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## GROWTH IN AGRICULTURAL RESOURCE USE: AN APPLICATION OF EXPONENTIAL GROWTH CURVE

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**Abstract:** Agriculture is the means of livelihood for around two thirds of the work force of India. Agriculture is the production, processing, marketing and use of foods, fibers and bye products from plant crops and animals. It was the key development that led to the rise of human civilization with the husbandry of domesticated animals plants creating food surpluses that enabled the development of more densely populated and stratified societies. At the time of independence, the revenue from the agriculture sector was quite low compared to what it is today. The main reason for the increase in the revenue is the increase in agricultural production that was brought about by the Green revolution, over the years, agriculture has emerged as one of the top priorities of the Central & state governments. In 2000, the government announced the first over “National Agriculture Policy”.

The resources taken were consumption of fertilizers, consumption of electricity in agricultural sector, short term and long term credit, number of tractors, area under high yielding varieties, net irrigated and gross irrigated area and total cropped area. It was computed using the exponential trend equation i.e.:

$$Y = ab^t$$

$$\text{Log } Y = \log a + t \log b$$

taking

$$\hat{b} = (1+r)$$

$$r = (b-1) \times 100$$

Where

$Y$  = study variable; area, production, yield or

Resource variables

$a$  = constant

^

$b$  = regression coefficient

$t$  = time,  $t = 1 \dots \dots \dots n$

$r$  = compound growth rate in percent

To test the significance of the compound growth rates,  $t$ -test applied was

$$t^* = r/S.E.(r)$$

Where  $t^*$  = calculated  $t$ -ratio, distributed with  $(n-2)$  degrees of freedom

$r$  = compound growth rate

S.E. ( $r$ ) = standard error of the compound growth rate, S.E. was calculated by fitting the following formula.

$$S.E. (r) = \frac{100xb}{\text{Log } 10^e} \sqrt{\frac{\Sigma (\log y)^2 - \frac{(\Sigma \log y)^2}{n} - (\log b)^2 \Sigma (t - \bar{t})^2}{(n-2) \Sigma (t - \bar{t})^2}}$$

Where the limit for  $\Sigma$  is,  $i = 1, 2, \dots, n$

**Keywords:** *Exponential Growth Curve*

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## I. Introduction

Agriculture is the production, processing, marketing and use of foods, fibers and bye products from plant crops and animals. It was the key development that led to the rise of human civilization with the husbandry of domesticated animals plants creating food surpluses that enabled the development of more densely populated and stratified societies. Agriculture encompasses a wide variety of specialties and techniques, including ways to expand the lands suitable for plant rising, by digging water channels and other forms of irrigation Cultivation of crops on arable land and the pastoral herding of livestock on rangeland remain at the foundation of agriculture. In the developed world, the range usually extends between sustainable agriculture and intensive farming.

Agriculture is the means of livelihood for around two thirds of the work force of India. This makes it one of the most important sectors of the economy. At the time of independence, the revenue from the agriculture sector was quite low compared to what it is today. The main reason for the increase in the revenue is the increase in agricultural production that was brought about by the Green revolution, over the years, agriculture has emerged as one of the top priorities of the Central & state governments. In 2000, the government announced the first over “National Agriculture Policy”.

In this context an efforts has been made to study the growth of Indian Agricultural especially by exponential growth curve. The specific objective of the current study is to study the growth in resource use.

## II. Technical Programme

The resources taken were consumption of fertilizers, consumption of electricity in agricultural sector, short term and long term credit, number of tractors, area under high yielding varieties, net irrigated and gross irrigated area and total cropped area. It was computed using the exponential trend equation i.e.:

	Y	=	ab <sup>t</sup>
taking	Log Y	=	log a + t log b
	^		
	b	=	(1+r)
	r	=	(b-1) x 100
	Where		
	Y	=	study variable; area, production, yield or Resource variables
	a	=	constant
	^		
	b	=	regression coefficient
	t	=	time, t = 1 .....n
	r	=	compound growth rate in percent

To test the significance of the compound growth rates, t-test applied was

$$t^* = r/S.E( r)$$

Where  $t^*$  = calculated t-ratio, distributed with (n-2) degrees of freedom

$r$  = compound growth rate

S.E. (r) = standard error of the compound growth rate, S.E. was calculated by fitting the following formula.

$$S.E. (r) = \frac{100xb}{\text{Log } 10^e} \sqrt{\frac{\sum (\log y)^2 - \frac{(\sum \log y)^2}{n} - (\log b)^2 \sum (t - \bar{t})^2}{(n-2) \sum (t - \bar{t})^2}}$$

Where the limit for  $\Sigma$  is,  $i = 1, 2, \dots, n$

### III. Result and Discussion

The resources taken were the number of tractors, electricity consumption in agricultural sector, fertilizer consumption of nutrients, long term and short term credit use, net irrigated area, net sown and total cropped area and area under high yielding varieties.

#### Fertilizer consumption

Among all the study states highest per hectare consumption of fertilizer was recorded in Punjab 175 kg followed by Haryana, Andhra Pradesh and Uttar Pradesh. The reason for highest consumption of fertilizer in this state's due to the cultivation of five cereals Rice and Wheat and due to high percentage of irrigated area to the cropped area. The least consuming state was found Rajasthan just consuming 36 kg per hectare followed by Madhya Pradesh due to less potential of irrigation. The overall consumption for India's average was 89 kg. The highest growth rate in the consumption of fertilizer was recorded in Madhya Pradesh where consumption grew at the rates of 11.05 percent per annum followed by Rajasthan 9.67 percent, Bihar 7.65 percent and Maharashtra 7.40 percent per annum. The growth rate for India as whole turns out to be 2.99 percent per annum. Among all the study states the growth in consumption of fertilizer in Punjab was low just 1.75 percent to all India average level because Punjab had already high consuming of fertilizer state in 1980-81, as compare to other states.

#### Electricity consumption

The highest electricity consumption per thousand to net sown area was recorded in Punjab 1486 KWH followed by Haryana 1088 and Karnataka 1004. The reason for high electricity consumption was due to the advancement in technology on high use of machines in cultivation procedure. The least electricity consuming state was Bihar 224 KWH followed by West Bengal 283 KWH. and Rajasthan 314 KWH. The reason may be less mechanization of agriculture in these states. The overall consumption India as a whole was 517 KWH per hectare.

The highest growth in consumption of electricity was recorded in West Bengal. Where it grew at the rate of 21.12 percent per annum followed by Madhya Pradesh 17.40 percent and Karnataka 13.22 percent per annum. The least growth was observed in Bihar where electricity consumption grew at the rate of 6.15 percent per annum, followed by Haryana 7.06 percent and Punjab 7.31 percent per annum. The consumption level of electricity in Punjab and Haryana states were already very high in 1980-81 as compare to other study states in 2014-15. The reason for this may be due to the high mechanization and advancement of the technology in both study states. The overall growth for India as a whole was very low. It was just 5.27 percent per annum. Which is below than all study states?

#### Credit Use

The highest consumption of short term agricultural credit was found in Haryana. It was 450 crores per thousand net sown area in 2014-15 followed by Punjab 393 crores for the same year least consumption of credit was seen in Bihar just 6.13 crore rupees per thousand net sown area in 2014-15 followed by West Bengal 40 crores. All India level the average consumption of short term credit was 94.35 crore. Even the consumption of credit in Uttar Pradesh, Madhya Pradesh, Bihar, West Bengal, Rajasthan and Karnataka was below the all India average consumption. Highest growth in short term credit was found in Haryana. Where the use grew at the rate of 15.90 percent per annum followed by Maharashtra 15.77 percent, Andhra Pradesh 15.25 percent and Madhya Pradesh 14.96 percent per year. Least growth was found in Bihar just 8.24 percent per annum, which is below than the All India average level 9.07 percent per annum.

Long term expansion of credit was found in Punjab 77.14 crore per thousand net sown area in 2014-15 followed by Haryana 60 crore for the same period. The high consumption of long term credit by both these states due to high mechanization of agricultural in these states. The least long term credit expansion was seen in Madhya Pradesh 4.39 crores followed by Bihar 5.04 crore and West Bengal 6.95 crore for the year 2014-15. Among the study states the long term credit expansion in Madhya Pradesh, Maharashtra, Bihar, West Bengal, Rajasthan, and Karnataka was below the all India average level say the tune of 17.26 crore per thousand net sown area in 2014-15. The highest growth in the use of long term credit was recorded in Andhra Pradesh. Where it grew at the rate of 16.60 percent per annum followed by Punjab 12.81 percent, Rajasthan 11.88 percent, and Haryana 11.76 percent per annum. Least growth was recorded in Bihar just 5.19 percent per annum. The West Bengal recorded Negative growth in long term credit expansion. Where it declined at the rate of 0.34 percent per annum. Highest expansion of long term credit is the indicator of improvement of technology as well as the mechanization of agriculture on improvement in the soil fertility level.

#### **Area under H.Y.V.**

The highest area under high yielding variety to total cropped area was seen in Punjab 822 hac followed by Bihar 710 hac in 2014-15. The less area under H.Y.V. was found in Rajasthan 179hec, followed by Madhya Pradesh 367 hac. At India level the area under high yielding variety was 415 hact. to total cropped area.

The highest growth in the expansion of area under H.Y.V. was recorded in Bihar, where it grew at the rate of 4.72 percent per annum followed by Karnataka 4.70 percent, Uttar Pradesh 4.22 percent per annum. The least growth was recorded in Punjab just 0.92 percent per annum followed by Andhra Pradesh 1.11 percent and Rajasthan 1.89 percent per annum. The less growth in the expansion of area under H.Y.V. in Punjab was due to that it had already highest area under H.Y.V. in 1980-81 as compare to the other study states in 2014-15. The C.G.R. of area expansion for all India was 2.95 percent per annum.

#### **Tractors**

The highest number of tractors to per thousand net sown area was found in Haryana 573 ns. Followed by Punjab 381 ns and Uttar Pradesh 206 ns. The highest number of tractor are in these states indicate the highly mechanization of Agriculture in these states. The less number of tractors was recorded in West Bengal just 32 ns followed by Andhra Pradesh 53 ns. Among the study states. The number of tractors in Madhya Pradesh, Maharashtra, Bihar, West Bengal, Andhra Pradesh, Rajasthan and Karnataka were below the all India average fig 123 ns. The highest growth in the number of tractors was recorded in West Bengal where it grew at the rate of 13.90 percent followed by Bihar 11.37 percent and Madhya Pradesh 14.13 percent per annum. The least growth was recorded in Punjab just 3.20 percent per annum, followed by Karnataka 4.60 percent per annum. At India level the C.G.R. was found 3.15 percent per annum.

#### **Net irrigated area:**

The highest net irrigated area to net sown area was observed in Punjab it was 955 ha followed by Haryana 755 ha and Uttar Pradesh 763 hac. This shows the highest irrigated area under these states. The less irrigated area was found in Maharashtra 143 ha, followed by Karnataka 219 ha, and Madhya Pradesh 324 ha. Whereas all India net irrigated area to net sown area turned out 390 ha. Which shows that 61 percent area of India is unirrigated? The highest growth under net irrigated area was recorded in Madhya Pradesh where it grew at the rate of 5.67 percent per annum followed by Rajasthan 2.99 percent, and Karnataka 2.66 percent per annum. Among the study states Andhra Pradesh recorded the marginally increment just 0.003 percent per annum followed by Punjab 0.62 percent and West Bengal 0.63 percent per annum. For India level the growth in net irrigated area was 1.25 percent per annum.

#### **Gross irrigated area**

The highest gross irrigated area to gross cropped area was recorded in Punjab 924 ha, followed by Haryana 792 ha, and Uttar Pradesh 688 ha. Which shows that these states have high potential of irrigation facilities? The least gross irrigated area was recorded in Maharashtra 146 ha, followed by Karnataka 240 ha in 2014-15. The gross irrigated area for India was 401.71 ha which is higher among the study states

like Madhya Pradesh, Maharashtra, West Bengal, Andhra Pradesh, Rajasthan and Karnataka. The highest growth in gross irrigated area was recorded in Madhya Pradesh where it grew at the rate of 5.32 percent per annum followed by Bihar 3.01 percent, Rajasthan 2.88 percent and Karnataka 2.72 percent per annum. The least growth was recorded in Punjab where it grew marginally 0.15 percent per annum. In absolute term the gross irrigated area of Punjab remained concentrated near about 920 to 950 ha. From the study period 1980-81 to 2014-15. The C.G.R. for India as a whole was found 1.24 percent per annum.

### Net Sown Area

Net sown area depends upon the total geographical area of the particular state. With the present scenario it is very hard for any state to increase the net sown area because of population explosion on industries expansion. Among the study states the highest net sown area was in Madhya Pradesh 19794000 hect. Followed by Maharashtra 18216 thousand ha, Uttar Pradesh 17474 thousand ha and Rajasthan 17000 thousand ha. The least net sown area was found in Haryana 3700 thousand hect, followed by Punjab 4200 thousand ha, and West Bengal 5463 thousand hac. The Net sown area for India as a whole is 143076 thousand hect, for the year 2014-15.

The highest growth in Net sown area was recorded in Andhra Pradesh where it grew at the rate of 1.11 percent per annum followed by Rajasthan 0.73 percent and Karnataka 0.63 percent per annum. The least growth was recorded in West Bengal 0.004 percent, Uttar Pradesh 0.07 percent, and Maharashtra 0.08 percent and in Haryana 0.098 percent per annum. The negative growth was recorded in Bihar. For India as a whole there was non-significant growth observed.

### Total cropped area

The contribution of any states toward the growth of agriculture or the proportion of agriculture in growth also depends upon the total cropped area. The highest total cropped area was found in Uttar Pradesh. It was 26129 thousand hectare in 2014-15, followed by Madhya Pradesh 25341 thousand hectare and Maharashtra 21950 thousand hect in 2014-15. The less cropped area was found in Haryana 6200 thousand hect, followed by Punjab 7900 thousand hect in 2014-15. The total cropped area depends upon the total area of particular state. The highest growth in total cropped area was observed in Rajasthan where it grew at the rate of 1.29 percent per annum, followed by West Bengal 1.23 percent and Punjab 1.06 percent per annum for the study period. The least growth was observed in Uttar Pradesh. Where as the Bihar states recorded the negative growth in total cropped area where it declined at the rate of 0.06 percent per annum. The over all growth of total cropped area for whole India was 0.53 percent per annum.

**TABLE NO. 1 LEVEL OF RESOURCE USE FROM 1980-81 TO 2014-15 AND THEIR GROWTH IN THE SELECTED FOOD GRAIN PRODUCING STATES OF INDIA**

AGRICULTURAL DEVELOPMENT INDICATORS PER THOUSAND TO NET SOWN HECTARE															
States	No. of Tractors			Net irrigated area			Gross irrigated area			Net sown area (000 hectares)			Total cropped area (000 hectares)		
	1980-81	2014-15	C.G.R.	1980-81	2014-15	C.G.R.	1980-81	2014-15	C.G.R.	1980-81	2014-15	C.G.R.	1980-81	2014-15	C.G.R.
<b>Andhra Pradesh</b>	17	53	6.25*	317	334	0.003 NS	282	342	0.30*	11325	12891	1.11*	13047	14000	0.67 NS
<b>Bihar</b>	17	106	11.37**	305	509	1.84**	337	464	3.01*	7861	7337	-0.26*	10628	10141	-0.06 <sup>N</sup> <sub>s</sub>
<b>Haryana</b>	150	573	7.92*	605	755	1.30**	593	792	1.49*	3660	3700	0.098 NS	5826	6200	0.63*
<b>Karnatak a</b>	30	74	4.60*	141	219	2.66**	160	240	2.72*	10391	11000	0.63**	11228	12555	0.83*
<b>Madhya Pradesh</b>	12	35	11.13**	137	324	5.67**	129	266	5.32*	18841	19794	0.30**	21756	25341	0.96*
<b>Maharash</b>	25	83	7.12	106	143	2.19**	119	146	1.60*	1813	1821	0.08N	2000	2195	0.67*

tra									*	0	6	S	8	0	*
<b>Punjab</b>	233	381	3.20* *	833	955	0.62**	928	924	0.15*	4210	4200	0.18N S	6229	7900	1.06* *
<b>Rajasthan</b>	31	115	7.15* *	205	336	2.99**	200	322	2.88* *	1577 7	1700 0	0.73*	1859 6	2169 3	1.29* *
<b>Uttar Pradesh</b>	74.0 8	206	6.66* *	56.8 5	763	1.69**	541	688	1.75* *	1723 8	1747 5	0.07*	2477 3	2612 9	0.31* *
<b>West Bengal</b>	3	32	13.90 **	321	350	0.63**	258	274	0.85* *	5565	5463	0.004 NS	7393	9059	1.23* *
<b>All India</b>	46	123	3.15* *	285	390	1.25*	290	401. 71	1.24*	1419 28	1430 76	0.12N S	1767 50	1889 15	0.53* *

Note : \*, \*\* Significant at 5% and 1% level of significance

**TABLE NO .2 LEVEL OF RESOURCE USE FROM 1980-81 TO 2014-15 AND THEIR GROWTH IN THE SELECTED FOOD GRAIN PRODUCING STATES OF INDIA**

AGRICULTURAL DEVELOPMENT INDICATORS PER THOUSAND TO NET SOWN HECTARE															
STATES	Fertilizer consumption (tons nutrients)			Electricity consumption(MWH)			Short Term Credit (0000 Rs.)			Long term credit (0000 Rs.)			Area under H.Y.V. (hectares)		
	1980-81	2014-15	C.G.R.	1980-81	2014-15	C.G.R.	1980-81	2014-15	C.G.R.	1980-81	2014-15	C.G.R.	1980-81	2014-15	C.G.R.
<b>Andhra Pradesh</b>	50	135	5.96**	116	863	12.66* *	12.3 6	98.5 1	15.25* *	4.00	28	16.60* *	282	421	1.11* *
<b>Bihar</b>	19	95	7.65**	83	224	6.15**	2.16	6.13	8.24*	1.78	5.04	5.19*	320	710	4.72* *
<b>Hayarana</b>	43	136	7.01**	382	1088	7.06**	41	450	15.90* *	11.4 7	60	11.76* *	372	546	2.34* *
<b>Karnataka</b>	34	100	5.82**	142	1004	13.22* *	13.4 7	73	14.01* *	5.77	10	6.03**	170	375	4.70* *
<b>Madhya Pradesh</b>	11	49	11.05* *	24	417	17.40* *	6.36	46.8 3	14.96* *	1.32	4.39	8.66**	191	367	3.32* *
<b>Maharashtra</b>	26	75	7.40**	113	549	11.15* *	9.37	103	15.77* *	3.30	11.3 0	7.26**	277	397	2.10* *
<b>Punjab</b>	131	175	1.75**	475	1486	7.31**	51	393	13.74* *	10.6 8	77.1 4	12.81* *	676	822	0.92* *
<b>Rajasthan</b>	7	36	9.67**	55	314	11.05* *	5.77	51.2 9	13.02* *	2.24	12	11.88* *	119	179	1.89* *
<b>Uttar Pradesh</b>	51	121	5.07**	174	560	7.90**	9.28	55.3 9	12.95* *	5.22	33.4 7	9.50**	332	642	4.22* *
<b>West Bengal</b>	35	106	6.55**	16	283	21.12* *	6.64	40	11.01* *	6.28	6.95	- 0.34NS	337	497	2.30* *
<b>All India</b>	34	98	2.99**	107	517	5.27*	10.8 4	94.3 5	9.07**	4.57	17.2 6	4.16*	263	415	2.95* *

Note : \*, \*\* Significant at 5% and 1% level of significance

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