gram Yield	0.058	1.917 (.056)	3.677 (.056)
All India	Wheat	0.354	6.443 (.000)	41.508 (.000)
	Gram Yield	0.129	6.450 (.000)	41.604 (.000)

Source: Own.
Note: Figures in the parenthesis represent p values.

The trend in the production of Gram crop in North India vis-a-vis All India is presented in figure 4. The trend curve for Gram yield is almost straight (stagnant) at regional level (North India) as well as at the national level (All India). The mean predicted gram yield increase by 0.66 quintals per hectare in North India and is not statistically significant at 5 per cent level of significance. Whereas, the trends for All India production in Gram yield shows significant increases, i.e. 1.67 quintals per hectare. To sum up, the above analyses reflect that the higher temperature may be one of the causes of lower production of Kharif crops in North India, whereas the same is associated with a higher yield of rabi crops when compared to all India yields of both crops. However, North India receives less rainfall in both seasons when compared to All India. The maize yield trend curve is almost stagnant as well insignificant and substantially lower than that of all India, whereas the trends in the production of Rice crop is considerable higher in All India than its Northern region. The trends in the production of the wheat crop in North India is higher than all India, whereas the trends in the yield of Gram crop for All India is significantly more than that of the Northern Region.

3.3 Forecasting the trend of Kharif and Rabi crops

This section is devoted to the predation of production of selected crops in both Kharif and Rabi season based on trend coefficients as discussed in the previous section.

Table 5: Predicted Yields (PY) of selected Kharif and Rabi Crops in North India and India

(Quintals per Hectare)

Corp	Region	Yield (base period)	PY for the year 2040	PY for the year 2060	PY for the year 2080	PY for the year 2100
Maize	North India	15.29 (0.00)	15.41 (0.30)	16.27 (0.28)	17.13 (0.26)	17.99 (0.26)
	All India	17.31 (0.60)	24.18 (1.53)	29.47 (1.09)	34.76 (0.90)	40.05 (0.76)
	Yield Gap	3.02	8.78	13.20	17.63	22.06
Rice	North India	18.08 (1.90)	23.91 (1.24)	28.39 (0.94)	32.87 (0.79)	37.35 (0.68)
	All India	19.98 (1.10)	28.22 (1.59)	34.56 (1.12)	40.90 (0.92)	47.24 (0.78)
	Yield Gap	1.90	4.31	6.17	8.03	9.89
Wheat	North India	27.32 (0.70)	33.11 (1.24)	42.87 (0.94)	49.63 (0.79)	56.38 (0.68)
	All India	17.49 (0.80)	24.98 (1.65)	30.74 (1.15)	36.50 (0.94)	42.26 (0.79)
	Yield Gap	-9.83	-11.13	-12.13	-13.13	-14.12
Gram	North India	6.96 (0.10)	8.11 (0.64)	8.99 (0.54)	9.87 (0.49)	10.75 (0.45)
	All India	7.46 (0.60)	10.35 (1.49)	12.58 (1.08)	14.81 (0.89)	17.04 (0.75)
	Yield Gap	0.50s	2.24	3.59	4.94	6.29

Source: Own.

Note: 1. Figures in the parenthesis represent the growth rate (%) of the respective years.

2. Yield Gap is the difference in Yields (All India -North India) for a particular crop.

Table 5 shows that the predicted value of Maize crop in both North India and All India shows a marginally declining growth rate from the year 2040 to 2100, despite the visible increase in per hectare yields of both crops. The maize yield production gap in North India and All India was 3.02 quintals per hectare in base year will be expected to increase by 8.78 quintals per hectare by the year 2040, 13.20 quintals per hectare in 2060, 17.63 quintals per hectare in the year 2080 and 22.06 quintals per hectare in the year 2100. Interestingly, the yield gap is likely to increase by seven times in the production of Maize crop by 2100 in favour of All India as compared to North India.

Similar trend forecasts take place in the case of Rice crop in both North India as well as All India. The difference in the production of Rice crop in both North India and All India was just 1.90 quintals per hectare (in the base year), rising 4.31 quintals per hectare by the year 2040, 6.17 quintals per hectare in 2060, 8.03 quintals per hectare in 2080 and 9.89 quintals per hectare by the year 2100. Hence, the yield gap is expected to increase to five folds in favour of All India compared to North Indi

Furthermore, in case of both the selected Rabi crops, despite the substantial increase in per hectare productivity yields of both crops, the growth rate momentum is decreasing for the forecasted years, i.e., 2060, 2080 and 2100. Moreover, in the case of the Wheat crop, different tends are observed as the yield gap which was 9.83 quintals per hectare (base year), expected to increase by 11.13 quintals per hectare, 12.13 quintals per hectare, 13.13 quintals per hectare, and 14.12 quintals per hectare respectively for 2040, 2060, 2080 and 2080 in favour of North India which will be almost 1.5 times than the yields in All India. Further, in case of Gram crop yield gap forecasted for North India and all India, from the base the year (0.50 quintals per hectare), 2.24 quintals per hectare (2040), 3.59 quintals per hectare (2060), 4.94 quintals per hectare (2080) and 6.94 quintals per hectare by the year 2100 in favour of All India when compared to North India and the yield is expected to be threefold by the turn the century.

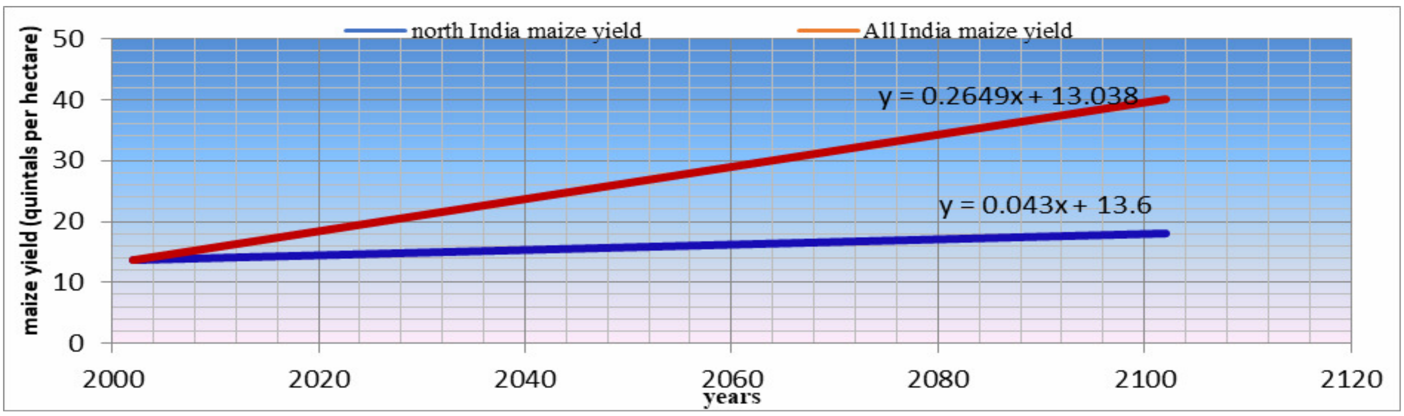

Fig. 1: Projected Maize yield trend in all India and North India.

Figure 1 displays the forecasted values of Maize crop in both North India as well as All India, and the yield gap is clearly visible. The gulf of yield difference is increasing year by year in the both the North region and all India in the production Maize crop. All India production seems to be maintaining its lead considerable till 2100 AD in the Maize production.

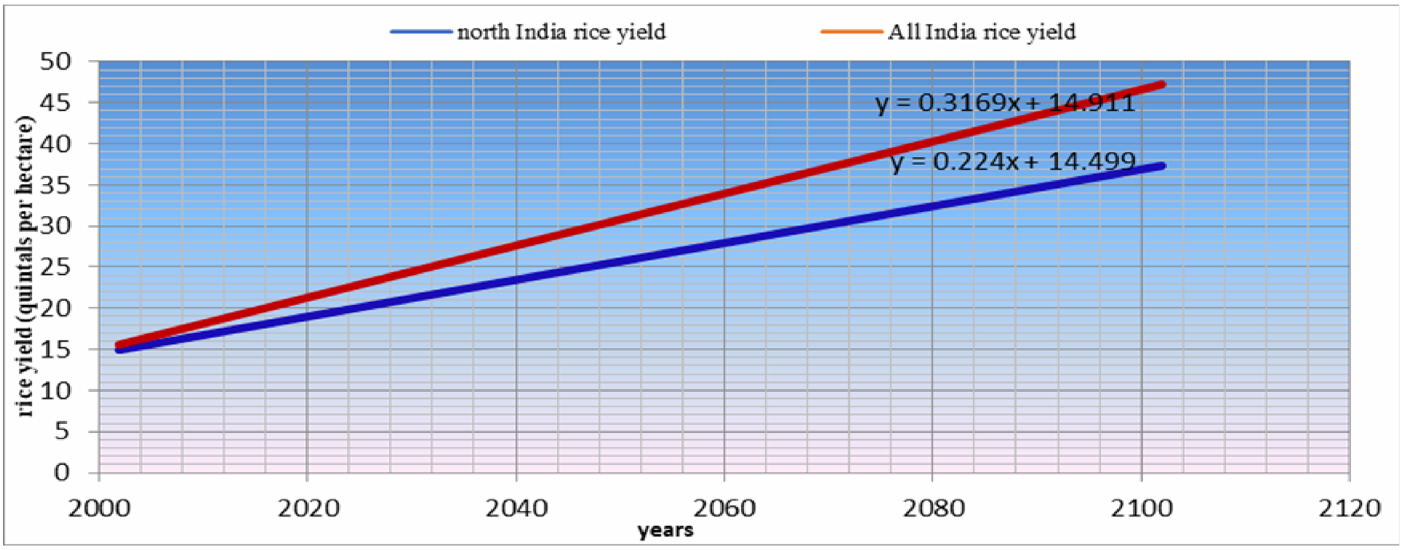

Fig. 2 : Anticipated Rice yield trends in all India and North India.

The projected values of Rice crop in both North India as well as All India is displayed in the figures 2, which shows the gap in the expected yield of Rice is increasing smoothly till 2100. The gap is tilted toward All India till 2100 AD.

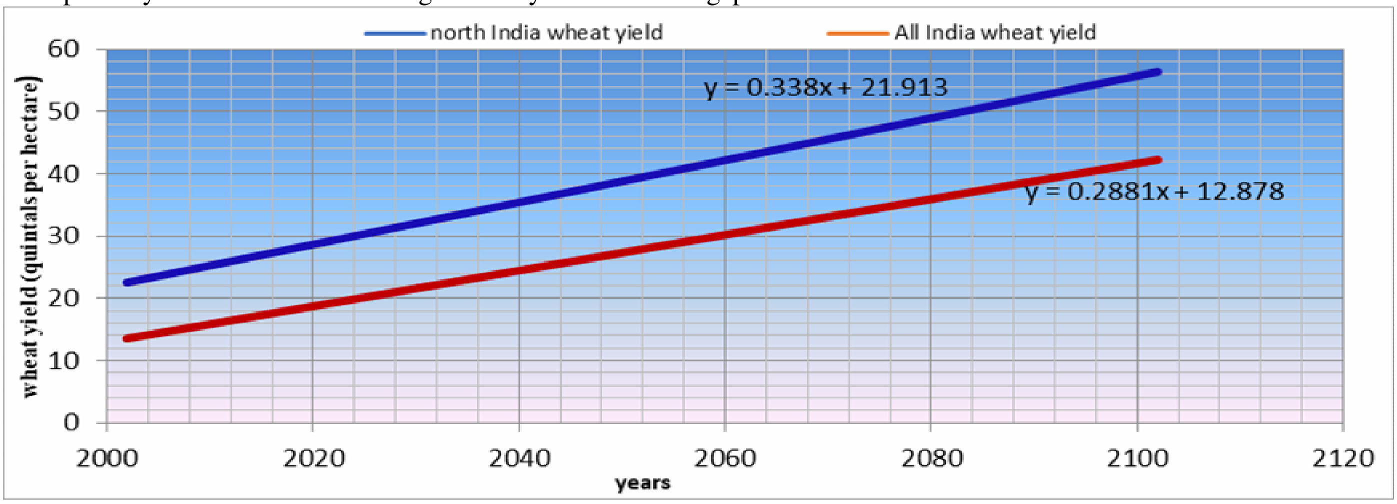

Fig. 3: Likely yields of Wheat crop in North India and All India.

Figure 3 exhibits the projection in the production of Wheat crop till 2100 in both North India as well as All India. The yield gap is evident and almost maintaining a parallel difference in the production of Wheat crop where North India maintains the gap in its favor till 2100 AD.

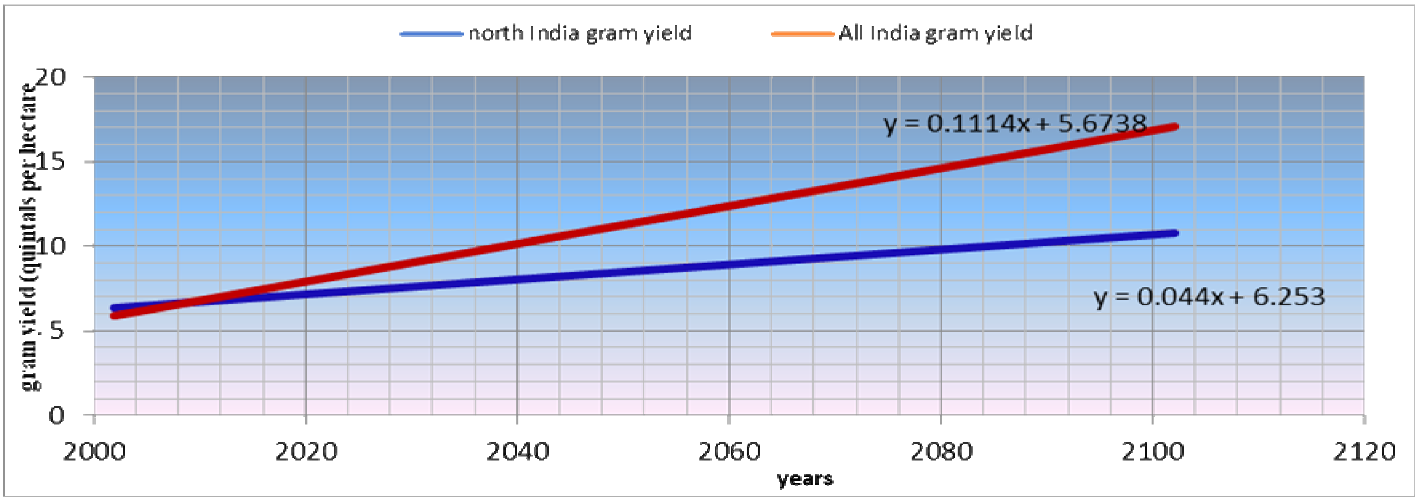

Fig. 4: Forecasts Gram yield trend in North India and All India.

The figure 4 demonstrates the anticipated yield in the production of Gram crop till 2100 AD in both Northern region and National level. The trend in the yield of Gram is clears in favour of All India when compared to the Northern Region of India.

To conclude, the predicted value of both the selected crops in Kharif season, i.e., Maize and Rice, show a deceleration growth till the year 2100, but the yield gap in the production of both crops will be increasing decades by decades in favour of All India when compared to North India. Therefore, our first maintained hypothesis that the trend forecast for Kharif crops in Northern India and All India do not differ is rejected as the trends show variations in the projections in both Kharif crops till 2100AD. A similar trend in the prospective yields in the selected Rabi crops are visible in the future projections of yields in both rabi crops w.e.f. 2040 to 2100. Nevertheless, the yield difference in case of the Wheat case was in favour of North Indian while that of Gram crop the yield differences are more tilted towards all India. Hence, the second upheld hypothesis of the study that Northern India and All India have same trend projections in the yield of Rabi Cops is also rejected because there are substantial expected differences the growth rate of the both studied crops.

Conclusions and Suggestions

The trends in the production yields of two Kharif crops -Maize and Rice, and two Rabi crops-Wheat and Gram, has been estimated for 118 agroclimatic zones and 35 agroclimatic zones respectively for India and North India; The study uses purposive sampling methods for collecting the time series data for sixteen years (1998-2014) on climate variable like temperature and rainfall besides the crop production statistics. The findings indicate that North India is experiencing a higher mean temperature in Kharif crop and lower in Rabi season when compared to All India. Interestingly, the mean rainfall in All India is considerably higher than that of North India in the duration of both the Kharif and Rabi season. The results further showcase that in North India, the yield of Kharif crops is lower and of Rabi is higher, when compared to All India.

The conclusions added that the yield of Kharif crops exhibits a deceleration in growth in yield of both crops, but the yield difference in both crops seems widening decades by decades till 2100AD favouring the yields in All India. Analogous trends are visible in the projected yields of Rabi crops w.e.f. the year 2040 to 2100 in both North India and All India.

Nonetheless, the yield difference in case of Wheat crop expected to in favour of North Indian, while that of Gram crop tilting towards all India. The findings advocate that the slowing down of the growth rates of selected food crops may be speeded up for maintains the self-sufficiency in the production of foodgrains to feed the increasing population and which can be effectively done by the use and adoption of new technology. The Northern region of India, known as a bowl of wheat for India, requires more focus for augmenting the production of Maize, Rice and Gram in the same tune as it is excelling in the production of wheat. The study further, suggests that in light of the increasing mean temperature and lesser mean rainfall due to climate change in North India as compared to India, the extra effort may be required to not only to enhance the yield of the food crops but also to remains at the same levels.

Limitations: The study is an effort to estimate the trend behaviour in the yields of two crops each in Kharif season (Maize and Rice) and Rabi season (Wheat and Gram) in Northern region of India and all India only. The trends projections are made with the assumption that various variables crucial in the production of these crop like climatic, edaphic and socio-economic variables remain constant. The study also bears the limits of the trend method of forecasting.

Future research agenda: The present research is specially designed for analysing the trend behaviour of two food crops each in both Kharif and rabi seasons, hence the research may be carried out for more crops including the commercial crops for all the comparison of all the Zones. The future research may also take the case of other climatic, edaphic and socio-economic variables, besides using other meidos of forecasting on longitudinal data.

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