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Changing Agriculture Scenario in Son-Karamnasa Interfluve in Bihar, India

Dr. Dilip Kumar

Assistant Professor, Department of Geography, Shaheed Bhagat Singh Evening College, University of Delhi, New Delhi (India)

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***Corresponding Author**
Email:dilipgis[at]gmail.com

ABSTRACT

There are various agricultural and environmental issues arising due to the climate change. The changes in the rainfall pattern and temperature leads to changes in the water resources, productivity and changing scenario in the agriculture. These changes also directly and indirectly influence the human society specially the poor people, for their livelihood as well as the economy of the nation, ultimately disrupt the sustainability. The concept of sustainability and development has close relationship with the climate change. United Nations Sustainable Development Goal (SDGs)13 aims isto "take urgent action to combat climate change and its impact", while acknowledging that the United Nations Framework Convention on Climate Change is the primary international, intergovernmental forum for negotiating the global response to climate change.SDGs2 is to end hunger, achieve food security and improve nutrition and promote sustainable agriculture. Eradicating poverty and hunger are integrally linked to boosting food production, agricultural productivity and rural incomes. The aim of the study is to discuss the impact of climate change on decreasing the agriculture production in Son-Karamnasa interfluve in Bihar, covering four district such as Bhojpur, Buxar, Rohtas and Bhabhua, which is a part of Middle Ganga plain region. The study is purely based on the secondary data and field visits in the study area. The analysis reveals that there is highly probalility of increase in the frequency and intensity of drought in Bhabhua and Rohtas districts and flood in Buxar and Bhojpur district. The increase in the temperatures shorten crop cycles by reducing early flowering and shortening the grain-filling period, thereby reducing yield per unit area.

1. Introduction

Climate change is a change of climate in global or regional pattern. The average surface temperature of the earth has risen about 1.1 degree Celsius since late 19th century due to human-induced emissions into the atmosphere especially carbon dioxide. (https://climate.nasa.gov/evidence/). Most of the warming occurred in the past 35 years, with 16 and 17 warmest years on record occurring since 2001. Not only 2016 the warmest year on record, but eight of the 12 months that make up the year-from January through September, with the exception of June -were the warmest of record for those respective months. In 2017, average annual change in global surface temperature is 0.9 degree Celsius (figure 1).

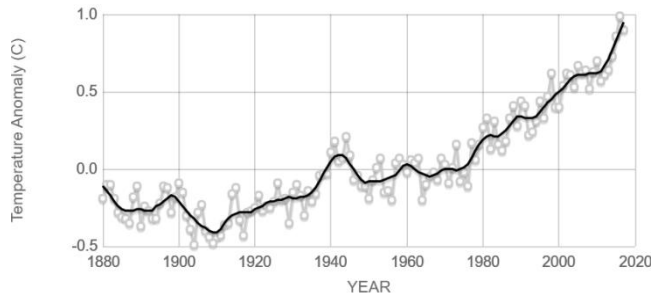

Figure 1: Global temperature rise (source: climate.nasa.gov)

2. National Mission for Sustainable Agriculture

Government of India has developed the National Action Plan on Climate Change (NAPCC), 2008 with eight national missions to advocate for effective, cooperative and equitable global approach in the United Nations Framework convention on Climate Change (UNFCCC). The NAPCC missions are National Solar mission, National Mission for enhanced Energy Efficiency, National Mission on Sustainable Habitat, National Water Mission, National Mission for Sustaining the Himalayan Ecosystem, National Mission for a Green India, National Mission for Sustainable Agriculture and National Mission on Strategic Knowledge for Climate Change. The NAPCC seeks to promote understanding of climate change, adaptation, mitigation, energy efficiency and natural resource conservation for overall growth of the country, similarly, Bihar Action Plan for Climate Change is also focusing on agriculture and animal husbandry; forests and biodiversity; water resources and disaster management; urban development and transport; industries and mining; energy; and human health.Government of India has formulated National Mission for Sustainable Agriculture (NMSA) which is one of the eight missions outlined under National Action Plan on Climate Change (NAPCC). The mission aim is to promote sustainable agriculture through a series of adaptation measures focusing on ten significant dimensions encompassing Indian agriculture such as improved cropsseeds, livestock and fish culture, water use efficiency, pest management, improved farm practices, nutrient management, agricultural insurance, credit support, markets, access to information and livelihood diversification (NMSA, 2014). During 12thFive year plan (2012-17) Government of India, special emphasis on soil and water conservation, water use efficiency, soil health management and rainfed area development. The Son-Karamnasa interfluve is located in the middle ganga plain (part of indo-gangetic plains) has naturally

fertile soil is one of the major assets of the study area, and conducive to agriculture, but the climate change and its impacts provides the challenges in agriculture.

3. Study area

The research area extends between 83° 19' 38" East to 84° 51' 3" East and 24° 30' 11" North to 25° 45' 34" North. Administratively, study area has four districts i.e. Bhojpur, Buxar, Bhabhua (Kaimur) and Rohtas in Bihar. It is covered by Ballia, Ghazipur, Chandauli and Sonbhadra districts of Uttar Pradesh in north and west; Garhwa and Palamau of Jharkhand in the south; Aurangabad, Arwal, Patna and Saran district of Bihar in east and north-east of the study area.

It has a well-defined natural boundary surrounded by rivers from all direction except some part in south-west. It is bounded by river Son from east and south, river Karamnasa flowing in west and the river Ganga in north. The highest point in the study area is 640.4 metre above the mean sea level in the Rohtas plateau and maximum area is less than 200 metre above the mean sea level. The slope is also providing favorable condition for the cultivation of various crops. The study area is fall under Zone III South Bihar Alluvial Plains agro-climatic zone where major crops are rice, gram, wheat, horticultural crops including mango, guava, banana, bel, jackfruit, onion, potato, chillies and marigold. The important cropping sequence in ths zone is Rice-wheat, rice-gram, rice-lentil, rice-rai.Maximum number of drainage found in the southern part of the study area in the plateau region and foothills are mostly non-perennial, but in the plains, large network of Son canal system exists. The ponds are also found in the study area having perennial and non-perennial in nature.

Geologically, the rocks belong to middle Proterozoic sedimentary sequence of Vindhyan super-group and unconsolidated to semi-consolidated alluvial sequence of late Pleistocene to late Holocene age. There exist varied lithologies like shale, sandstone, limestone, conglomerates etc. Physiographically, the research area is divided into two parts; Bhojpur plain and Rohtas plateau. Bhojpur plain is a third order of Middle Ganga Plain South known as Ganga-Son Divide East (Bhojpur plain) and Rohtas plateau is geographically third order of VindhyanchalBaghelkhand North Plateau known as Rohtas-Bijaigarh upland (Singh, 1989). Both Grand Chord, Delhi - Kolkata main railway line and the Grand Trunk road (GT road) are passes through this plain. The Indrapuri barrage on the river Son near Dehri-on-Son enhances the agricultural prosperity of the Bhojpur plain and is prosperous rice dominated agricultural area irrigated by canal system. The Rohtas-Bijaigarh upland is relatively a more dissected and highly underdeveloped region. It is mostly used as summer pastures for the foothill plains. The Kaimur limestone and Amjhor pyrites tend to provide opportunities for economic development. Geomorphologically, maximum area comes under alluvial plain with excellent ground water potential for agricultural practices. Along the river Ganga, large area is belonging to the flood plain. There is very less area belongs to dissected plateau, pediments and residual hills where ground water is poor which does not fit for agricultural use and belongs to notified forest. According to Census of India (2011), the total population of the study area was 90,21,061 persons that is 8.7 per cent to total population of Bihar state whereas, in 2011 census it was 8.9 per cent to total population of the Bihar state. The total decadal increases are 22.56 per cent during 2011 to 2011. The population density of each district was 1139 (Bhojpur), 1002 (Buxar), 763 (Rohtas) and 488 (Kaimur) persons per sq. km while the literacy rate was 70.47 % (Bhojpur), 70.14 % (Buxar), 73.37% (Rohtas) and 69.34% (Kaimur).

4. Climatic scenario

In general, winter, summer and monsoon are three distinct seasons in Bihar. In winter temperature varying between 7 and 16 degree Celsius, with very little rainfall. Summer season spreads over March to mid-June with temperature rises up to 45 degree Celsius. During monsoon season, mid-June to September, temperature between 24 and 35 degree Celsius with cloudy sky and high humidity.The average rainfall varies from 1100 to 1250 mm. Rainfall and temperature are two main climatic variable that affects agriculture, so it is necessary to understand the scenario of these two parameters in Bihar. Based on temperature and rainfall time-series from 1951 to 2010, annual mean temperature is increase by 0.01 degree Celsius and similar in mean temperature in monsoon season. Mean temperature in post-monsoon is increased by 0.02 degree Celsius. The observation about annual maximum temperature shows no trend but in winter season mean maximum temperature decreases by -0.01 degree Celsius and -0.02 degree Celsius during summer. During the monsoon and post-monsoon season, it is increased by 0.01 degree Celsius. The projected maximum surface temperature during 2011-2040 will be increase by 0.6 to 1 degree Celsius in western Bihar and minimum surface temperature will be increase by 1.2 to 2 degree Celsius.Rainfall in the monsoon season shows significant increase by 0.59 mm per year but negative trend is found in winter rainfall that is -0.06 mm per year.Future projected changes in June, July and August month rainfall during 2011 to 2040 with respect to 1961-1990 will be 5 per cent deficit in southern and western Bihar but 5 -10 per cent surplus in eastern and central Bihar (Government of Bihar, 2015).

5. WaterResources

Rivers, streams and springs: There are twenty eight perennial and sixty two non-perennial rivers and streams in the study area (Appendix 2.3). The only rivers of any importance are the Ganga, Son, Karamnasa, Kudra and Durgauti. The river Ganga washes the northern boundary of the district for a distance of about 132 kilometres and separates it from Ghazipur and Ballia districts in the Uttar Pradesh and from Saran district in Bihar. It touches the study area near Chausa village in Buxar district where it is also met by the river Karamnasa. From there it flows north-eastwards and then eastwards and finally north-eastwards again leaving the district at its confluence with the river Son. All the rivers of the district fall into the river Ganga either directly or after combining with each other (Figure 2.6). The river Kuhira and the river Sora meet the river Durgauti after, which they are met by the river Kudra. Finally they all fall into the river Karamnasa. The river Goria and river Dharmauti also fall into the river Karamnasa. The Konch, Ganghat, Chher and the Banasriver which in the later stage is known as the river Gangi all fall into the river

Ganga. The river Son rises near the sources of the river Narmada and Mahanadi in the elevated plateau of Central India and enters the district at the tri-junction of Sonbhadra in Uttar Pradesh, Garhwa and Kaimur (Bhabhua) in Bihar.It washes the southern and the eastern borders of the district for a distance of about 170 kilometres. It has a deep bed but dries up in about February. The river Kudra, also rising in the Kaimur hills, falls into the river Durgauti after flowing for a distance of about 80 kilometres within the district. It has very little water during the dry season. The river Durgauti which also raise in the Kaimur hills is met by the river Kuhira and the river Sora and finally by the river Kudra before it falls into the river Karamnasa. It contains water almost all the year round. The springs are also found in the study area. Springs are the natural concentrated outflow points of water that has flowed underground.

Lake / Pond: In the Son – Karamnasa interfluve has 4,202.5 hectares of land is under the lake or ponds which cover only 0.4 per cent of the total area of the study area in four districts. Among these 2,809.9 hectares of lands have perennial lake or pond and 1392.6 hectares of land under the non-perennial ponds. The most of the non-perennial pond are found in around the plateau. The perennial ponds are found in the centre of the study area due to the large network of Son canal.

Canal: In the Son-Karamnasa interfluve canal is also the main source of irrigation (Table 1). Arrah, Behea, Dumraon, Buxar, Chausa and Garrachausey canal are the major branches of Son canal system. It covers the whole area between the pediment zone in the south and the main railway line (between Pt. DeenDayalUpadhyaya– Patna railway line) in the north (Figure 2.6). There is one more canal system of river Durgauti. The total length of the canal in the study area is approximately 2,383.4 kilometres.

Table 1: total irrigated area through different sources (unit in hectare)

District Name	Canal	Tube-well	Other sources	Total irrigated area
Bhojpur	40781	135775	11538	188094
Buxar	44421	66410	3079	113910
Rohtas	262570	36037	32227	330834
Kaimur	98493	54414	13630	166537

6. Challenges due to climate changes

Floods

In September 2013, the flood situation in Kaimur, Bhojpur, Buxar turning extremely serious. The disaster management team was forced to evacuate around five villages in Bhojpur districts (Gupta, 2013). The flooding of son river following heavy discharge of water caused inundation of hundredsof villages in central Bihar districts of Bhojpur, Jehanabad and Patna (The Pioneer, 2016). In the Son-Karamnasa interfluve, flooding is considered as a serious limitation for agriculture especially in the northern part of study area. The low lying area and back water from river Karamnasa are the main reasons of the flood in the study area. The tri-junction of river Ganga, Ghaghara and Son also lead to flood in this region. The analysis reveals that there are 2,38,191.6 hectares of land is affected by the flood which constitute 21.7 per cent of the study area. Among these 1,60,039.9 hectares of area has moderate flood and 78,152.7 hectares of area has severe flood. The severe flood (more than four months) occurs along the river Ganga (figure 2) and river Son in Bhojpur and Buxar district in the northern part of the study area. Bhabhua and Rohtas districts have moderate flood, occurred in less than four months and it is occurs mainly along the river Karamnasa and their tributaries (figure 3).

Figure 2: Photograph of flood affected area in Bhojpur district

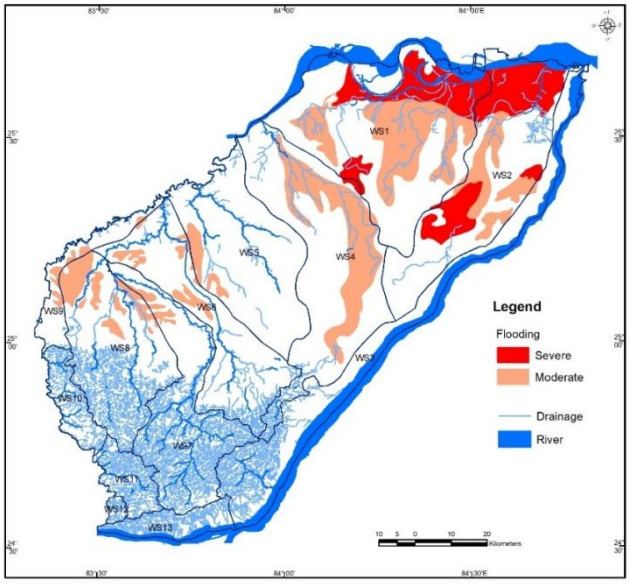

Figure 3: Flood affected area

Drought

Drought is a temporary reduction in water or moisture availability significantly below the normal or expected amount for the specific period. This condition occurs either due to inadequacy or rainfall, or lack of irrigation facilities, under exploitation or deficient availability for meeting the normal crop requirements in the context of the agro-climatic conditions prevailing in any particular area. This has been scientifically computed as moisture index. Drought can be defined as adverse moisture index or adverse water balance which may be attributable not only to a prolonged dry spell due to lack or insufficient rainfall but also due to such other factors as excessive evapo-transpiration losses, high temperature, low soil holding capacity etc. (Gupta, 2001). The Rajendra Agricultural University, Pusa, Bihar has four meteorological stations located at Pusa (Samastipur), Madhepura, Sabour (Bhagalpur) and Bikramganj (Rohtas). These are located in the three agro-climatic zones of Bihar. The deficiency of rainfall at Bikramganj (Rohtas) is more discernible than the excess and deficiency at other meteorological stations. The station has received only 547.4 mm of rainfall as against expected normal value of 792 mm, thereby making it short by 31 per cent. For the year 2002, the Indian Meteorological Department predicted a normal rainfall with ± 8 per cent model error. Unfortunately, Bihar simultaneously / succession has to face drought and flood. In the month of June and July, rainfall was less than the normal in several districts such as in Supaul, Rohtas, Monghyr, Gopalganj, Gaya, Siwan, Bhagalpur, Bhojpur, Buxar and Madhubani. These districts faced drought like situations. The five blocks in Bhojpur and five block in Buxar district has been estimated as drought affected in year 2002 (Rai, 2002). The study area is facing severe drought every year during kharif season. In 2013, except Rohtas, study area is affected by drought. The main region for this drought is monsoon onset and uneven spatial distribution. The pre-monsoon drought is more severe as compare to post-monsoon season. There is a shifting pattern of pre and post monsoon. June, July and October are the drought prone months (Ghosh and Mukhopadhyay, 2014).

7. Agriculture scenario

Agriculture is most important for food and livelihood of the population. It provides the primary source of livelihood for 36 per cent pf the world's total workforce. In the heavily populated countries of Asia and Pacific share ranges from 40 to 50 per cent, and sub-Saharan Africa, two-thirds of the working population still makes their living from agriculture (ILO, 2007). In India, agriculture plays an important role in employment generation in the Indian economy, with nearly half of the Indian population being dependent on agriculture and allied activities for livelihood. As per the National Sample Survey Office (NSSO), in 2011-12, the share of agriculture im employment was 48.9 per cent (www.home.kpmg.com). Climate change is affecting the various dimensions of food security such as availability, accessibility, utilization and food systems stability. It is also affecting the on human health, livelihood assets, food production and distribution channels, as well as changing purchasing power and market flows. Its impacts will be both short term, resulting from more frequent and more intense extreme weather events, and long term, caused by changing temperatures and precipitation patterns, People who are already vulnerable and food insecure are likely to be the first affected. Agriculture-based livelihood systems that are already vulnerable to food insecurity face immediate risk of increased crop failure, new patterns of pests and diseases, lack of appropriate seeds and planting material, and loss of livestock. People living on the coasts and floodplains and in mountains, drylands and the Arctic are most at risk (www.fao.org).

Food production capacity has been facing an ever-growing number of challenges, including a world population expected to grow to nearly 9 billion by 2050 and a declining man-land ratio. Some 20 to 40 per cent of the world's potential crop production is already lost annually because of the effects of weeds, pests and diseases. The area under cultivation, production and yield is also decreasing. The statistics of the seven major crops such as rice, wheat, maize, mustard, gram, lentil and arharanalysed (figure 4,5,6,7,8,9,10). The analysis reveals decreasing trends in area under crop, production and crop yield between financial year 2013-13 and 2015-16 except mustard crop where it was in increasing trend. Crop-wise analysis reveals that area under rice crop was increased by 18919 ha constituted 4.1 per cent during this period but in Bhojpur district, it was decrease by -17294 ha. constitute -16.4 per cent and in Buxar district it was increased by 16.2 per cent (Table 2). The production of this

crop is overall change by -7 per cent. -28.3 per cent production was change in Bhabhua district followed by Bhojpur district but significant increase in Rohtas and Buxar districts (Table 3). The overall productivity (yield) of rice crop was change by -12.2 per cent (Table 4). The production was increased in Buxar and Rohtas districts but the productivity was decreased by -12.3 and -3.7 per cent respectively. The area under maize crop was increased by 19.2 per cent study area but the production (-6.7 per cent) and yield (-24.7 per cent) was decreased also in all districts. The statistics of the wheat, mustard, gram, lentil and arhar crops shows the area under this crop, production and yield was drastically decline. Area under mustard in Rohtas district was declined (-45.3 per cent) but positive sign in was observed in Buxar district (37.6 per cent). The yield of the mustard was declined during 2012-13 and 2015-16, whereas, the information was not available for Bhojpur district in 2012-13. The Statistics also reveals the maximum area under crop was decreased in arhar crop (-15.8 per cent), mustard (-13.1 per cent), gram (-11 per cent), lentil (-9.4 per cent) and wheat (-1.2 per cent).

The statistic about production reveals that the production of all crops was decreased. The maximum production decreased in arhar (-59.5 per cent) followed by gram (-43.9 per cent), lentil (-39.3 per cent), mustard (-20.3 per cent), wheat (-16 per cent), maize (-6.7 per cent) and least decline in rice (-7 per cent). The statistics about the crop yield also show the decrease in the production in all crops. Maximum decreased was observed in arhar (-42.4 per cent), followed by gram (-34.2 per cent), lentil (-28.6 per cent), maize (-24.7 per cent), rice (-12.2 per cent), wheat (-12.1 per cent) and mustard (-8.7 per cent.)

The district-wise analysis reveals that area under maize was decreased by -52.6 per cent in Buxar district, whereas -45 per cent area under mustard and –36.7 per cent gram was decreased in Rohtas district. Maximum positive changes in crop area was found in maize (72.7 per cent) in Bhojpur district and mustard (37.6 per cent) in Buxar district. The maximum production decreased in maize (-77.9 per cent) in Buxar district, production of gram was decreased by-64.2 per cent, -54.3 per cent in mustard, -35.6 per cent in wheat, -43.8 per cent maize, -33 per cent in lentil and -27.9 per cent in Rohtas district (Table 5).

8. Mitigation strategy and strengthening resilience

Strengthening resilience involves adopting practices that enable vulnerable people to protect existing livelihood systems, diversify their sources of income, change their livelihood strategies or migrate, if this is the best option.Floods cannot be controlled totally however, flood damage can be minimized by proper flood control measures. Human activity tends to concentrate in flood-liable areas which are often convenient and attractive locations for settlement and other economics endeavors resulting in greater flood damages. If loses due to floods in terms of life and property and to minimized, the solution in not merely to provide relief measures, but also to undertake necessary measures encompassing a wide range of activities namely long and short range prediction, prevention, warning, monitoring and relief along with floodplain regulation. This involves the interaction among different government and private agencies on one hand and the people of the country facing the disaster on the other hand, in making use of information and carrying out the above tasks. Further, by controlling the river by structural measures, the flood damage may be minimized to some extent but on the other hand flood waters are going waste, silt may be deposited on the bed of the river to reducing its channel capacity etc. Therefore, researchers and engineers attention is being focused on various methods to mitigate the floods to reduce damages and at the same time to best utilize flood water.

Floods are the regular feature in the Bihar state causing huge inundation, congestion of drainage and erosion of river banks. The major rivers of south Bihar spill over their banks during and after heavy rains in their catchment areas, due to poor outfall conditions and inadequate channel capacity. The situation is worsening every year on account of the increased encroachment of the plains, low outfall capacity of the rivers due to heavy siltation and deforestation in the catchment areas and poor drainage conditions. Flood management is more effective than the flood control. Thus, for its management, the important management areas are wasteland, water-storage, embankments and the construction of small scale integrated projects, to be given priority (Singh and Kumar, 2004). There are following measures for river basin management:

- Scientific land use planning of the upper reaches of the river with emphasis on discouragement for the use of forestland for any other purpose.
- Identification of erosion prone areas along the rivers through multi-year satellite data to delineate river reaches for flood mitigation measures.
- Protection of natural drainage system all over the river basins while planning for development of transport infrastructure.
- Study of drainage pattern and duration of flood inundation along with the frequently flooded rivers.

The long-term measures normally reduce the frequency of floods and associated damages. The water has flooded the catchment areas of river systems in Bihar; the need is to remove the floodwater as quickly as possible so that the loss of kharif crop can be reduced and land is available for timely cultivation of rabi crops. It is possible only through a network of scientifically designed and constructed surface drains in the flood plain areas of the river systems so that the recession time of flood water is curtailed and land is available by middle of October for sowing. There should be scientific agricultural strategies after the recession of floods (Rai, 2002). The timeliness of sowing of crops should receive highest priority while planning for increased agricultural productivity. Thus, prepositioning of all inputs for sowing in time should be the prime concern of the development agencies. Bringing much needed awareness about techniques and technology for efficient and integrated crop management. Immediately after receding of floods, various crops should be sown, for which seeds are easily available. Training to farmers as a means of technology transfer and distribution of leaflets indicating as what to do and what not to do is considered important. Government farms should be utilized for production of breeder and foundation seeds. The farmer should be federated at block and district level for the production of large amount of certified

seeds. Human Resource Development is important, both as a short and a long-term measure. Training to farmers for rejuvenation of old orchards and intercropping in these orchards should be given a priority. As floods are quite common and on and off there is on-*slaught* of drought, there is an urgent need of establishing a seed bank of important crops and their varieties/hybrids suitable to meet the contingent situations. Over and above the annual requirement seed need to be producedand stored with government assistance. As new tools, techniques, means, mechanisms and systems are now available for storage, transport and value addition to straws as fodder for animals, the concept of fodder and feed bank could be put to reality with government efforts. The government should incorporate an agenda for development which is speedy and inclusive. It requires the strengthening of administrative system, institutional reforms and people participation. Government of Bihar, has made a comprehensive plan to mitigate the impact of climate change. They are building an institutional linkage with ICAR and it participating organisation for technical advice, capacity building and research. To bridging the yield gap between existing and potential capacity, by using bio-technology to develop improved and diversified varieties of crops those are flood and draught tolerant. They are promoting efficient irrigation systems, demonstration of appropriate technology, capacity building and skill development. Strengthening weather services and early warning systems through enhanced agromet systems.

9. Conclusion

The Son -Karamnasa interfluve has critical environmental problems like flood and drought, which are regular phenomena. Drought like condition are occurred in the whole study area but mostly occurs in the foothill of the Rohtas and Kaimur plateau before the beginning of rainy months due to small and non – perennial streams, the canal system cannot serve these areas due to foothills. The flood occurs in the low-lying area along the rivers in the month of September to November, that affect the kharif crops and sometime it also affects the rabi crops. The analysis reveals that maximum area under crop, production and productivity was declined in rabi and annual crop than kharif crop such as maize and rice.This is a must to make the farming remunerative. Hence, there is need to encourage private and public investment in this sector. To bring much needed commercialization in agriculture, measures are essentially called for market intervention mechanisms right in the area of production. Strengthening research and development support system, as economy is likely to be substantially agriculture dependent in the foreseeable future, there is no option but to invest far more than ever before in research and development in agriculture.

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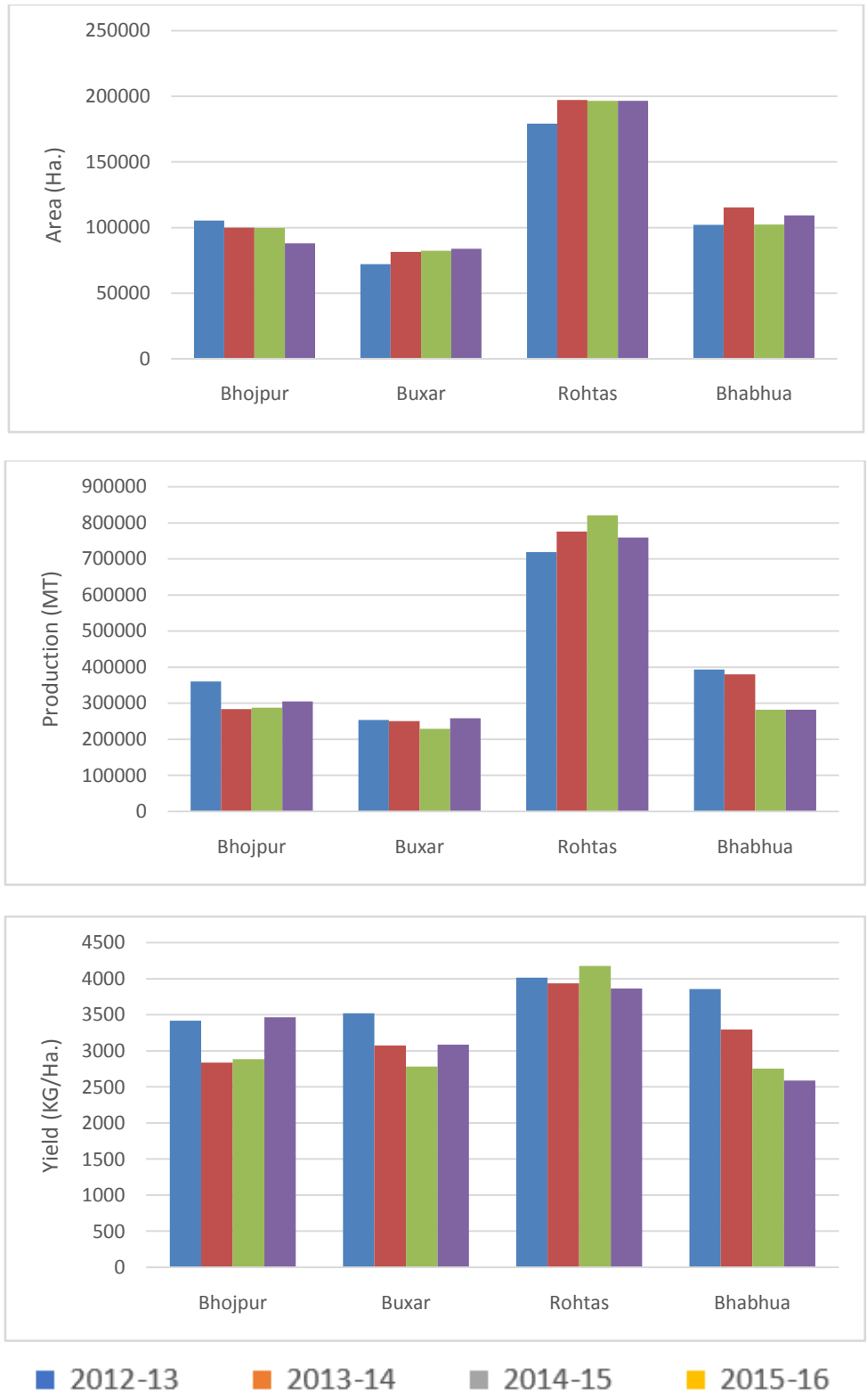

Figure 4: Area, Production and Yield of Rice Crop

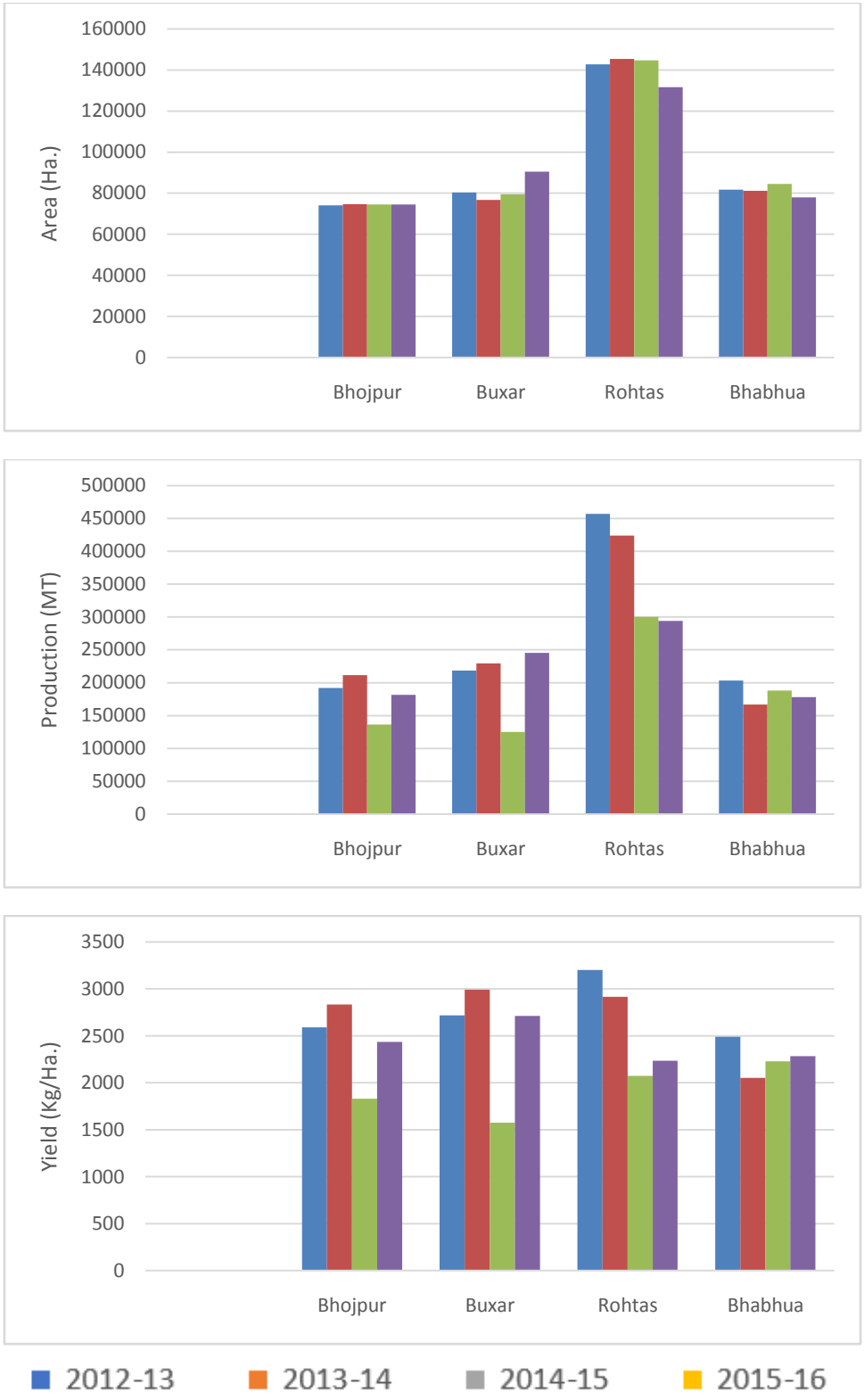

Figure 5: Area, Production and Yield of Wheat Crop

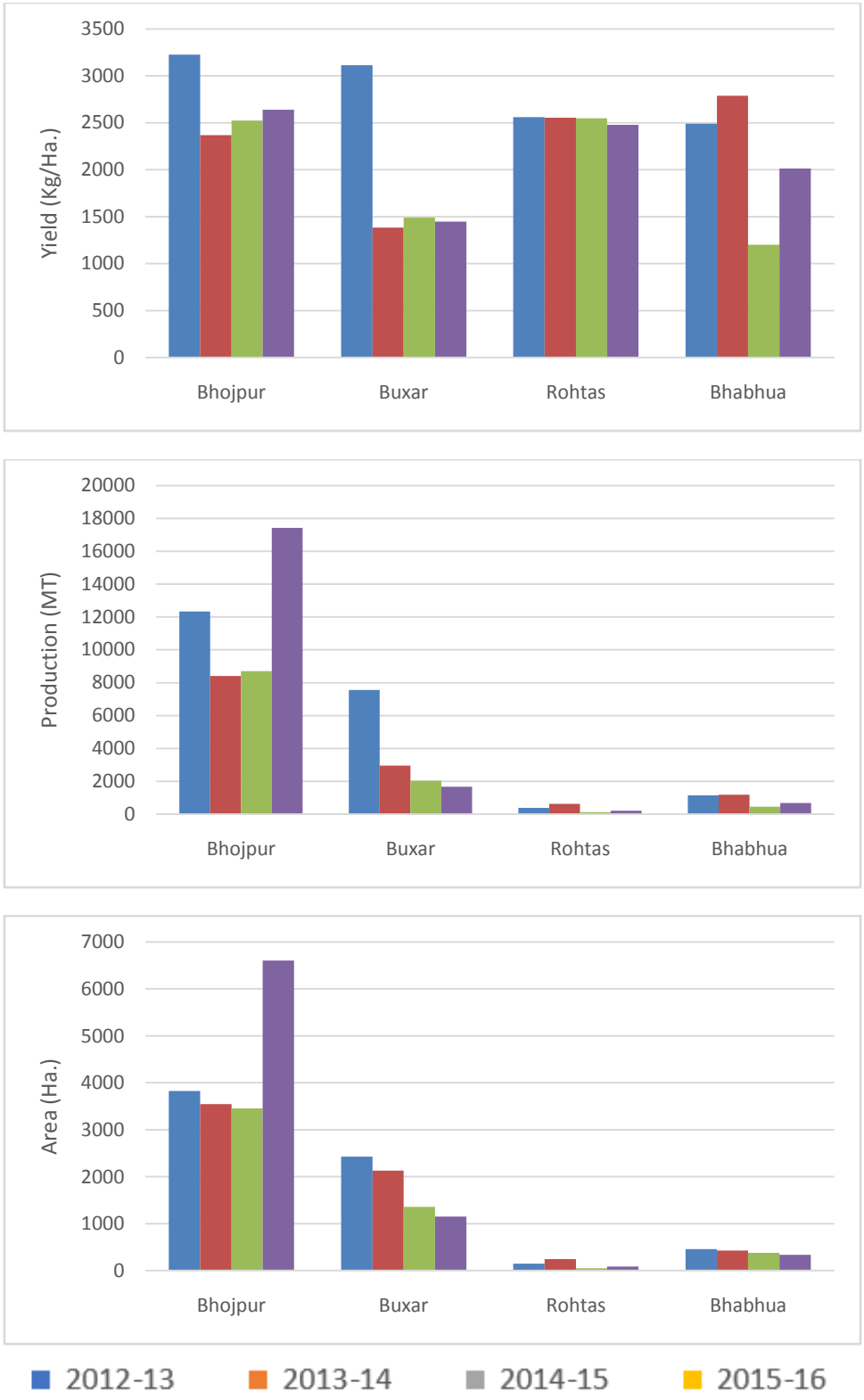

Figure 6: Area, Production and Yield of Maize Crop

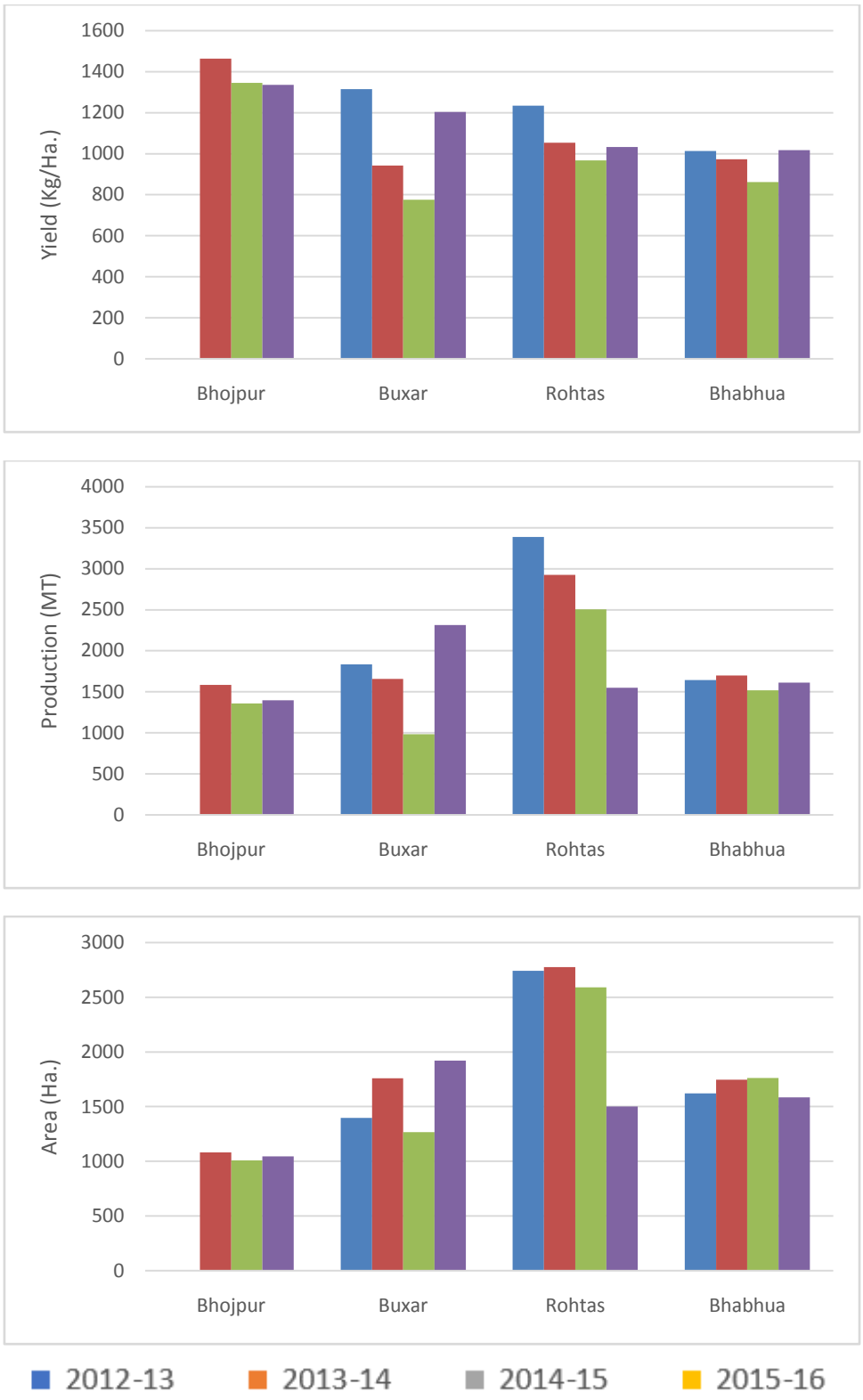

Figure 7: Area, Production and Yield of Mustard Crop

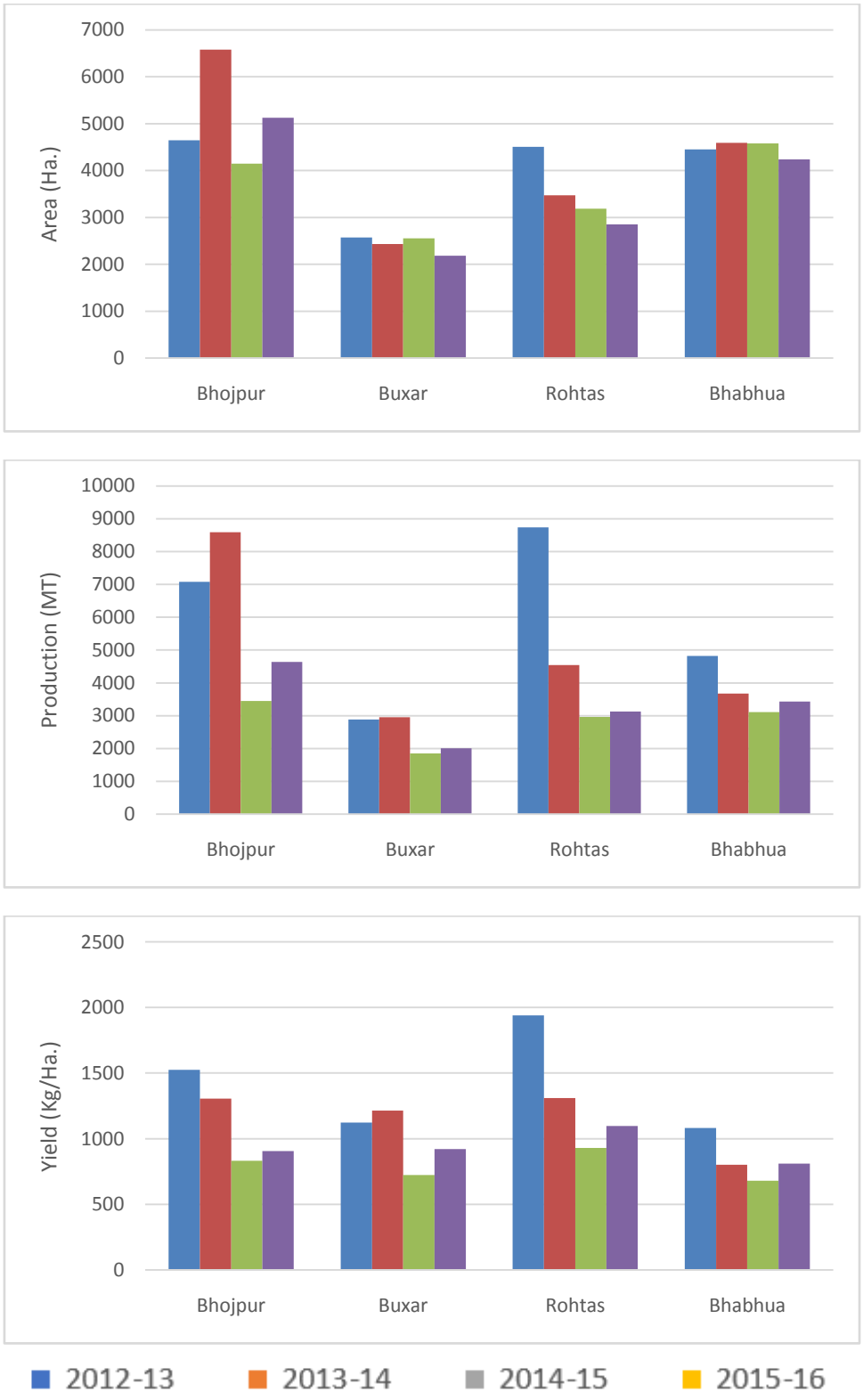

Figure 8: Area, Production and Yield of Gram Crop

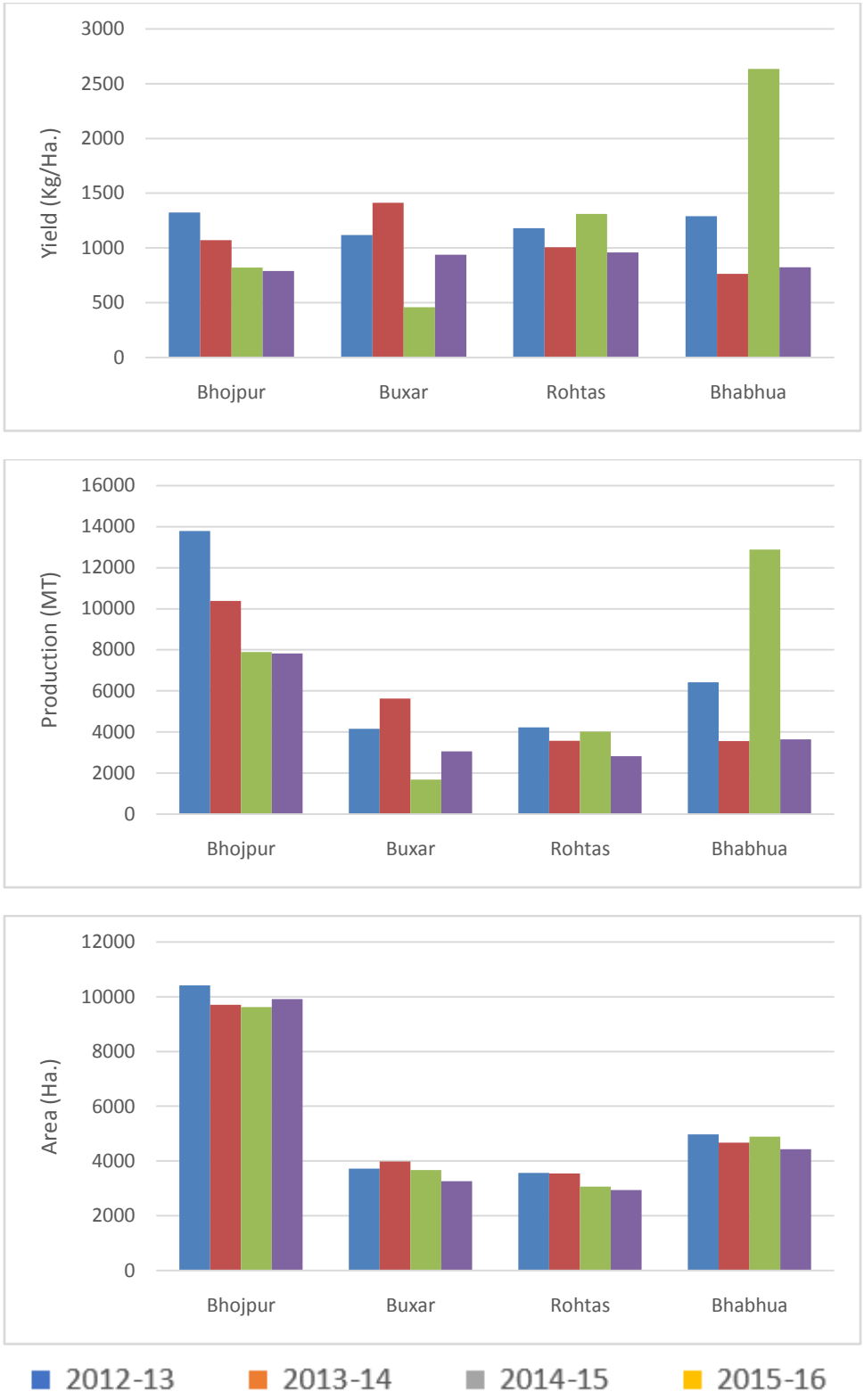

Figure 9: Area, Production and Yield of Lentil Crop

Figure 10: Area, Production and Yield of Arhar Crop

Table 2: Area of deferent crops (in Hectare)

Crops	District	Area (ha.)				Changes (2013-16)	
		2012-13	2013-14	2014-15	2015-16	2013-16	Per cent
Rice	Bhojpur	105334	99843	99762	88040	-17294	-16.4
	Buxar	72105	81392	82233	83817	11712	16.2
	Rohtas	179197	197145	196508	196657	17460	9.7

	Bhabhua	102114	115422	102380	109155	7041	6.9
Wheat	Bhojpur	74136	74643	74572	74450	314	0.4
	Buxar	80302	76680	79483	90524	10222	12.7
	Rohtas	142786	145337	144730	131579	-11207	-7.8
	Bhabhua	81719	81171	84502	77967	-3752	-4.6
Maize	Bhojpur	3825	3547	3454	6605	2780	72.7
	Buxar	2428	2131	1359	1152	-1276	-52.6
	Rohtas	148	245	51	86	-62	-41.9
	Bhabhua	459	424	375	333	-126	-27.5
Mustard	Bhojpur	NA	1081	1009	1045	NA	NA
	Buxar	1396	1760	1267	1921	525	37.6
	Rohtas	2743	2777	2590	1500	-1243	-45.3
	Bhabhua	1622	1747	1762	1586	-36	-2.2
Gram	Bhojpur	4647	6580	4149	5125	478	10.3
	Buxar	2571	2434	2552	2183	-388	-15.1
	Rohtas	4506	3470	3187	2852	-1654	-36.7
	Bhabhua	4453	4590	4580	4237	-216	-4.9
Lentil	Bhojpur	10417	9702	9625	9915	-502	-4.8
	Buxar	3717	3981	3670	3261	-456	-12.3
	Rohtas	3570	3548	3069	2936	-634	-17.8
	Bhabhua	4975	4667	4888	4430	-545	-11.0
Arhar	Bhojpur	1604	1046	1051	1234	-370	-23.1
	Buxar	341	403	345	302	-39	-11.4
	Rohtas	1078	1116	838	842	-236	-21.9
	Bhabhua	1800	1791	1837	1683	-117	-6.5

Table 3: Production of deferent crops (in MT)

Crops	**District**	**Production (MT)**				**Changes (2013-16)**	
		2012-13	**2013-14**	**2014-15**	**2015-16**	**2013-16**	**Per cent**
Rice	Bhojpur	359978	283386	287837	305027	-54951	-15.3
	Buxar	253840	250244	228893	258642	4802	1.9
	Rohtas	719137	776198	820981	759630	40493	5.6
	Bhabhua	393863	380460	281879	282272	-111591	-28.3
Wheat	Bhojpur	192024	211555	136534	181382	-10642	-5.5
	Buxar	218296	229524	125280	245576	27280	12.5
	Rohtas	457110	424008	300101	294213	-162897	-35.6
	Bhabhua	203507	166655	188249	177966	-25541	-12.6
Maize	Bhojpur	12340	8407	8713	17431	5091	41.3
	Buxar	7561	2948	2026	1668	-5893	-77.9
	Rohtas	379	626	130	213	-166	-43.8
	Bhabhua	1143	1182	450	670	-473	-41.4
Mustard	Bhojpur	NA	1583	1358	1396	NA	NA
	Buxar	1836	1658	982	2313	477	26.0
	Rohtas	3388	2927	2505	1550	-1838	-54.3
	Bhabhua	1645	1700	1519	1613	-32	-1.9

Gram	Bhojpur	7082	8593	3452	4638	-2444	-34.5
	Buxar	2887	2955	1848	2011	-876	-30.3
	Rohtas	8742	4542	2961	3126	-5616	-64.2
	Bhabhua	4818	3677	3110	3436	-1382	-28.7
Lentil	Bhojpur	13792	10381	7902	7833	-5959	-43.2
	Buxar	4156	5625	1688	3062	-1094	-26.3
	Rohtas	4220	3569	4020	2816	-1404	-33.3
	Bhabhua	6418	3561	12880	3646	-2772	-43.2
Arhar	Bhojpur	9268	2321	1928	1600	-7668	-82.7
	Buxar	451	965	689	479	28	6.2
	Rohtas	2856	1710	1053	2058	-798	-27.9
	Bhabhua	3472	2919	2432	2361	-1111	-32.0

Table 4: Yield of deferent crops (in MT)

Crops	**District**	**Yield(kg/ha)**				**Changes (2013-16)**	
		2012-13	**2013-14**	**2014-15**	**2015-16**	**2013-16**	**Per cent**
Rice	Bhojpur	3417	2838	2885	3465	48	1.4
	Buxar	3520	3075	2783	3086	-434	-12.3
	Rohtas	4013	3937	4178	3863	-150	-3.7
	Bhabhua	3857	3296	2753	2586	-1271	-33.0
Wheat	Bhojpur	2590	2834	1831	2436	-154	-5.9
	Buxar	2718	2993	1576	2713	-5	-0.2
	Rohtas	3201	2917	2074	2236	-965	-30.1
	Bhabhua	2490	2053	2228	2283	-207	-8.3
Maize	Bhojpur	3226	2370	2523	2639	-587	-18.2
	Buxar	3114	1383	1491	1448	-1666	-53.5
	Rohtas	2561	2555	2549	2477	-84	-3.3
	Bhabhua	2490	2788	1200	2012	-478	-19.2
Mustard	Bhojpur	NA	1464	1346	1336	NA	NA
	Buxar	1315	942	775	1204	-111	-8.4
	Rohtas	1235	1054	967	1033	-202	-16.4
	Bhabhua	1014	973	862	1017	3	0.3
Gram	Bhojpur	1524	1306	832	905	-619	-40.6
	Buxar	1123	1214	724	921	-202	-18.0
	Rohtas	1940	1309	929	1096	-844	-43.5
	Bhabhua	1082	801	679	811	-271	-25.0
Lentil	Bhojpur	1324	1070	821	790	-534	-40.3
	Buxar	1118	1413	460	939	-179	-16.0
	Rohtas	1182	1006	1310	959	-223	-18.9
	Bhabhua	1290	763	2635	823	-467	-36.2
Arhar	Bhojpur	5778	2219	1834	1297	-4481	-77.6
	Buxar	1323	2395	1997	1586	263	19.9
	Rohtas	2649	1532	1257	2444	-205	-7.7
	Bhabhua	1929	1630	1324	1403	-526	-27.3

Table 5: District-wise changes in crop yield

Bhojpur District						
Crops	**Yield(kg/ha.)**				**Changes (2013-16)**	**Per cent**
	2012-13	**2013-14**	**2014-15**	**2015-16**	**2013-16**	**Per cent**
Arhar	5778	2219	1834	1297	-4481	-77.6
Gram	1524	1306	832	905	-619	-40.6
Lentil	1324	1070	821	790	-534	-40.3
Maize	3226	2370	2523	2639	-587	-18.2
Wheat	2590	2834	1831	2436	-154	-5.9
Rice	3417	2838	2885	3465	48	1.4
Mustard	NA	1464	1346	1336	NA	NA
Buxar District						
Maize	3114	1383	1491	1448	-1666	-53.5
Gram	1123	1214	724	921	-202	-18.0
Lentil	1118	1413	460	939	-179	-16.0
Rice	3520	3075	2783	3086	-434	-12.3
Mustard	1315	942	775	1204	-111	-8.4
Wheat	2718	2993	1576	2713	-5	-0.2
Arhar	1323	2395	1997	1586	263	19.9
Rohtas District						
Gram	1940	1309	929	1096	-844	-43.5
Wheat	3201	2917	2074	2236	-965	-30.1
Lentil	1182	1006	1310	959	-223	-18.9
Mustard	1235	1054	967	1033	-202	-16.4
Arhar	2649	1532	1257	2444	-205	-7.7
Rice	4013	3937	4178	3863	-150	-3.7
Maize	2561	2555	2549	2477	-84	-3.3
Bhabhua District						
Lentil	1290	763	2635	823	-467	-36.2
Rice	3857	3296	2753	2586	-1271	-33.0
Arhar	1929	1630	1324	1403	-526	-27.3
Gram	1082	801	679	811	-271	-25.0
Maize	2490	2788	1200	2012	-478	-19.2
Wheat	2490	2053	2228	2283	-207	-8.3
Mustard	1014	973	862	1017	3	0.3