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Dynamics of Major Cereals Productivity in Nepal

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ABSTRACT

Cereal crops have played major roles in addressing food security issues in Nepal. In recent years there have been fluctuations in crop production and demands situations due to various reasons. Thus, the present study aims to analyze the dynamics of major cereals productivity in Nepal from 1995 to 2014. Focus group discussions were done in mid-hills and tarai of Nepal in 2015. Percentage change, compound growth rate, annual rate of change, coefficient of variation, instability index were calculated to analyze results. The result shows that the area, production and productivity of major cereals had an increasing trend over the study period. The major factors contributing on productivity increase in cereal crops were irrigation facilities, use of improved and hybrid seeds, chemical fertilizer and better technical knowhow among the farmers. For effective adoption of research outputs to improve the productivity emphasis should also be given on promotion of public private partnership (PPP) in research and development.

Keywords: Cereals, Food security, Policy intervention, Trend of cereals productivity

सारंश

नेपालको खाद्य सुरक्षाको चुनौतीलाई समाधान गर्न अन्नबालीको महत्वपूर्ण भूमिका रहि आएको छ । हालका वर्षहरुमा बालीको उत्पादन, उत्पादकत्व तथा खपतमा असन्तुलन भएको पाईन्छ । तसर्थ, नेपालमा लगाइने मुख्य अन्नबालीहरुको उत्पादकत्वमा ई.सं. १९९५ देखि २०१४ सम्म भएका उतार चढावको विश्लेषण गर्ने उद्देश्यले यो अध्ययन गरिएको हो । साथै समूह केन्द्रित छलफल मध्य पहाड तथा तराईमा २०१५ मा गरिएको थियो । परिवर्तन प्रतिशत (Percentage change), मिश्रित वृद्धि दर (Compound growth rate),वार्षिक वृद्धि दर (Annual growth rate),गुणांक विविधता (Coefficient of variation),अस्थिरता सूचकांक (Instability index) हरु प्रयोग गरी नतिजा विश्लेषण गरिएको थियो । नतिजानुसार समग्रमा मुख्य अन्नबालीहरुको क्षेत्रफल, उत्पादन तथा उत्पादकत्वहरुको बढ्दो प्रवृत्ति देखियो । उत्पादकत्व वृद्धिको मुख्य-मुख्य कारक तत्वहरुमा किसानहरुमा बढ्दो सिंचाई सुविधा, उन्नत तथा वर्णशंकर बीउको प्रयोग, रासायनिक मलको प्रयोगका साथै प्राविधिक ज्ञान रहेको पाइयो । अनुसन्धानका नतिजाहरु वास्तविक लाभार्थी सामु प्रभावकारी रुपमा पुर्याई अनुसन्धान तथा विकासमा सार्वजनिक नीति साझेदारीमा प्रोत्साहन गर्दै माथि उल्लेखित कारक तत्वहरुमा विचार गर्दा अन्नबालीको उत्पादन क्षमता अनुसार उत्पादन हुने देखिन्छ ।

INTRODUCTION

Agriculture plays a crucial role in Nepalese economy as about 60.4% of population is engaged in agriculture for their livelihood (MoAD 2015). Besides generating employment, agriculture supports national economy by contributing 33% in Gross Domestic Production (GDP). Nepalese agriculture, though diversified, is mostly dominated by three major cereal crops viz. rice, wheat and maize which jointly account 30.92% of Agricultural GDP of the country (MoAD 2015). These crops are vital for food security of the country. The country's self-sufficiency in food grain production has not been achieved as its growth could not keep pace with increasing demand for food. Nepal ranks 72nd position with Global Hunger Index (GHI) of 22.0 among the world countries (IFPRI 2017).

Over the decades, Government of Nepal has introduced many policies and periodic plans to enhance productivity, profitability and commercialization of the agriculture sector. Among them, Agricultural Perspective Plan (APP) from 1995 to 2014 was the important one, expected to enhance the livelihood of Nepalese farmers substantially, if implemented appropriately. APP had aimed to accelerate the agriculture growth rate and commercialization through increased factor productivity (APP 1995). Many policies supportive

to APP, like National Agricultural Policy (2004), Agribusiness Promotion Policy (2006), National Seed Policy (2000), National Fertilizer Policy (2002) and Irrigation Policy (2003) have been formulated after the APP was launched. Despite all these efforts, the extent of productivity growth and commercialization is low and hence 32 out of 75 districts are still food deficit in Nepal (MoAD/FAO/WFP 2015). The major challenges of Nepalese agriculture and food security at present are (1) increasing use of agriculture land for non-agricultural purposes (2) increasing out-migration of economically active population (3) negative effect of climate change (4) inadequate use of quality fertilizer (5) limited use of improved technologies and (6) small and fragmented lands that hinder mechanization and commercialization (Shrestha 2012). There is a large yield gap in yield of cereal crops which is about 1 t/ha between research station and farmers' field, however, minimization of the yield gaps by country's Research and Development sector might improve the food security in the country (Amagain and Timsina 2005). After the APP (1995-2014), Government of Nepal has brought another plan known as Agriculture Development Strategy (ADS; 2015-2035) to address food and nutritional security through development of private and cooperative sector as one of the strategic component focusing on public private partnership (PPP) approach in several areas (MOAD 2014). Gairhe et al (2016) also highlighted the importance of PPP approach in the development of agriculture sector in Nepal.

Despite the positive aggregate national cereal balance in the recent years, domestic production has not been enough to meet the rice demand (MoAD/FAO/WFP 2015). Food import is galloping in the country as five years import data shows that the import value has inclined from NRs. 44.43 billion in 2009-10 to NRs. 127.51 billion in 2013-14. The statistics showed that the import value of cereals from India was NRs. 35.12 billion of which rice share was NRs. 23.79 billion and the maize share was 7.43 billion in 2013-14 (Kathmandu Post 2015).On the contrary, Timsina et al (2012) reported that Nepal has sufficient food to meet the national demand and tarai of Nepal had about 506247 t of food surplus in 2011, however at the same time; the remaining two agro-ecological regions (Hill and Mountain) were in the food deficit condition.

Bhandari (2012) analyzed 56 years annual average total yield of major cereals from 1950/51 to 2006/07 which was 1830 kg/ha. However, above and below the average yield in different years were observed. He reported several reasons such as new technology, drought, soil fertility, farm management practices, variety of seeds, diseases and insects prevalence, and the weather were responsible for variations. Lamichhane et al (2015) highlighted maize technology intervention in western hills.

IFPRI (2011) reported the production growth in maize in the year 2001 to 2009 largely driven by yield enhancement, which shows a 2.4% growth rate, rather than by an increase in area. This increase in yields of maize is largely attributed to the use of hybrid maize seed. Similarly, as compared to the previous decade, the production growth rates of both rice and wheat declined in the period 2001–2009 (IFPRI 2011). Such analysis on the cereal production trends and dynamics in terms of area, production and productivity might be useful to understand the cause and effects. Therefore, the present work focuses on dynamics of major cereal crops over two decades and such knowledge might be useful in implementation of Agriculture Development Strategy and formulating policies for enhancing the food security situation.

MATERIALS AND METHODS

Time series data was collected from secondary sources published by government and non government agencies. Primary data was obtained through field survey with focus group discussion (FGD) from two ecological domains namely Mid hills (Syangja and Baglung Districts) and Tarai (Rupandehi, Parsa and Bara Districts). The sites were Tulsi Bhanjyang (Syangja), Kundule (Baglung), Biruwaguthi (Parsa), Fatehpur (Bara) and Mainahiya (Rupendehi). These sites were purposely selected on the basis of accessibility, where agricultural R&D programs were carried out. FGD was conducted by using a check list to collect data related to farm production, productivity and to know the farmers perception regarding the changes in the productivity of rice, maize and wheat over these periods. The analysis was done by using 20 years data from 1995 to 2014 (APP period) on area, production and productivity of major cereals namely rice, wheat and maize. This period was further divided into two periods (1995-2004 and 2005 to 2014) for the clear understanding of the changes in the area, production and productivity of the major cereals.

Percentage Change

The change in percentage was calculated by using the following formula:

$$\text{Percentage change} = (\text{Change value} - \text{Original value})/ \text{Original value} \times 100$$

Compound Growth Rate (g) Analysis

Past performance of any variable is indicated by growth of particular variables. Growth of any variable indicates its past performance. The study of growth is frequently used in economic studies to see the trend of a particular variable over a time period. It visibly indicates the performance of the variable under concern, thus can be interpreted for policy decisions. Exponential growth function was used to estimate the growth in the area, production and productivity of major cereals, which is given below:

$Y_t = ab^t u_t$ ……………………..…… (1)

Where,

Y_t : Dependent variable for which growth rate was estimated
a: Intercept
b:Coefficient of regression (1+g)
t: Years which takes values, 1, 2, …………, n
u_t: Disturbance term for the year t

For the estimation purpose, the equation was transformed into log linear form and ordinary least square (OLS) technique was used for estimation. The compound growth rate (g) in percentage was then computed from the relationship:

$g = \{\text{Antilog of } (\ln b)-1\} \times 100$

Regression coefficient significance was tested by using the student's' test.

Annual Rate of Change

Linear time trend equation was estimated by using OLS technique to find the annual rate of change in area, production and productivity of major cereals.

Coefficient of Variation

To find out the variation in any time series data, simple analytical technique like coefficient of variation is useful (Gairhe 2011, Gupta and Sharma 2010, Ramasamy et al 2005). It is estimated as follows:

$CV = (SD/ Mean) \times 100$
Where, SD = Standard Deviation

Instability Index

To study the fluctuation or instability in any time series data, a simple analytical technique instability index is very much useful. It is estimated as follows:

i. Parameter of a log-linear trend line is estimated for the variable (Yt) to which instability is to be estimated
ii. If the parameter that is estimated is statistically significant, then the instability index (IIN) is defined as
 $IIN = CV \times (1-r^2)^{0.5}$
 Where, CV = Coefficient of Variation
 r^2 = Coefficient of Determination
 $CV = (SD/ Mean) \times 100$
 Where, SD = Standard Deviation
iii. If the estimated parameter is not significant in the regression equation, then the CV itself is the instability index.

RESULTS

Trend of Major Cereals in Nepal

The trend of rice, maize and wheat area in Nepal from 1995 to 2014 has been shown in **Figure** 1. The trend line depicts that the area under rice was slightly decreasing, whereas the area under maize and wheat were increasing. The increment was higher in wheat area as compared to maize area in the study period. The area of rice, maize and wheat were 1496790, 791700, 653500 ha in 1995, and were 1425346, 882395, 762373 ha in 2014, respectively.

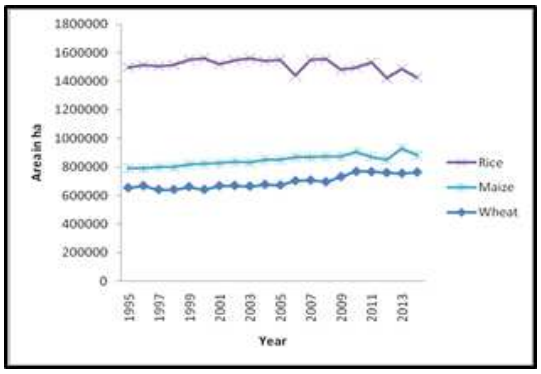

Figure 1. Rice, maize and wheat production area in Nepal from 1995 to 2014

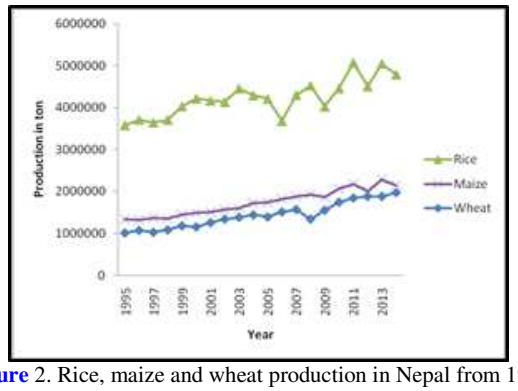

Figure 2. Rice, maize and wheat production in Nepal from 1995 to 2014.

The trend of rice, maize and wheat production in Nepal from 1995 to 2014 is shown in **Figure** 2 depicting that the production of rice, maize and wheat were increasing during the study periods. The production of rice, maize and wheat were 3578830, 1331060, 1012930 mt in 1995, and were 4788612, 2145291, 1975625 mt in 2014, respectively. The rice, maize and wheat productivity from 1995 to 2014 in Nepal has been given in **Figure** 3 depicting that the productivity of rice, maize and wheat were increasing. The productivity of rice, maize and wheat were 2391, 1681, 1550 kg/ha in 1995 and were 3360, 2431, 2591 kg/ha in 2014, respectively.

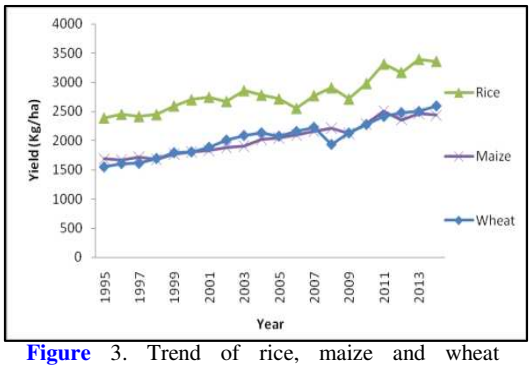

Figure 3. Trend of rice, maize and wheat productivity in Nepal from 1995 to 2014

Average and Percentage Change in Major Cereals in Nepal

The average area, production and productivity of major cereals in Nepal from 1995 to 2014 has been shown in **Table** 1 segregated into three different periods, from 1995-2004 (first), 2005-2014 (second) and 1995-2014 (overall). The average area, production and yield of maize and wheat were higher in second term, and overall period as compared to first period. Rice average area was higher in first period than second and overall period, however production and yield were higher in second period and overall period as compared to first period. The area coverage under rice cultivation in Nepal still depends on monsoon rain. The total area of irrigation merely increased from 1134000 ha to 1180330 ha between 1995 and 2004 and reached up-to 1368900 ha in 2014 (FAOSTAT, 2017). The production and productivity of all the major cereals had shown increasing trend.

Table 1. Average of area, production and productivity of major cereals in Nepal

Year	1995 to 2004			2005 to 2014			1995 to 2014		
Crops	Area (ha)	Prod (t)	Yield (t/ha)	Area (ha)	Prod (t)	Yield (t/ha)	Area (ha)	Prod (t)	Yield (t/ha)
Rice	1530241	3992941	2.61	1493630	4460957	2.99	1511935	4226949	2.80
Maize	817665	1467676	1.79	878103	1989330	2.26	847884	1728503	2.03
Wheat	657901	1197496	1.82	731677	1671468	2.28	694789	1434482	2.05

Source: MoAD 2015

Percentage change in average area, production and yield of major cereals from 1995-2004 to 2005-2014 is presented in **Table** 2. The result witnessed positive change and percentage increase in area, production and yield of rice, maize and wheat except rice area. The rice area was decreased by 2.39 %, but production and yield were increased by 11.72 and 14.64 % respectively. Maize area, production and yield were increased by 7.39, 35.54 and 26.28 %, respectively. Similarly the wheat area, production and productivity were also showed increment by 11.21, 39.58 and 25.27 percent respectively.

Table 2. Percentage change in average area, production and productivity of major cereals in Nepal

Year	Change from 1995-2004 to 2005-2014			Percentage change from 1995-2004 to 2005-2014		
Crop	Area	Prod	Yield	Area	Prod	Yield
Rice	-36611	468016	0.38	-2.39	11.72	14.64
Maize	60438	521654	0.47	7.39	35.54	26.28
Wheat	73776	473972	0.46	11.21	39.58	25.27

Source: MoAD 2015

Growth Rates of Major Cereals in Nepal

Compound growth rate of major cereals is shown in **Table** 3. In maize and wheat, the area, production and productivity were increasing significantly however in rice; only production and productivity increased over the period of two decades. The productivity of rice, maize and wheat were increasing at the rate of 1.65, 2.30, and 2.52% per annum, respectively. The area of rice was not significant and maize and wheat areas were growing 0.69 and 1.02% per annum, respectively.

Table 3. Compound growth rate of area, production and productivity of major cereals in Nepal

Year	1995 to 2004			2005 to 2014			1995 to 2014		
Crop	Area	Prod	Yield	Area	Prod	Yield	Area	Prod	Yield
Rice	0.38*	2.41**	2.03**	-0.60	2.48*	3.11**	-0.21	1.43**	1.65**
Maize	0.80**	2.87**	2.06**	0.41	2.63**	2.21**	0.69**	3.00**	2.30**
Wheat	0.36	4.17**	3.79**	1.43**	4.10**	2.64**	1.02**	3.57**	2.52**

*Note: ** significance at 1 percent level and * significance at 5 percent level*
Source: MoAD 2015

The annual rate of change in area, production and productivity of major cereals is shown in **Table** 4. In the two decades, the rice yield increased by 47 kg/ha whereas maize yield increased by 46 kg/ha while wheat yield increased by 50 kg/ha each year.

Table 4. Annual rate of change in area, production and productivity of major cereals in Nepal (Area in ha, Production in ton, and yield in kg/ha)

Year	1995 to 2004			2005 to 2014			1995 to 2014		
Crop	Area	Prod	Yield	Area	Prod	Yield	Area	Prod	Yield
Rice	5763	94690	52	-9009	108399	92	-3155	60384	47
Maize	6484	41939	37	3681	51523	49	5805	50817	46
Wheat	2350	49276	68	10242	67009	60	7109	50063	50

Source: MoAD 2015

Variability of Major Cereals in Nepal

The coefficient of variation in area, production and productivity of major cereals in Nepal is shown in **Table** 5. In overall period the highest variation in yield was observed in wheat followed by maize and rice.

Table 5. Coefficient of variation of area, production and productivity of major cereals in Nepal

Year	1995 to 2004			2005 to 2014			1995 to 2014		
Crop	Area	Prod	Yield	Area	Prod	Yield	Area	Prod	Yield
Rice	1.54	7.73	6.48	3.50	9.80	10.14	2.89	10.40	11.04
Maize	2.45	8.97	6.53	2.71	8.87	7.31	4.44	17.79	13.76
Wheat	2.01	12.85	11.43	4.79	13.37	9.29	6.59	21.37	15.23

Source: MoAD 2015

The instability index of area, production and productivity of major cereals in Nepal is depicted in **Table** 6. Instability index was found higher in rice and wheat than that of maize yield.

Table 6. Instability index of area, production and productivity of major cereals in Nepal

Year	1995 to 2004			2005 to 2014			1995 to 2014		
Crop	Area	Prod	Yield	Area	Prod	Yield	Area	Prod	Yield
Rice	1.03	2.86	2.27	3.00	6.52	4.14	2.61	6.05	4.84
Maize	0.47	2.19	1.88	2.40	4.04	3.11	1.79	3.27	2.57
Wheat	1.70	2.97	1.48	2.23	5.98	5.01	2.57	5.01	4.52

Source: MoAD 2015

Focus Group Discussion (FGD) was carried out by using a check list to collect the information related to farm production and productivity. Percentage changes in productivity of major cereals from 1995 to 2015 in five districts are shown in **Table** 7. The result revealed that the highest percentage increment in rice and wheat were observed in Rupandehi and least in Baglung districts. In case of maize, highest increment was observed in Bara district i.e. 650% but in the study sites of Rupandehi; farmers are not cultivating maize since many years. It can be concluded from FGD that the productivity growth was much higher in the study area than that was found in national average data published by government sources. This difference might be resulted from selection bias of survey sites where production facilities were probably rich as compared to general farming condition of other areas. However, the time series data have been questioned several times for their reliability in formal and informal occasions. The use of conventional method of data collection has been criticized and modern GIS tool has been suggested to the government agencies.

Table 7. Percentage increase in productivity of major cereals from 1995 to 2015 in five districts

S. No.	Ecological domain	District	Rice	Maize	Wheat
1	Mid hill	Baglung	60.00	222.6	68.00
2	Mid hill	Syanga	100.00	100.0	100.00
3	Tarai	Rupendehi	275.00	*	230.00
4	Tarai	Parsa	166.67	100.0	118.18
5	Tarai	Bara	220.00	650.0	200.00

Source: FGD 2015 ** Not cultivated in the survey site*

DISCUSSION

It is likely that the increase in productivity besides the adoption of improved varieties and hybrids were due to the increase use of chemical fertilizer and technical knowledge of farmers. The data obtained from the Farmers Group Discussion (FGD) was suggestive that there was substantial increase in major cereal productivity in mid hills and tarai plains during last two decades mainly due to the use of improved varieties such as Loktrantra, Sukhadhan, Sabitri, Hardinath 1, Ram Dhan, Radha 4, Khumal 10, and Khumal 13 and hybrids Gorakhnath, US 312, DY 18, DY 28, Arize 6444 (**Appendix** 1.5). The highest increase in productivity (275%) in rice was reported in Rupandehi (**Table** 7) due to the use of hybrids. Similarly, increase in maize productivity reported by FGD was resulted from the adoption of improved varieties such as Manakamana 1, Manakaman 3, Manakamana 5, Rampur Composite, Poshilo Makai, and hybrids (DKC 9081, Pioneer 3522, 10V10). The highest increase in maize productivity (650%) was possible in Bara due to dominance of hybrid maize. Increase in wheat productivity was by the adoption of modern varieties (Vijaya, Gautam, Vrikuti, Aaditya, and WK 1204). The highest increase in wheat productivity (230%) in Rupandehi was responded due to the use of improved varieties developed by National Wheat Research Program (NWRP) located in the same district (**Appendix** 1.5). The productivity increase in maize, wheat and rice were coincided well with the varietal release and registration by Nepal Agricultural Research Council (**Appendix** 1.5).

MoAC (2010) reported that 83% area was covered by modern varieties of rice in the hills, whereas it was 89% in tarai plains. Different studies in different districts indicate variation in coverage of modern varieties of rice which ranges from 50% to 99% in hilly districts and from 88% to 100% in different tarai districts (SARPOD 2011, SARPOD 2013, SARPOD 2014, Shrestha et al 2012, Timsina et al 2012). Similarly, MoAC (2010) reported that 94% area was covered by modern varieties of wheat in the hills, whereas it was 100% in the tarai plains. Other studies indicated similar variation in coverage of modern varieties of wheat which ranges from 65% to 95% in hilly districts and from 94% to 100% in tarai (Shrestha et al 2012, Timsina et al 2016a, Timsina et al 2012). Moreover, MoAC (2010) reported that 87% area was covered by modern varieties of maize in the hills, whereas it was 99% in tarai plains. Shrestha et al (2012) and Timsina et al (2016b) reported that modern varieties of maize covered 60 to 90% in hilly districts and 80% to 100% in tarai districts of Nepal (**Appendix** 1.4).

As the production and productivity of all the major cereals have shown increasing trends but the increase in rice, maize and wheat cultivated area was not significant. The maize and wheat areas were growing only 0.69 and 1.02% per annum, respectively. The other factors contributed to increase in the productivity were the increase in use of chemical fertilizer and irrigation. The FAO statistics showed that during the study period the consumption of chemical fertilizer has increased from 111524 ton in 2003 to 273238 ton in 2014 (FAOSTAT, 2018) and Bista et al (2016) also reported that there has been increase in the use of chemical fertilizer consumption over the years. Similarly, the total area under irrigation has increased from 1134000 ha in 1995 and to 1368900 ha in 2014 (FAOSTAT, 2017).

Present study showed that the crop productivity can be resulted by composite function of variety, technology, fertilizer, and irrigation facilities, in general. Since there is no fertilizer plant in the country at present, farmers suffer from irregular supply of imported fertilizers. In this direction, fertilizer plants should be built in the country for assurance of regular supply of fertilizer.

CONCLUSION

The area, production and productivity of major cereals have an increasing trend over the last two decades in the country. Increased irrigation facilities, use of improved and hybrid seeds and increased use of chemical fertilizer have contributed to productivity improvement in cereal crops. Better technical knowhow among the farmers has also crucially helped to rise in the productivity. Total crop production could be increased either by increase in the area or in the productivity. Since the scope of crop area increase is limited, the focus should be given to further productivity enhancement by input supply such as fertilizer, irrigation and quality seed, pest control, minimum support price, buffer stock, trade and distribution to promote the cereal cultivation and assuring market.

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APPENDICES

Appendix 1.1. Compound growth rate function for area, production, productivity of major cereals for period I (1995 to 2004)

Crops	Variables	CGR	A	B	R^2	F	t
Rice	Area	0.38	14.22	0.00	0.55	9.82	3.13
	Production	2.41	15.07	0.02	0.86	50.64	7.12
	Productivity	2.03	7.75	0.02	0.88	57.24	7.12
Maize	Area	0.80	13.57	0.01	0.96	204.58	14.30
	Production	2.87	14.04	0.03	0.94	125.80	11.22
	Productivity	2.06	7.38	0.02	0.92	88.87	9.43
Wheat	Area	0.36	13.38	0.00	0.29	3.20	1.79
	Production	4.17	13.76	0.04	0.95	141.92	11.91
	Productivity	3.79	7.29	0.04	0.98	469.65	21.67

Appendix 1.2. Compound growth rate function for area, production, productivity of major cereals for period II (2005 to 2014)

Crops	Variables	CGR	A	B	R^2	F	t
Rice	Area	-0.60	14.25	-0.01	0.27	2.95	-1.72
	Production	2.48	15.17	0.02	0.56	10.07	3.17
	Productivity	3.11	7.83	0.03	0.83	40.03	6.33
Maize	Area	0.41	13.66	0.00	0.22	2.23	1.49
	Production	2.63	14.36	0.03	0.79	30.53	5.53
	Productivity	2.21	7.60	0.02	0.82	36.27	6.02
Wheat	Area	1.43	13.42	0.01	0.78	28.89	5.37
	Production	4.10	14.10	0.04	0.80	32.02	5.66
	Productivity	2.64	7.58	0.03	0.71	19.46	4.41

Appendix 1.3. Compound growth rate function for area, production, productivity of major cereals for overall period (1995 to 2014)

Crops	Variables	CGR	A	B	R^2	F	t
Rice	Area	-0.21	14.25	0.00	0.19	4.11	-2.03
	Production	1.43	15.10	0.01	0.66	35.13	5.93
	Productivity	1.65	7.76	0.02	0.81	75.60	8.70
Maize	Area	0.69	13.58	0.01	0.84	93.57	9.67
	Production	3.00	14.04	0.03	0.97	515.67	22.71
	Productivity	2.30	7.37	0.02	0.97	498.16	22.32
Wheat	Area	1.02	13.34	0.01	0.85	100.79	10.04
	Production	3.57	13.79	0.04	0.95	309.54	17.59
	Productivity	2.52	7.35	0.02	0.91	186.40	13.65

Appendix 1.4. Area covered by modern varieties of Rice, Wheat and Maize

Crops	Hills	Tarai
Rice	Overall 83% (MoAC 2010) 50% in Doti, 95% in Kavre (Shrestha et al 2012) 95.2% in Bhaktapur, 73.5% in Dhading, 33.2% in Dhankuta, 22.4% in Jumla, 97.5% Kavre, 99% in Nuwakot, 7.2% Sangkhuwasabha, 94.5% in Sindhuli (SARPOD 2011) 85.7% in Palpa and 92.6% in Syanja (SARPOD 2013) 61.4% in Doti (SARPOD 2014)	89% (MoAC 2010) 95% in Rupandehi, 100% in Bara (Shrestha et al 2012) 97.7% in Bara, 96.3% in Jhapa, 89.6% in Mahottari, 94.2% in Morang , 96.5 in Sarlahi (SARPOD 2013) 88.5% in Sunsari and Mahottari (Timsina et al 2012) 94.2% in Kailali, 92.5% in Kanchanpur (SARPOD 2014)
Wheat	94% (MoAC 2010) 65% in Doti, 95% in Dhankuta (Shrestha et al 2012)	100% (MoAC 2010) 98% in Sunsari, 100% in Bara, Rupandehi, Banke and Kailali (Shrestha et al 2012) 94% in Sunsari, Rupandehi and Banke (Timsina et al 2016a)
Maize	87% (MoAC 2010) 60% in Doti, 95% in Kavre (Shrestha et al 2012) 60% in Baglung, 65% in Palpa (Lamichhane et al 2015) More than 70% in Kavre and Lamjung (Timsina et al 2016b)	99% (MoAC 2010) 85% in Rupandehi, 100% in Sunsari, Bara and Kailai (Shrestha et al 2012)

Appendix 1.5. List of rice, maize and wheat varieties released and registered during the study period (1995-2014) with their productivity

Rice Varieties	Year	Released/ registered	Productivity (ton/ha)	Recommended domain
Radha 4	1195	Released	3.20	Tarai of Mid Far western and Far Western Region
Radha 11	1995	Released	4.00	Mid tarai
Radha 12	1995	Released	4.60	Eastern tarai
Macchapuchre 3	1996	Released	5.00	Mid to high hills from 1400 to 2000 masl
Khumal 6	1999	Released	7.80	Kathmandu valley and similar conditions of mid hills
Rampur Masuli	1999	Released	5.70	Tarai, inner tarai and lowland up to 900 masl of mid hills
Chandannath 1	2002	Released	5.05	Jumla and similar climatic conditions
Chandannath 3	2002	Released	5.30	Jumla and similar climatic conditions
Manjushri 2	2002	Released	10.08	Kathmandu valley
Khumal 11	2002	Released	8.50	Kathmandu valley
Loktantra	2006	Released	3.60	Tarai, inner tarai, lower hills and river basin of mid hills
Mithila	2006	Released	3.5-4.5	Tarai, inner tarai and lowland mid hills
Ram	2006	Released	4.0-7.2	Tarai and inner tarai
Barkhe 3004	2006	Released	3.80	Tarai and inner tarai
Pokhreli Jethobudo	2006	Released	2.60	Pokhara valley from 600 to 900 masl
Khumal 8	2007	Released	7.70	Mid hills and lower hills
Sunaulo Sugandha	2008	Released	3.80	Tarai and inner tarai
Ghaiya 1	2010	Released	2.5-3.5	Unirrigated upland, tarai plain and valleys in mid hills
Lalka Basmati	2010	Released	2.5-3.5	Central and eastern tarai
Hardinath 2	2010	Released	3.1-4.2	Tarai and inner tarai
Tarahara 1	2010	Released	4.20	Central and eastern tarai
DY 18	2010	Registered	9.17	Tarai and inner tarai
DY 28	2010	Registered	8.86	Tarai and inner tarai
DY 69	2010	Registered	9.52	Tarai and inner tarai
Khumal 10	2011	Released	4.78	Kathmandu valley and similar conditions of mid hills
Khumal 13	2011	Released	4.17	Kathmandu valley and similar conditions of mid hills
Sukha Dhan 1	2011	Released	3.2-4.2	Eastern and Western tarai, inner tarai and river basins upto 500 masl in mid hills
Sukha Dhan 2	2011	Released	2.3-3.5	Eastern and Western tarai, inner tarai and river basins upto 500 masl in mid hills
Sukha Dhan 3	2011	Released	2.5-3.6	Eastern and Western tarai, inner tarai and river basins upto 500 masl in mid hills
Barkhe 2014	2011	Released	3.80	Tarai
Swarna Sub1	2011	Released	4.0-5.0	Tarai, inner tarai and irrigated area and lowland upto 500 masl of mid hills
Barkhe 1027	2011	Registered	3.30	Un-irrigated tarai, semi irrigated and un-irrigated area upto 1000 masl of mid hills
Samba masuli sub1	2011	Released	3.5-4.0	Tarai, inner tarai and irrigated area and lowland upto 500 masl of mid hills
Tara F1	2011	Registered	5.10	Tarai and inner tarai
SurajF1	2011	Registered	5.77	Tarai and inner tarai
Prithivi F1	2011	Registered	6.00	Irrigated area of tarai and inner tarai
Arise 6444 F1	2011	Registered	4.43	Irrigated area of tarai and inner tarai
PHB 71 F1	2011	Registered	5.26	Irrigated area of tarai
US 312 F1	2011	Registered	5.46	Tarai and inner tarai
Champion F1	2011	Registered	5.15	Irrigated area of eastern to western tarai and inner tarai
Raja F1	2011	Registered	4.94	Irrigated area of eastern to western tarai and inner tarai
RH 257 F1	2011	Registered	4.99	Tarai and inner tarai
Gorakhnath 509 F1	2011	Registered	4.82	Tarai and inner tarai
Loknath 505 F1	2011	Registered	4.79	Irrigated area of tarai and inner tarai
PAC 801 F1	2011	Registered	7.79	Irrigated area of tarai and inner tarai
Reshma 786 F1	2011	Registered	4.91	Irrigated area of eastern tarai
BaishaliF1	2011	Registered	6.35	Irrigated area of eastern tarai
Lekali Dhan 1	2014	Released	4.07	High hills upto 1500-2600 masl
Lekali Dhan 3	2014	Released	3.90	High hills upto 1500-2600 masl
Sukkha Dhan 4	2014	Released	2.7-4.0	Un-irrigated land of tarai, Inner tarai and Mid hills upto 500 masl
Sukkha Dhan 5	2014	Released	3.2-4.2	Unirrigated land of tarai, Inner tarai and Mid hills upto 500 masl

Rice Varieties	Year	Released/ registered	Productivity (ton/ha)	Recommended domain
Sukkha Dhan 6	2014	Released	3.0-4.0	Unirrigated land of tarai, Inner tarai and Mid hills upto 500 masl
Arun 1	1995	Released	4.00	Western Tarai and Mid hills
Ganesh 1	1997	Released	5.00	High hills
Manakamana 3	2002	Released	5.50	Mid hills of Eastern, Central and Western Development regions from 1000 to 1700 masl
Gaurab Hybrid Makai	2003	Released	8.10	Tarai and Inner Tarai
Deuti	2006	Released	5.70	Mid hills
Sitala	2006	Released	6.08	Hills
Manakamana 4	2008	Released	5.30	Eastern to western mid hills at altitude less than 1600 masl
Posilo makai 1	2008	Released	5.30	Eastern to western mid hills at altitude less than 1600 masl
Manakamana 5	2010	Released	5.27	Mid hills east of Karnali
Manakamana 6	2010	Released	5.34	Eastern and mid-western hills
Bayo 9681 F1	2010	Registered	6.5-8	Mid hills of central region during summer, eastern tarai during winter
RajkumarF1	2010	Registered	8.0-9.0	Tarai, Inner tarai, river basin and valleys upto 700 masl
Nutan KH 101 F1	2010	Registered	6.5-8	Tarai, Inner tarai, river basin and valleys upto 700 masl
Super 900 M F1	2010	Registered	8.0-12.0	Mid tarai- winter and summer season
DKC 9081 F1	2011	Registered	10.0-12.0	Mid tarai for winter season
All rounderF1	2011	Registered	7.0-10.0	Tarai area- winter and summer season
DKC 7074 F1	2011	Registered	6.0-8.0	Mid hills of central region - summer season , mid tarai for spring season
30 P 30 F1	2011	Registered	6.0-7.0	Mid hills of central region for summer season, tarai for winter season
30 B 11 F1	2011	Registered	8.0-9.0	Mid hills of central region for summer season, tarai for winter season
Bisko 940 F1	2011	Registered	7.13	Central tarai and hills
C 1921 F1	2011	Registered	5.14-7.5	Eastern and central tarai, river basin and upland of mid hills
CP 808 F1	2011	Registered	9.95	Eastern and central tarai
CP 666 F1	2011	Registered	6.97	Eastern and central tarai
Godawari 989 F1	2011	Registered	7.36	Eastern and central tarai, river basin and upland of mid hills
Early 2 F1	2011	Registered	5.69	Eastern and central tarai, river basin and upland of mid hills
TCS 9696 F1	2011	Registered	8.34	Central tarai and hills
Rampur Hybrid 2	2012	Released	3.55-7.0	Inner tarai and tarai east of Narayani river
RML 4	2012	Released	2.5-3.0	Inner tarai and tarai east of Narayani river
NML 2	2012	Released	2-2.5.0	Inner tarai and tarai east of Narayani river
Aditya 929 F1	2012	Registered	7.20	Inner tarai and tarai east of Narayani river
Pro Agro 4262 F1	2012	Registered	8.29	Inner tarai and tarai east of Narayani river
Bisko 940 New F1	2012	Registered	7.74	Inner tarai and tarai east of Narayani river
CP 838 F1	2012	Registered	7.11	Inner tarai and tarai east of Narayani river
10 V 10 F1	2012	Registered	7.46	Inner tarai and tarai east of Narayani river
DMH 7314 F1	2012	Registered	6.66	Inner tarai and tarai east of Narayani river
DMH 849 F1	2012	Registered	6.85	Inner tarai and tarai east of Narayani river
MM 1107 F1	2012	Registered	9.00	Inner tarai and tarai east of Narayani river
Decalb Double F1	2012	Registered	6.79	Inner tarai and tarai east of Narayani river
Big boss F1	2012	Registered	8.39	Inner tarai and tarai east of Narayani river
NMH 731 F1	2012	Registered	7.92	Inner tarai and tarai east of Narayani river
Pioneer 3522 F1	2012	Registered	8.65	Inner tarai and tarai east of Narayani river
Pioneer 3785 F1	2012	Registered	8.45	Inner tarai and tarai east of Narayani river
9220 F1	2012	Registered	7.67	Inner tarai and tarai east of Narayani river
TX 369 F1	2012	Registered	9.00	Inner tarai and tarai east of Narayani river
C 1946 F1	2012	Registered	9.70	Inner tarai and tarai east of Narayani river
Khumal Hybrid Makai 2	2014	Released	8.5-9.08	Summer season in Mid Hills and winter season in tarai and Inner tarai
KYM 33	2014	Released	2.50	Summer season in Mid Hills and winter season in tarai and Inner tarai
KYM 35	2014	Released	1.50	Summer season in Mid Hills and winter season in tarai and Inner tarai
Resunga Composite	2014	Released	5.20	Hills of Central and Western Region from 700 to 1400 masl

Rice Varieties	Year	Released/ registered	Productivity (ton/ha)	Recommended domain
Gulmi 2	2014	Registered	5.40	Gulmi and Arghakhanchi Districts from 700 to 1400 masl
Achyut	1997	Released	4.50	Upland lower than 1000 masl
Rohini	1997	Released	4.10	Tarai upland lower than 1000 masl
Pasang Lamhu	1997	Released	6.70	Mid hills
Kanti	1997	Released	5.50	Hills
BL 1473	1999	Released	4.00	Tarai upland lower than 1000 masl
Gautam	2004	Released	3.40	Tarai upland upto 500 masl
WK 1204	2007	Released	3.40	Mid hills and high hills
Aditya	2010	Released	4.79	Tarai upland upto 500 masl
NL 971	2010	Released	4.53	Tarai upland upto 500 masl
Bijaya	2011	Released	4.45	Tarai upland upto 500 masl
Gaura	2012	Released	4.2-5.0	Mid hills and high hills
Dhaulagiri	2012	Released	3.6-4.9	Mid hills and high hills