Mathematical Analysis of Economic Development and Agriculture in India

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Abstract— **Agriculture is an integral part of the world's economy, mainly for developing countries. It is the primary source of employment, income, and food, and these basic needs fulfilled by agriculture all over the world. Agriculture in India is one of the most prominent sectors to its economy and about 70% of the population depends on Agriculture. The foodgrains production has increased from 50.82 million tones in 1950-51 to 296.65 million tones during 2019-20. In the present paper, an attempt has been made to study the production trend and growth rate for foodgrains using mathematical techniques. It is observed that area sown has constantly increased from 115.39 M hectare in 1959-60 to 127.43 M hectare during 1989-90 and then there is declined in area in 1999-2000 (123.11 M hectare). The production has also increased from 78.11 M tones in 1959-60 to 292.86 M tones in 2019-20. The productivity level has been 681 kg/ha during 1959-60 which has gone up to 2312 kg/ha during 2019-20. State-wise analysis has also been carried out for foodgrains producing States. The future projection for production and yield for have been worked using least square techniques. Authors have also suggested the strategies for enhancing the foodgrains production.**

Index Terms: **Foodgrains, Growth Rate, Least Square Technique, Production, Yield**

INTRODUCTION

India is a global agricultural powerhouse. It is the world's largest producer of milk, pulses, and spices, and has the world's largest cattle herd (buffaloes), as well as the largest area under wheat, rice and cotton. It is the second largest producer of rice, wheat, cotton, sugarcane, farmed fish, sheep & goat meat, fruit, vegetables and tea. Uttar Pradesh is the largest State of India and is pre-dominant in agricultural crops. While agriculture in India has achieved grain self-sufficiency but the production is, resource intensive, cereal centric and regionally biased. India also needs to improve its management of agricultural practices on multiple fronts. The total food grain production is estimated to be 305 million tones during 2020-21.

METHODOLOGY

Secondary data has been used from the published reports and datasets.
The following formulae were used:
Three Year Moving Average

$$Y_{t+1} = \frac{Y_t + Y_{t+1} + Y_{t+2}}{3}$$

Where Y_t is variable (area sown, production or yield)
And t is period, say, t = 0,1,2…..

Growth Rate
The moving averages have been used to estimate growth rates.

$$R_t = \frac{Y_1 - Y_0}{Y_0} * 100$$

Where R_t is the simple growth rate during two periods
Y_t -> Value of the variable of the time t.
Y_0 -> Value of the variable of the initial period

METHODOLOGY OF PROJECTION

Least Square Technique has been applied for the following linear model:
Y = a + b X
Where Y is foodgrains production
a is constant
b is regression of Y on X,
X is year (X=1 for 1994-95
          =2 for 1999-2000 & so on)

RESULTS AND DISCUSSIONS

Agriculture, with its allied sectors, is unquestionably the largest livelihood provider in India, more so in the vast rural areas. Sustainable agriculture, in terms of food security, rural employment, and environmentally sustainable technologies are essential for holistic rural development. Table -1 presents the major wheat producing countries in the world. It is seen from this table, that China is the highest producing country and has 17.5% share. India is the second highest country with 13.5% share followed by Russia with 9.7% share. Thus China, India and Russia together produce more than 40% wheat in the world.

Table 1: Major Wheat producing countries in the World

Country	Production M Tones	%age Share of the country	Cumulative %age Share
China	133.6	17.45	17.45
India	103.6	13.53	30.97
Russia	74.5	9.73	40.70
United States	52.3	6.83	47.53
France	40.6	5.30	52.83
Canada	32.3	4.22	57.05
Ukraine	28.4	3.71	60.76
Pakistan	24.4	3.19	63.95
Germany	23.1	3.02	66.96
Argentina	19.5	2.55	69.51
Others	233.5	30.49	100.00
TOTAL	765.8	100	

Major Wheat Producing Country
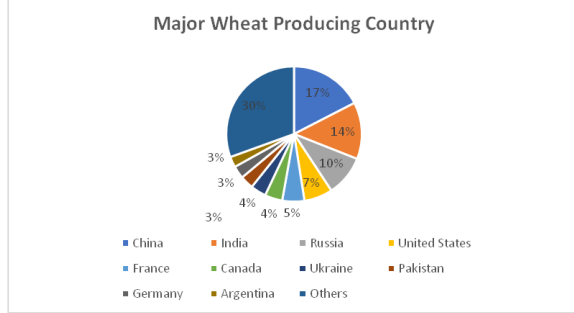
Table 2: Major Rice Producing countries in the World

Country	Production M Tones	%age Share of the country	Cumulative %age Share
China	211.4	27.98	27.98
India	177.6	23.51	51.49
Indonesia	54.6	7.23	58.72
Bangladesh	54.6	7.23	65.94
Vietnam	43.4	5.74	71.69
Thailand	28.3	3.75	75.43
Myanmar	26.3	3.48	78.91
Philippines	18	2.38	81.30
Pakistan	11.1	1.47	82.77
Brazil	10.4	1.38	84.14
Others	119.8	15.86	100.00
TOTAL	755.5	100.00	

Table -2 presents the major Rice producing countries in the world. It is seen from this table, that China is the highest producing country with 27.9% share followed by India with 23.5% share. China and India and Russia together produce more than 51% rice in the world.
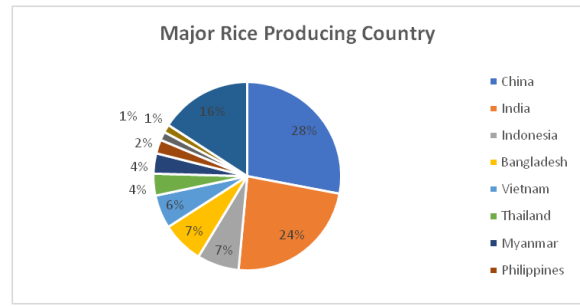

Major Rice Producing Country

Table -3 Three years moving average of area, production and yield of the Foodgrains

Year.	Area Sown M Hect	Growth rate per annum	Production M Tones	Growth rate per annum	Yield Kg/Hect	Growth rate per annum	Irrigated area %age
1959-60	115.39		78.61		681		18.85
1969-70	122.77	0.64	100.64	2.80	819	2.03	23.79
1979-80	126.96	0.34	123.73	2.29	974	1.89	29.6
1989-90	127.43	0.04	172.45	3.94	1353	3.89	34.83
1999-2000	123.11	-0.34	203.41	1.80	1652	2.21	43.88
2009-10	123.61	0.04	232.36	1.42	1879	1.37	48.12
2019-20	126.67	0.25	292.86	2.60	2312	2.30	52.16

Table-3 presents the three yearly moving averages of area sown, production and yield for foodgrains. Yield rates have been estimated using three year moving averages of area sown and production. It is observed that area sown has constantly increased from 115.39 M hectare in 1959-60 to 127.43 M hectare during 1989-90 and then there is declined in area in 1999-2000 (123.11 M hectare). The production has also increased from 78.11 M tones in 1959-60 to 292.86 in 2019-20. The productivity level has been 681 kg/ha during 1959-60 which has gone up to 2312 kg/ha during 2019-20. This table also shows annual growth rates during different periods. During 1959-

60 to 1969-70 the highest growth rate in area sown i.e. 0.645% was observed which was declining constantly up-to 199-2000. The production level has shown positive growth rates per annum during all the periods. The growth rate has been highest at the level

of 3.94 % per annum during 1979-80 to 1999-2000 and lowest i.e. 1.42% during 1999-2000 to 2009-10 In case of yield, the highest growth rate was observed during 1979-80 to 1989-90 (i.e. 3.89%) and lowest (1.37%) during 1999-2000 to 2009-10.

Table –4 Area, Production and Yield of Foodgrains (2018 – 2019)

	Area M Hect	%age of Total Area	Cumulative % Share Area	Production M Tones	%age of Total Production	Cumulative % Share Production	Yield Kg/ ha.
Uttar Pradesh	19.49	15.62	15.62	54.64	19.16	19.16	2803
Madhya Pradesh	16.35	13.10	28.72	32.21	11.29	30.45	1970
Punjab	6.77	5.43	34.15	31.53	11.06	41.51	4658
Rajasthan	14.81	11.87	46.02	21.29	7.46	48.97	1437
West Bengal	6.36	5.10	51.11	18.69	6.55	55.52	2938
Haryana	4.56	3.65	54.77	18.15	6.36	61.89	3981
Bihar	6.5	5.21	59.98	15.6	5.47	67.36	2402
Maharashtra	9.62	7.71	67.69	10.3	3.61	70.97	1071
Karnataka	7.66	6.14	73.83	10.89	3.82	74.79	1422
Andhra Pradesh	4.02	3.22	77.05	10.84	3.80	78.59	2694
Tamil Nadu	3.5	2.80	79.85	10.39	3.64	82.23	2972
Telangana	3.06	2.45	82.30	9.28	3.25	85.48	3035
Others	22.08	17.70	100.00	41.41	14.52	100.00	1875
ALL INDIA	124.78	100.00		285.21	100.00		2286

The state-wise analysis for Foodgrains is presented in Table-4. It is seen that the major states producing about 75% of the total foodgrains are Uttar Pradesh (19.1%), Madhya Pradesh (11.2%), Punjab (11%), Rajasthan (7.4%) , West Bengal (6.5%), Haryana (6.3%), Bihar (5.4%), Maharashtra (3.6%) and Karnataka (3.82%). The highest productivity has been observed of the order of 4658 kg per ha in Punjab followed by Haryana 3981 per ha, Telangana 3035 Kg per ha, Tamil Nadu 2972 kg per ha, West Bengal 2938 kg per ha, Uttar Pradesh 2803 kg per ha and and Andhra Pradesh 2694 kg per ha.
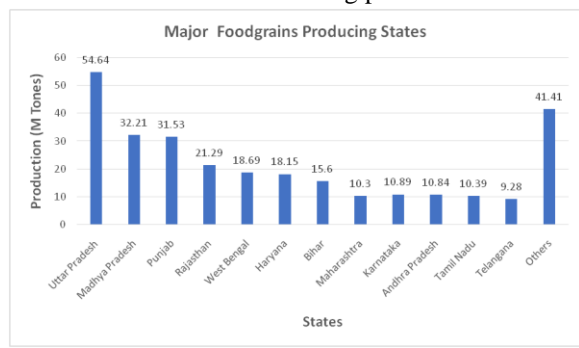
The following Table presents the projected area sown, production and yield for Foodgrains for 2024-25, 2029-30 and 2034-35. The least square model has been used for projection. It is seen that the estimated area will be 125.7 M hect in 2024-25,

126.4 M Hect in 2029-30 and 127.07 M hect in 2034-35. The production has been estimated of the order of 294.96 M Tones in 2024-25 and 333.37 M Tones in 2034-35. The projected yield will be 2343 kg/hect, 2487 kg/hect and 2630 kg/hect in 2024-25,2029-30 and 2034-35 respectively.

Table –5 Projected Area, Production and Yield for Foodgrains

	2024-25	2029-30	2034-35
Area M Hect	125.7	126.4	127.07
Production M Tones	294.96	314.17	333.37
Yield Kg/ hect.	2343	2487	2630

CONSTRAINTS

Even after over seven decades of planning since the independence, majority of the farmers are still facing problems of poor production and/or poor returns. Major constraints in Indian agriculture are:

- According to 2015-16 Agriculture Census, the total number of operational holdings was 146.45 million with average size of 1.08 hectares (ha). The highest percentage share in 2015-16 was observed in marginal category (68.5%) followed by small (17.6%), semi-medium (9.6%), medium (3.8%) and large category (0.6%).

- Farming for subsistence which makes scale of economy in question with majority of small holdings.
- Low-access of credit and prominent role of unorganised creditors affecting decisions of farmers in purchasing of inputs and selling of outputs
- Less use of technology, mechanisation and poor productivity for which first two points are of major concern
- Very less value addition as compared to developed countries and negligible primary-level processing at farmer's level.
- Poor infrastructure for farming making more dependence on weather, marketing and supply chain suitable for high value crops.

CONCLUDING NOTE

Future of agriculture is a very important question for the planners and all other stakeholders. Government and other organisations may address the key challenges of agriculture in India, including small holdings of farmers, primary and secondary processing, supply chain, infrastructure supporting the efficient use of resources and marketing, reducing intermediaries in the market. There is a need for work on cost-effective technologies with environmental protection and on conserving our natural resources. Reforms to land distribution, water management and food distribution systems will further enhance productivity and help India meet its growing demand for food.

REFERENCES

[1] Agricultural Statistics at a Glance (2020), Ministry of Agriculture &Farmers Welfare, Department of Agriculture, Cooperation & Farmers Welfare, Directorate of Economics & Statistics, Govt of India.

[2] Annual Report (2020-21), Ministry of Agriculture & Farmers Welfare, Department of Agriculture, Cooperation & Farmers Welfare, Govt of India.

[3] Department of Agriculture, Cooperation & Farmers Welfare, Government of India website, https://agricoop.nic.in

[4] All India Report on Agriculture Census 2015-16, Ministry of Agriculture &Farmers Welfare, Department of Agriculture, Cooperation & Farmers Welfare, Govt of India.

[5] S C Gupta, VK Kapoor - Fundamentals of Mathematical Statistics, Seventh Revised Edition, Sultan Chand & Sons (1980)

[6] C. H. Hanumantha Rao (1994) – "Agricultural growth, rural poverty and environmental degradation in India" – Oxford university press, New Delhi.

[7] Kishore Kumar & P C Agrawal (2004) – "Water Resource Management for sustainable agricultural production" – National conference on environment and challenges in central Himalaya, Srinagar (Garhwal), Nov. 2004.

[8] P C Agrawal & Kishore Kumar (2005) – "Technology & Environment impact on agricultural production"- International conference on environment and development – Challenges & Opportunities. Delhi University, Delhi (March – 2005)

[9] Agricultural situation in India, 2006, Directorate of Economics and Statistics, Ministry of Agriculture, Govt of India.

[10] Prabha Rani, PC Agrawal & Kishore Kumar (2010)- " Strategic role of Information Technology for Rural Prosperity in India", Journal of IPEM , Vol5 4, Issue No. 1, Jan – June 2010 pp 1-6

[11] H. Swain and R.R. Bhakur (2006) - "Trends and variability of some cereals, pulses and commercial crops in Rajasthan"

[12] Ramesh Chand and S.S. Raju(2007) "Risk in Indian Agriculture - A case study of six major crops".