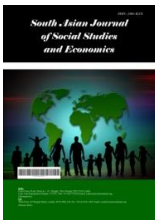

South Asian Journal of Social Studies and Economics

6(2): 17-34, 2020; Article no.SAJSSE.55683
ISSN: 2581-821X

Agriculture Development in India: A State Level Analysis

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/SAJSSE/2020/v6i230162
Editor(s):
(1) Dr. Silvius Stanciu, "Dunarea de Jos" University of Galati, Romania.
(2) Dr. John M. Polimeni, Albany College of Pharmacy and Health Sciences, USA.
Reviewers:
(1) Ismail Olawale, Ahmadu Bello University, Zaria, Nigeria.
(2) Romer C. Castillo, Batangas State University, Philippines.
Complete Peer review History: http://www.sdiarticle4.com/review-history/55683

Original Research Article

Received 02 February 2020
Accepted 08 April 2020
Published 13 April 2020

ABSTRACT

Agriculture plays vital role in the process of economic development of less developed countries like, India. Besides providing food for the nation, agriculture absorbs labor, provides saving, contributes to the market of industrial goods and earn overseas exchange. The present study attempted to examine the performance of Indian agriculture during post green revolution period and economic reform period. A semi-log model was used to calculate compound annual growth rate of major food and non-food crops. Descriptive statistics were used to examine the land use pattern change and cropping pattern change. Fertilizer use ratio was calculated to examine the judicious use of chemical fertilizers. Study findings reveal that though, green revolution moved out from the food crisis arisen in the early sixties in some extent, but it also brought regional disparities in the resources use, productivity and cropping pattern. Promotional price policy for some cash crops leads to scarcity in others. Change in an environmental factors, along with economic and technological factors are increasing degree of the vulnerability in farm profits in particular and the livelihood of farmers in general. The present study suggested following policy implications. First, there is need of ultramodern technology that provides up-to-date weather information. Second, government should promote home-made bio-fertilizers and organic farm practices. Third, an intensive survey should be carrying out to understand the farm requirement of marginal farmers and based on the feedback mechanism, technology would be develop. Fourth, private investors should be invited to develop a food chain

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mechanism to procure the food items at the time of harvesting and release in the off-cropping season for price stability. Lastly, India needs land reforms, in which, land consolidation and identification of real farmers should be given first priority.

Keywords: Regional imbalances; CAGR; agriculture development; cropping pattern change; fertilizers consumption.

1. INTRODUCTION

Agriculture plays vital role in the process of economic development of less developed countries like, India. Besides providing food for the nation, agriculture absorbs labor, provides saving, contributes to the market of industrial goods and earn overseas exchange [1]. In India, agriculture has the main source of national income and occupation since independence [2]. During the first decade of independence, agriculture and allied activities contributed about 51.81 percent to India's national income and around 73 percent of the total working population were engaged in agriculture and allied sector. However, the share of agriculture to national income substantially has declined from 51.81 percent in 1951 to 18.20 percent in 2013-14 [2]. In spite of this, agriculture still has prominently playing vital role in the India's economic growth. Agriculture provides row materials for industrial sector and creates employment opportunities in the ever-growing service sector.

Since independence, Indian agriculture has been significantly progressing; it grew at the rate of one percent per annum for sixty years during pre-independence era 1860-1920. Further, it springs up at the rate of about 2.6 percent per annum in the post- independence era 1951-56 [1]. An increase in total cropped area was the main source of agriculture growth from fifties to eighties [2]. During mid-eighties, a structural change in the production was observed. Area was moderately declined, while per hectare production was increased substantially due to technological transformation. Apart from technological transformation, land reforms, an introduction of agricultural price commission with the objective to ensure remunerative prices to producers, new agricultural strategies, viz., introduction of hybrid seeds, chemical fertilizers, new cultivation & harvesting tools, improved irrigation facilities, agriculture credit & insurance, investment in research and extension services and improvement of rural infrastructure were taking place.

All these developments in Indian agriculture are contributed by a series of actions taken by the Indian government during mid-sixties. However, things are not always gone in the right direction. The dark side of agricultural development is that, it has increased disparity among the operational land holders, increases water scarcity & depletion, and increases water logging & salinity. The agricultural investment statistics also show deceleration trends in economic reform period during 1999-2012. Furthermore, natural calamities, higher interest rates, an increase in the wage rates, increase in prices of fertilizers, seeds & pesticides and lower minimum support price have increased degree of vulnerability in marginal and small farmers (i.e., about 86 percent).

With these evidences, the present study aimed to answer the following questions; (i) how a change in total cropped area and total net irrigated area has contributed into nation's food security, (ii) how land use pattern provided opportunities to increase agricultural production, (iii) how Green Revolution disproportionately affected the production of main food and non-food crops, (iv) Is an Indian agriculture sustainable occupation for marginal and small farmers, (v) Are Indian farmers judiciously using chemical fertilizers and (vi) how climatic factors are influencing the agriculture production and are responsible for agriculture production variability and creating seasonal food insecurity).

2. MATERIALS AND METHODS

2.1 Semi-log Model

The present study estimated the growth rate of food grains and non-food grains at national level and net sown area, gross sown area, consumption of fertilizers, number of tractors during post- Green Revolution period (PGRP) of 1966-90 and Economic Reform Period (ERP) 1991-2012 at the national and state level by using semi-log quadratic regression model, as follows.

$$Y_t = Y_0(1 + r)^t \quad (1)$$

Where r is the compound (i.e., over time) rate of growth of Y. taking the natural logarithm of equation 1, we can write

$$\ln Y_t = \log Y_0 + t \ln(1 + r) \quad (2)$$

Now letting

$$B_1 = \ln Y_0 \quad (3)$$

$$B_2 = \ln(1 + r) \quad (4)$$

We can write equation (2) as

$$\ln Y_t = \beta_1 + \beta_2 T \quad (5)$$

Adding this disturbance term to equation (5), we obtain

$$\ln Y_t = \beta_1 + \beta_2 T + U_t \quad (6)$$

Model looks like, equation 6 is called semi-log model because only one variable (in the case of regressand) appears in the logarithmic form Gujarati [3].

3. RESULTS AND DISCUSSION

3.1 Land Use Pattern Change

Table 1 shows the trends of land use pattern change in India over a post-Green Revolution period. The present study has calculated the percentage change in area to total reporting area under the eight sub-categories of land use classification, viz., forest area, area not available for cultivation, permanent posture and grazing land, land under miscellaneous, culturable waste land, fellow land, current fellow and net sown area for the periods, viz., 1966-70, 1971-80, 1981-90, 1991-2000 and 2001-12. The results show that forest cover marginally increased about two percent during 1966-2012 at the cost of area not available for cultivation, permanent pasture and grazing land, land under miscellaneous and culturable waste. Further, net sown area is relatively associated with agricultural practices, shows marginally increased by about 1.22 percent during 1966-2012 respectively. Furthermore, an area more than once shows positive outcome of Green Revolution. Table 1 also indicates that area more than once use for cultivation increased about two percent during 1966-1990 and continuous increased by about six percent during 1991-2012.

3.2 CAGR of NSA, GSA, NIA and GIA: A State-level Analysis

It is noted that after policy reforms in agriculture (Green Revolution), total cropped area was increased at the national-level. The estimated compound annual growth rate (CAGR) shows that gross sown area (GSA) has marginally increased about 0.24 percent annually during 1991-2012 (Table 2). Nevertheless, net sown area (NSA) has declined by about 0.09 percent during the same period. CAGR of irrigation sources (both surface and ground water) net irrigated area (NIA) and gross irrigated area (GIA) show a marginal increased by about 1.26 and 1.55 percent during 1991-2012 at national-level. Disparity in CAGR of NSA, GSA, NIA and GIA has observed at the state level. Among the states, NSA has increased in Gujarat by 0.39 percent during 1991-2012. On the other hand, states like, Bihar, Himachal Pradesh, Karnataka, Kerala, Maharashtra, Orissa, Tamil Nadu, Uttar Pradesh, Madhya Pradesh and West Bengal NSA has declined by about 2.35, 0.38, 0.16, 0.47, 0.25, 11.50, 0.89, 0.30, 1.96 and 0.26 percent. However, GSA shows lower declined trends in CAGR. It has declined in the Bihar, Himachal Pradesh, Kerala, Orissa, Tamil Nadu and Madhya Pradesh by about 2, 0.18, 0.58, 1.62, 1.20 and 1.18 percent in one hand and on the other hand, it has increased in Gujarat, Haryana, Jammu and Kashmir, Karnataka, Maharashtra, Punjab, Rajasthan and West Bengal by about 0.53, 0.62, 0.34, 0.28, 0.43, 0.23, 0.23 and 0.55 percent during respectively. The regional disparities have also observed in NIA and GIA at state level. Bihar is only the state, which shows a decline in a CAGR of NIA. In Bihar, NIA was declined by about 0.41 percent. On the other hand, remaining states NIA show increased in CAGR during the same period. It has increased in Gujarat, Haryana, Karnataka, Kerala, Maharashtra, Punjab, Rajasthan, Uttar Pradesh, Madhya Pradesh and West Bengal by about 2.55, 0.69, 2.22, 1.04, 1.17, 0.34, 1.99, 1.07, 1.43 and 2.83 percent during. Moreover, the CAGR of GIA also shows regional variations. GIA was increased in Andhra Pradesh, Bihar, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Karnataka, Kerala, Maharashtra, Punjab, Rajasthan, Uttar Pradesh, Madhya Pradesh and West Bengal by about 0.96, 0.35, 2.94, 1.39, 0.46, 0.40, 1.99, 1.84, 0.43, 2.17, 1.22, 1.42 and 4.63 percent.

Possibly there are three main reasons responsible for the positive CAGR of GSA. First, increase in NIA and GIA due to agricultural subsidy in irrigation. State governments of Uttar Pradesh, Punjab, Haryana, Karnataka, Maharashtra and Madhya Pradesh had provided free cost of surface water through canal irrigation.

Table 1. Trends in land use pattern in India

Period	1966-70	1971-80	1981-90	1966-90	1991-00	2001-12	1999-2012
Forest	20.82	21.72	22.01	21.52	22.51	22.86	22.69
Area Not Available for Cultivation	15.57	13.63	13.32	14.17	13.40	13.89	13.65
Permanent Posture & Grazing land	4.51	4.15	3.88	4.18	3.62	4.43	3.52
Land under Misc.	1.34	1.29	1.18	1.27	1.22	1.12	1.17
Culturable Waste Land	5.35	5.68	5.19	5.41	4.69	4.36	4.52
Fellow land	3.01	3.01	3.26	3.09	3.27	3.34	3.31
Current Fellow	4.26	4.42	4.98	4.55	4.60	4.97	4.79
Net Sown Area	45.14	46.12	46.17	45.81	46.70	46.03	46.36
More than once	7.13	9.19	11.89	9.40	14.82	16.34	15.58

Source: Source: Ministry of Agriculture and Farmers Welfare, Government of India, [4]. Note: values are percentage

Table 2. Compound annual growth of NSA, GSA, NIA and GIA during 1991-2012

State	Net sown area	Gross sown area	Net irrigated area	Gross irrigated area
Andhra Pradesh	-0.08^{NS}	0.15^{NS}	0.48^{NS}	0.96*
	(-0.56)	(0.86)	(1.63)	(2.73)
Bihar	-2.35*	-2.00*	-0.41**	0.35**
	(-9.12)	(-8.68)	(-2.10)	(2.13)
Gujarat	0.39*	0.53*	2.55*	2.94*
	(6.01)	(4.03)	(11.41)	(11.06)
Haryana	0.003^{NS}	0.62*	0.69*	1.39*
	(0.08)	(8.38)	(8.10)	(16.45)
Himachal	-0.38*	-0.18*	0.35^{NS}	0.46*
Pradesh	(-13.15)	(-5.40)	(1.63)	(8.03)
Jammu &	0.04^{NS}	0.0034*	-0.02^{NS}	0.40*
Kashmir	(1.47)	(8.35)	(-0.15)	(6.41)
Karnataka	-0.16***	0.28**	2.22*	1.99*
	(-1.78)	(2.15)	(11.06)	(7.24)
Kerala	-0.47*	-0.58*	1.04*	0.69*
	(-9.56)	(-5.65)	(10.24)	(2.83)
Maharashtra	-0.25*	0.43*	1.17*	1.84*
	(-7.37)	(6.15)	(5.42)	(11.50)
Orissa	-11.5*	-1.62*	-0.63^{NS}	-0.22^{NS}
	(-7.37)	(-3.50)	(-0.86)	(-0.30)
Punjab	-0.03^{NS}	0.23*	0.34**	0.43*
	(-1.11)	(5.33)	(2.41)	(8.37)
Rajasthan	0.24^{NS}	0.84**	1.99*	2.17*
	(0.65)	(1.97)	(6.35)	(6.64)
Tamil Nadu	-0.89*	-1.20*	0.30^{NS}	-0.18^{NS}
	(-5.62)	(-5.98)	(0.92)	(-0.51)
Uttar Pradesh	-0.30*	-0.07^{NS}	1.07*	1.22*
	(-6.27)	(-1.31)	(10.63)	(12.42)
Madhya Pradesh	-1.96*	-1.18*	1.43*	1.42*
	(-6.76)	(-3.17)	(2.77)	(2.68)
West Bengal	-0.26*	0.55*	2.83*	4.63*
	(-4.29)	(4.78)	(5.96)	(6.11)
India	-0.09***	0.24*	1.26*	1.55*
	(-1.75)	(3.05)	(13.55)	(12.93

*Source: Source: Ministry of Agriculture and Farmers Welfare, Government of India, [4], Note Parenthesis value are t-statistics, *, ** & *** indicates one, five & ten percent level of significance and NS indicates non- significant*

Second, increase in rural electrification, promoted to use ground water with subsidized electricity or very nominal charges in the absence of strict environmental law. Lastly, price support policy for high irrigational crops like, wheat, rice and sugarcane had motivated to the farmers, especially small and marginal farmers to grow these crops [5].

3.3 Cropping Pattern Change

Table 3 depicts land use pattern change. It was observed that policy maker had diverted the resources in favor of main food crops (wheat and rice) and non-food crop (sugarcane) to insure food security in India. During 1966-70, the food grain and non-food grain crops shared the total cropped area by about 81.52 and 18.48 percent, while it has been changed during 2001-2012 by about 75.21 and 24.79 percent (Table 3). It is shifted in favor of non-food grain crops. Regional disparities in the expansion of total cropped area under food grain and non-food crops also observed. The total cropped area under food grain crops has increased substantially in the states viz., Bihar, Orissa, Punjab, Rajasthan, Uttar Pradesh and West Bengal by about 3.33, 3.98, 2.20, 0.82, 1.06 and 0.36 percent during 1966-2012, whereas it has marginally increased in Haryana, Jammu & Kashmir and Karnataka by about 0.55, 0.14 and 0.7 percent (Table 4). On the other hand, it has declined substantially in Andhra Pradesh, Gujarat, Madhya Pradesh and Tamil Nadu by about 1.86, 0.82, 3.93 and 1.58 percent, while, it has marginally declined in Kerala and Maharashtra by about 0.40 and 0.73 percent during the same period.

Similarly, the total cropped area under non-food grain crops substantially has increased in Madhya Pradesh, Rajasthan, West Bengal and Andhra Pradesh by about 7.83, 6.11, 6.26, 6.26 and 0.98 percent, while it has marginally increased in Haryana, Himachal Pradesh, Jammu and Kashmir, Kerala and Maharashtra by about 0.85, 0.27, 0.65 and 0.09 percent during 1966-2012 (Table 5). On the other hand, it has substantially declined in Uttar Pradesh, Tamil Nadu, Punjab and Karnataka by about 15.54, 3.61, 2.36 and 1.87 percent. Further, it has marginally declined in Bihar, Gujarat and Orissa by about 0.96, 0.99 and 0.52 percent.

Moreover, rapid shift in the cropping pattern in favor of food grain crops during 1966 to till mid-eighties has observed. After that, shift in the cropping pattern in favor of non-food grain crops observed up to 2012 (Table 3). State level disparities in the shift of food to non-food crops and non-food to food crops have reflection of national-level. There are four major reasons for these disparities at national as well as state-level. First, farmers have adopted new agricultural technology, such as hybrid seeds, chemical fertilizers and mechanical tools etc. disproportionately. Second, farmers have lower and disproportionate access of irrigation. Since the starting years of Green Revolution, coverage of irrigation has increased the cropped area of irrigation intensive crops such as rice, wheat and sugarcane, while area under less irrigation intensive crops substantially declined during post-Green Revolution period. Third, average land size in the states like, Uttar Pradesh, Haryana, Punjab, Madhya Pradesh, Karnataka and Rajasthan has a higher average land size compare to national level and farmers belonging to these states substantially contributed in the national food stock. Lastly, agricultural subsidy has decisive role in the agriculture production. So-called high yield producing states also have received higher share of the agricultural subsidy during post-Green Revolution period.

3.4 Performance of India Agriculture

The performance of Indian agriculture has been broadly categorized into three periods, viz., pre-Green Revolution during 1951-65, post-Green Revolution during 1966-90 and Economic Reform Period during 1991 to 2012. The present study estimates the growth pattern of area and production in two periods, viz., post-Green Revolution Period (PGRP) and Economic Reform Period (ERP) by using state as well as national-level data.[1] CAGR of food grain and non-food grain crops has increased by about 0.60 and 0.95 percent during PGRP (Table 6). CARG of major food grain crops, viz., rice and wheat shows that it has increased by 0.61 and 2.06 percent annually. Further, the CAGR of area of major non-food grain crops viz., sugarcane and total oilseeds has increased by 1.61 and 1.40 percent annually. However, the CAGR of area under cotton crop has declined by 0.27 percent annually.

During ERP, CAGR of area under food and non-food grain crops shows a marginal decline by 0.44 and 0.61 percent annually. CAGR of food

[1] *Due to non- availability of state level data of most of food grain and non-food grain crops during 1951-65, the present study restricted during 1966 to 2012 period.*

grain crops show a marginal increase in area under wheat sugarcane, total oilseeds and cottons by 0.83, 1.32, 0.22 and 1.52 percent.

Table 3. Shift in cropped area from food to non-food crops

Decade	Food grains	Non-food grains	Total
1966-70	120177 (81.52)	27244 (18.48)	147421 (100.00)
1971-80	124814 (81.53)	28274 (18.47)	153089 (100.00)
1981-90	131573 (80.86)	31143 (19.14)	162717 (100.00)
1991-00	130615 (77.09)	38820 (22.91)	169434 (100.00)
2001-12	122182 (75.21)	40272 (24.79)	162454 (100.00)

Source: Ministry of Agriculture and Farmers Welfare, Government of India, [4]. Note: values are in '000' hectares, while parenthesis values are in percentage

Table 4. Selected state wise total cropped area under food grains

State	1966-70	1971-80	1981-90	1990-2000	2001-12
Andhra Pradesh	9233	9223	8752	7807	7112
	(7.68)	(7.39)	(6.65)	(5.98)	(5.82)
Bihar	9597	9922	9741	9404	13827
	(7.99)	(7.95)	(7.40)	(7.20)	(11.32)
Gujarat	4879	6783	7609	4229	3961
	(4.06)	(5.43)	(5.78)	(3.24)	(3.24)
Haryana	3657	3995	3982	4068	4392
	(3.04)	(3.20)	(3.03)	(3.11)	(3.59)
Himachal Pradesh	791	820	876	858	806
	(0.66)	(0.66)	(0.67)	(0.66)	(0.66)
Jammu & Kashmir	776	806	875	907	908
	(0.65)	(0.65)	(0.67)	(0.69)	(0.74)
Karnataka	7334	6974	7296	7633	7535
	(6.10)	(5.59)	(5.55)	(5.84)	(6.17)
Kerala	908	902	742	509	280
	(0.76)	(0.72)	(0.56)	(0.39)	(0.23)
Madhya Pradesh	16114	17227	18643	18848	12064
	(13.41)	(13.80)	(14.17)	(14.43)	(9.87)
Maharashtra	13205	13361	14776	14566	12535
	(10.99)	(10.70)	(11.23)	(11.15)	(10.26)
Orissa	5412	6203	7422	6389	10358
	(4.50)	(4.97)	(5.64)	(4.89)	(8.48)
Punjab	3594	4268	5288	5888	6344
	(2.99)	(3.42)	(4.02)	(4.51)	(5.19)
Rajasthan	11601	12393	12795	13570	12793
	(9.65)	(9.93)	(9.72)	(10.39)	(10.47)
Tamil Nadu	5023	5076	4540	4023	3176
	(4.18)	(4.07)	(3.45)	(3.08)	(2.60)
Uttar Pradesh	19154	19306	20819	21210	20763
	(15.94)	(15.47)	(15.82)	(16.24)	(16.99)
West Bengal	5811	6329	6216	6639	6347
	(4.84)	(5.07)	(4.72)	(5.08)	(5.20)
India	120177	124814	131573	130615	122182
	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)

Source: Ministry of Agriculture and Farmers Welfare, Government of India, [4]. Note: values are in '000' hectares, while parenthesis values are in percentage

Table 5. Selected state wise total cropped area under non-food grains

State	1966-70	1971-80	1981-90	1991-00	2001-12
Andhra Pradesh	2416	2498	3073	4182	3966
	(8.87)	(8.84)	(9.87)	(10.77)	(9.85)
Bihar	541	575	526	470	414
	(1.99)	(2.03)	(1.69)	(1.21)	(1.03)
Gujarat	3778	3839	3846	4339	5187
	(13.870	(13.58)	(12.35)	(11.18)	(12.88)
Haryana	531	582	813	1253	1128
	(1.95)	(2.06)	(2.61)	(3.23)	(2.80)
Himachal Pradesh	25	26	24	78	144
	(0.09)	(0.09)	(0.80)	(0.20)	(0.36)
Jammu & Kashmir	44	46	63	73	68
	(0.16)	(0.16)	(0.13)	(0.42)	(0.81)
Karnataka	2251	2433	2841	3372	2573
	(8.26)	(8.61)	(9.12)	(8.69)	(6.39)
Kerala	40	45	39	165	327
	(0.15)	(0.16)	(0.13)	(0.42)	(0.81)
Madhya Pradesh	2597	2731	3250	5890	6991
	(9.53)	(9.66)	(10.43)	(15.17)	(17.36)
Maharashtra	4705	4461	5287	5862	6627
	(17.27)	(15.78)	(16.98)	(15.10)	(17.360
Orissa	402	600	1099	659	384
	(1.47)	(2.12)	(3.53)	(1.70)	(0.95)
Punjab	903	952	928	901	621
	(3.31)	(3.37)	(2.98)	(1.70)	(0.95)
Rajasthan	1538	1702	2402	4423	4734
	(5.65)	(6.02)	(7.71)	(11.39)	(11.76)
Tamil Nadu	1498	1614	1553	1570	761
	(5.50)	(5.71)	(4.99)	(4.05)	(1.89)
Uttar Pradesh	5067	5253	4131	2802	1231
	(18.60)	(18.58)	(13.26)	(7.22)	(3.06)
West Bengal	647	704	960	1900	3474
	(2.37)	(2.49)	(3.08)	(4.90)	(8.63)
India	27244	28274	31143	38820	40272
	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)

Source: Ministry of Agriculture and Farmers Welfare, Government of India, [4]. Note: values are in '000' hectares, while parenthesis values are in percentage

CAGR of production of food and non-food crops show a marginal increase by 1.26 and 1.65 percent in the ERP. At crop level, CAGR of production of major food crops, viz., rice and wheat shows that it has increased by 2.90 and 5.30 percent. Further, CAGR of production of major non-food grain crops, viz., cotton, sugarcane and total oilseeds shows that it has increased by 2.50, 3.09 and 3.28 percent annually. CAGR of production of major food grain crops, viz., rice and wheat has increased by 1.34 and 1.91 percent, respectively. CAGR of production of major non-food grain crops, viz., cotton, sugarcane and total oilseeds also shows that it has increased by 5.29, 1.40 and 1.98 percent annually (Table 6). Similar CAGR of food grain and non-food grain crops in total has found. It has increased, but decreasing rate.

3.5 Determinants of Agriculture Production

The performance of Indian agriculture depends on numerous factors viz., economic, technological and environmental factors. Economic factors are most important for agricultural production, such as size of operational land holding. Technological factors, such as use of machinery (tractors), use of chemical fertilizers and pesticides are employed. Environmental factors, such as rainfall and temperature are used. The present study in this section investigates the change in use of the various factors at state as well as all India level during post green revolution and economic reform period.

Table 6. Compound annual growth rate of area and production during PGRP and ERP

Crop	PGRP		ERP	
	Area	Production	Area	Production
Rice	0.61*	2.90*	0.09^{NS}	1.34*
	(9.20)	(11.70)	(0.86)	(5.85)
Wheat	2.06*	5.30*	0.83*	1.91*
	(9.69)	(16.38)	(7.08)	(8.67)
Cotton	-0.27*	2.50*	1.52*	5.59*
	(-1.94)	(6.98)	(4.65)	(6.19)
Sugarcane	1.61*	3.09*	1.32*	1.40*
	(7.63)	(11.70)	(4.59)	(3.61)
Total Oilseed	1.40*	3.28*	0.22*	1.98*
	(9.19)	(8.73)	(0.85)	(3.81)
Total Food grains	0.60*	2.93*	-0.44*	1.26*
	(8.33)	(14.54)	(-3.41)	(6.40)
Total Non-food grains	0.95*	3.02*	0.61*	1.65*
	(8.66)	(13.27)	(3.07)	(4.75)

*Source: Source: Ministry of Agriculture and Farmers Welfare, Government of India, [4]. Note Parenthesis value are t-statistics, *, ** & *** indicates one, five & ten percent level of significance and NS indicates non- significant*

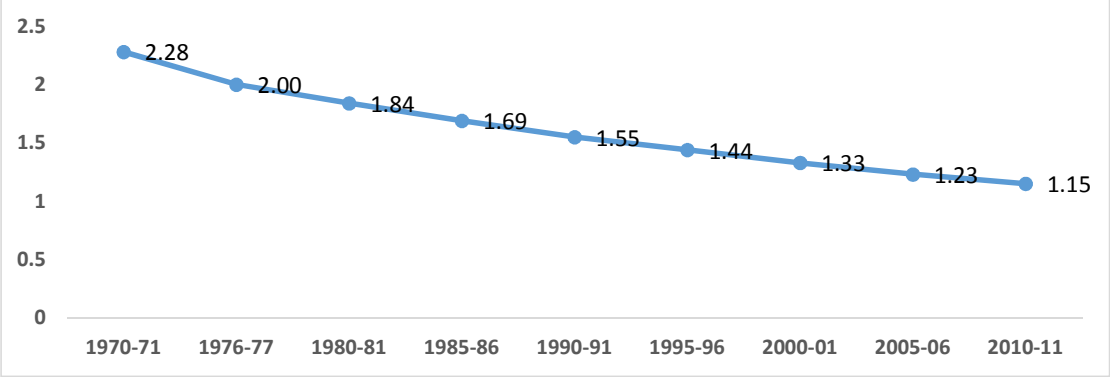

Fig. 1. All India average operation land holding size
Source: Department of Agriculture, Cooperation & Farmers Welfare, Government of India, [4]
Note: Values are in hectares

3.5.1 Economic factors

As an economic factors, the composition of operational land holdings across classes and social communities plays an important role for agricultural output. India is highly diverse nature in agricultural operations. Since majority of agricultural operational holders are marginal and small with regional difference, their numbers have increased in the subsequent years [4]. Fig. 1 shows declined in an average operation land holding size since 1970-71 to 2010-11. The average land size has substantially declined from 2.28 hectares in 1970-71 to 1.15 hectares in 2010-11. There are four possible reasons responsible for decline of land size. First, population growth has much higher. India has second most populous country in the world after China and it is continuously increasing [6]. Second, urbanization in India is in the fastest developing in the macrocosm. Consequently, new shelters and infrastructures require land for enlargement. Therefore, average farm size of land is now limiting year to year. Third, non-farm sector provides opportunities to semi-skill farmers. In the recent year, it is observed that non-farm sector growth is higher compared with farm sector with low risk and higher employment opportunities in all calendar months. Therefore, farmers those are having a small plot of land (landless small and marginal farmers) are shifting their primary occupation towards non-farm sector. Lastly, high input cost and lower returns with higher uncertainty. Other words, Indian agriculture become input intensive. It has increased the extra burden on the vulnerable marginal and small farmers.

Table 7. Number and area under class wise operational land holdings in India

Distribution of operational land holdings					
Period	**Marginal**	**Small**	**Semi-medium**	**Medium**	**Large**
1970–71	51.0	18.9	15.0	11.2	3.9
1980–81	56.4	18.1	14.0	9.1	2.4
1990–91	59.4	18.8	13.1	7.1	1.6
2000–01	62.9	18.9	11.7	5.5	1.0
2005–06	64.8	18.5	10.9	4.9	0.8
2010–11	67.0	17.9	10.0	4.3	0.7
Distribution of operational area					
1970–71	9.0	11.9	18.5	29.7	30.9
1980–81	12.0	14.1	21.2	29.6	23.0
1990–91	15.0	17.4	23.2	27.0	17.3
2000–01	18.7	20.2	24.0	24.0	13.2
2005–06	20.2	20.9	23.9	23.1	11.8
2010–11	22.2	22.1	23.6	21.2	10.9

Source: Department of Agriculture, Cooperation & Farmers Welfare, Government of India, [4]. Note: values are in percentage

Table 8. Selected state wise average operational land holdings

State	1995-96	2005-06	2010-11
Andhra Pradesh	1.36	1.20	1.08
Bihar	0.75	0.43	0.39
Gujarat	2.62	2.20	2.11
Haryana	2.13	2.24	2.25
Himachal Pradesh	1.16	1.04	0.99
Jammu and Kashmir	0.76	0.67	0.62
Karnataka	1.95	1.63	1.55
Kerala	0.27	0.23	0.22
Madhya Pradesh	2.28	2.02	1.78
Maharashtra	1.87	1.46	1.45
Odisha	1.30	1.15	1.04
Punjab	3.79	3.95	3.77
Rajasthan	3.96	3.38	3.07
Tamil Nadu	0.91	0.83	0.80
Uttar Pradesh	0.86	0.80	0.75
West Bengal	0.85	0.79	0.77
India	1.44	1.23	1.15

Source: Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture, Government of India, [4]. Note: values are in hectares

Additionally, agricultural census data from 1970-71 to 2010-11 shows that marginalization in has increased. Marginal farmers were 51 percent in 1970-71; they have increased by 17 percent, i.e., 67 percent in 2010-11 at the cost of large & medium farmers. The large farmer share was declined from 3.9 percent in 1970-71 to 0.7 percent in 2010-11. Subsequently, operated area has shifted from large farmers towards marginal and small farm holders. In 1970-71, 51 percent marginal farmers were owned 9 percent total cropped area. It has increased about 22 percent in 2010-11. On the other hand, 20 percent declined in the large farmer's total operated area during 1970-71 to 2010-11 (Table 7).

3.5.2 Regional shift in average land size

State wise shift in the average land size reflects that states having better institutional support such as water resources, investment and non-farm employment opportunities have higher average land size in the states, viz., Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Punjab and Rajasthan, whereas Andhra Pradesh, Bihar, Himachal Pradesh, Jammu and Kashmir, Kerala, Odisha, Tamil Nadu, Uttar Pradesh and West Bengal compare to all country level (Table 8). High yield food crops producing states, viz., Punjab Haryana, Tamil Nadu and Kerala show marginal decline in

the average land size across three agricultural census periods. On the other hand, states like, Bihar, Madhya Pradesh, Odisha and Rajasthan have shown sharp decline. It is a serious issue for policy point of view that when average land size is declining in one hand and on the other hand, demand of food items increasing. Will it be trapped with food insecurity? The current food crisis would be different from previous food crisis raised in the early fifties. In the fifties we were not fully used our natural, institutional and technological resources. Therefore, by using modern technology and expansion in the total cropped area, we sustain nation's food demand. But now we are at optimum level of agricultural operation and technically unable to increase total cropped area. Third, majority of farmers are own less than two hectare of land with high degree of vulnerability. Fourth, lack of political willingness in the development of agricultural sector also constrain of agricultural development.

The number of marginal farmers sharply has increased in backward states like, Bihar. In Bihar, marginal farmers were 80.14 percent in 1995-96 and it has increased by about 11 percent in 2010-11 (Table 9). Subsequently, states like, Uttar Pradesh and West Bengal the marginal farmers were 75.42 and 76.42 percent in 1995-96. They have increased to 79.23 and 82.17 in 2010-11. It was relatively much higher from national- level. The lower marginal owners from all India level are in Andhra Pradesh, Gujarat, Haryana, Karnataka, Maharashtra, Madhya Pradesh, Odisha, Punjab and Rajasthan. Among these states, Andhra Pradesh, Maharashtra, Madhya Pradesh and Punjab are high yield states. In other words, the rate of marginalization in the high yield states is lower and on the other hand, the rate of marginalization was higher in low yield states have observed.

From the farm output point of view, it is important that these marginal shareholders are not a real contributor in the national account statistics. They are, in other words called consumer rather than producers. An increase in the family size and decline land size put pressure of food insecurity. Therefore, they grow in majority food crops like, rice and wheat for own consumption rather than the profit motive.

3.5.3 Technological factors

Technological factors are also equally important and responsible for farm productivity. This section discusses about the performance of technological factors including consumption of chemical fertilizers and use of tractors during post green revolution period and economic reform periods.

Table 9. Selected state wise number and area under marginal operational land holdings

State	1995–96		2005–06		2010–11	
	Number	Area	Number	Area	Number	Area
Andhra Pradesh	59.42	20.20	61.58	22.69	63.95	26.08
Bihar	80.14	36.24	89.64	53.00	91.06	57.44
Gujarat	27.35	5.67	34.01	7.71	36.89	8.59
Haryana	47.16	10.99	47.66	9.66	48.11	9.87
Himachal Pradesh	64.43	23.00	68.27	26.65	69.72	28.48
Jammu & Kashmir	77.92	39.68	81.49	43.99	83.30	46.48
Karnataka	41.95	10.31	48.23	13.33	49.14	15.22
Kerala	93.95	53.27	95.63	57.62	96.33	58.64
Madhya Pradesh	40.38	8.20	40.45	9.92	43.86	12.09
Maharashtra	40.05	10.50	44.60	14.00	48.97	16.06
Odisha	54.08	20.68	59.62	26.74	72.17	39.53
Punjab	18.66	2.94	13.45	2.09	15.57	2.55
Rajasthan	30.03	3.67	33.51	4.85	36.47	5.86
Tamil Nadu	74.28	30.26	76.02	33.50	77.19	35.33
Uttar Pradesh	75.42	33.74	77.95	38.94	79.23	39.27
West Bengal	76.42	42.93	81.16	50.65	82.17	52.48
All-India	61.58	17.21	64.77	20.23	67.04	22.25

Source: Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture, Government of India, [4]. Note: values are in percentage

3.5.3.1 Chemical fertilizers consumption and agricultural productivity

By using chemical fertilizers during the PGRP, India sustains domestic food grains demand. The role of chemical fertilizers is important in the growth of Indian agriculture, as the net area available for cultivation is shrinking, due to the rising demand for land to build new houses, infrastructure and commercial outlets. In fact, the entire increase in farm output in the future may have to come from a rise in productivity. This will require improved technology and increased application of yield-enhancing plant nutrients. Therefore, a growth in fertilizer consumption is of paramount importance to raise food and agriculture production to meet the future requirements of the country. Among the core agendas of Green Revolution (use of hybrid seeds, improved irrigation and use of chemical fertilizers), use of chemical fertilizers was a second important agenda. Because hybrid seeds require chemical fertilizers to boost plant growth and total output. Therefore, after injection of fertilizer couple with high yielding varieties of rice and wheat since late 1960s, it has made possible to produce 15 to 20 tons of plant biomass (dry matter) per hectare per year. Therefore, farmers were started using of chemical fertilizer (especially nitrogen) at a massive level. Per hectare consumption of chemical fertilizer has increased four-fold during 1991-2012 from base year of 1965-66. It was 36 kilograms in 1965-66 and has increased 127 kilograms per hectare during 1991-2012 (Table 10). Regional disparities in the fertilizer consumption have also been taken place. States like Andhra Pradesh, Haryana and Punjab are most high fertilizer intensive states. In 1965-66 fertilizer consumption in these states was 41, 56 and 110 kilograms per hectare and it has increased by 180, 175 and 208 kilograms per hectare during 1991-2012. These states are using high yield varieties of rice, wheat and sugarcane, which need more fertilization coupled with improved irrigation. Andhra Pradesh has topped position for rice productivity per hectare. On the other hand, Odisha, Rajasthan, Madhya Pradesh, Kerala and Maharashtra are still using less. These states are using below 100 kilograms per hectare fertilizers. These regional variations show the scope for rising farm productivity by using fertilizer judiciously.

The judicious use of fertilizers not only make sustainable to farm practices, but also gives higher returns. The calculated CAGR shows positive growth in both two study periods, viz., PGRP and ERP in the nitrogen phosphate and potassium based fertilizer's consumption. It was observed that CAGR of nitrogen based fertilizer was slowed in ERP compared with in PGRP. It was 9.22 percent in PGRP and remained 3.26 percent in ERP (Table 11). Similarly, CAGR of phosphorus and potassium based chemical fertilizers shows slowed in ERP compared with PGRP level. It was 10.22 and 4.24 percent in PGRP and remained 9.17 and 5.67 percent in ERP at national-level. Further, regional disparities in the consumption of chemical fertilizers have found. Among the states, Bihar, Haryana, Madhya Pradesh, Punjab, Uttar Pradesh and West Bengal reported more than 10 percent annual growth rate during the PGRP period (Table 11). However, in the ERP period, CAGR sharply has declined. Even though, the majority of states show a decline in the consumption of nitrogen, phosphorus and potassium except in Haryana, Punjab and Uttar Pradesh. In these states consumption of potassium based fertilizers has increased sharply in ERP compared with PGRP period. It was 9.36, 7.34 and 7.60 percent in PGRP period and it has increased by 17.84, 8.92 and 7.90 percent in the ERP period.

There are three possible reasons for decline in CAGR of fertilizer consumption. First, initially, farmers in the early 1960s have used fertilizers (especially nitrogen based) without consideration of plant requirements. When, fertilizer use reached a threshold-level or beyond the plant carrying capacity. It has negative consequences in output. Therefore, famers have shifted the use of fertilizers from nitro to potassium based fertilizers. In other words, farmers have now judiciously using fertilizers. Further, shift from nitrogen based fertilizers towards potassium based fertilizers was also observed in the higher food grains yield states, viz., Haryana, Punjab and Uttar Pradesh. Second, introduction of new bio-fertilizer and early maturing varieties in arid and semi-arid regions; a recent report published by the government of India shows that more than 60 percent cropped area under rain-fed conditions. It means water is not available for farming throughout the cropping seasons. Therefore, early maturing varieties and judicious use of chemical fertilizers are best option to cope with adverse climatic conditions. Lastly, supportive government price policy for nitrogen based fertilizers increased nitrogen based fertilizers consumption markedly during PGRP period.

Table 10. Fertilizers consumption in selected states during 1966 to 2012

State	1966-67	1966-90	1991-2012	∆ (change)
Andhra Pradesh	41	60	180	120
Bihar	39	46	121	75
Gujarat	26	35	109	74
Haryana	56	67	175	108
Karnataka	45	51	121	70
Kerala	31	44	71	28
Madhya Pradesh	11	18	65	47
Maharashtra	22	29	96	67
Orissa	0.5	9	43	33
Punjab	110	138	208	71
Rajasthan	7	11	42	31
Tamil	56	80	166	86
West Bengal	45	57	138	81
Uttar Pradesh	55	77	140	63
Jammu & Kashmir	24	79	184	105
Himachal Pradesh	12	67	169	102
India	36	54	127	72

Source: Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture, Government of India, [4]. Note: ∆ indicates change in Fertilizers Consumption during 1966-90 to 1991-2012. Values are in kilogram per hectare

3.5.3.2 Balance v/s imbalance use of chemical fertilizers

Since the introduction of chemical fertilizers in the Indian agriculture, the debate on the balanced use of fertilizer and its relation to plant growth was always a policy concern. In general, the Nitrogen, Phosphorus and Potassium (NPK) ratio of 4:2:1 is considered to be optimum for India. It is hard to trace the origin of this ratio [7]. However, it is believed that the ratio is originated from field trials conducted during the 1950s, i.e., in the PGRP [8]. The calculated NPK ratios show that states like Karnataka, Kerala, Maharashtra, Tamil Nadu and West Bengal have used lower from the recommended ratio of NPK during PGRP. They have used NPK ratio of 3:1:1, 1:1:1, 3:2:1, 3:1:1 and 4:1:1 (Table 12). Further, high yield states, viz., Haryana, Madhya Pradesh, Punjab, Rajasthan and Uttar Pradesh have used much higher from the recommended ratio during PGRP. They have used NPK ratio of 32:7:1, 10:6:1, 19:7:1, 21:7:1 and 11:3:1. To maintain the high agricultural growth rate, these states have used more intensive chemical fertilization during the ERP period. During ERP period, farmers have not only increased the share of nitrogen based fertilizers but also increased the share of phosphorus and potassium based fertilizers (Table 12).

3.5.3.3 Growth in use of tractor

Traditionally, Indian farmers were used bulk for farm management before the introduction of tractor. Tractor has multi-purpose utility equipment. It is not only used in farming, but also used in the non-farm activities. It has labor cost cutting technology and helps to increase farm profits. Table 13 indicates that CAGR of tractors during 1966-90 and 1991-2012. It was observed that during 1966-90 that growth rate of tractor use in the agriculture were more than 10 percent in Andhra Pradesh, Bihar, Punjab, Haryana, Rajasthan and Uttar Pradesh. However, during 1991-2012 it has remained about 5 percent, except in Tamil Nadu.

3.5.4 Environmental factors

Temperature and rainfall are major environmental determinants, responsible for crop productivity in any piece of land. The distribution of rainfall and temperature is different and vary location to location. In the plains, it is higher and in hilly area, temperature generally remains lower. Due to this, the vegetation is also different like some crops are grown at lower temperature between 15- 21°C and at the same time, some crops grow with temperature between 20- 28°C [9]. Plant has a minimum threshold level. If temperature (day & night) increased beyond minimum threshold level, surely affects to the

growth of the plant. Along with IPCC [9] on global temperature and its negative consequences on global environment as well as human's livelihood several mainstream researchers [10,11,12] observed that temperature (day & night) adversely affected to the crop productivity and declined net farm revenue.

3.5.4.1 Variations in the rainfall distribution pattern

Sinha and Swaminathan [10]; Goswami et al. [13] and Kumar et al. [14] observed that rainfall pattern has shifted from southern parts towards central plains. Means drier regions would be received less rainfall and wetter regions would be received higher rainfall in the coming years. It is confirmed that Gujarat, Karnataka, Maharashtra, Orissa and West Bengal have received surplus rainfall by 103, 43, 20, 93 and 63 millimeter, whereas Andhra Pradesh, Bihar, Haryana, Himachal Pradesh, Kerala, Madhya Pradesh, Punjab, Rajasthan, Tamil Nadu and Uttar Pradesh have received less rainfall by 16, 108, 36, 13, 9, 48, 66, 7, 19 and 155 millimeter in the monsoon period during 1966-90 to 1991-2012 (Table 14). Further, it was observed that due to climate variability, monsoon rainfall distribution pattern has changed. Regional variations in the monsoon period restricted farmers to change cropping pattern along with sowing period or else ready to accept less profit. Goswami et al. [13] observed that less precipitation available for high water intensive *khariff* crops due to change in

Table 11. State wise compound annual growth rate of chemical fertilizers (Nitrogen, phosphorus and potassium) consumption during PGRP and ERP

State	1966-90			1991-2012		
	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
Andhra Pradesh	8.62* (15.41)	9.84* (17.68)	16.42* (8.52)	2.97* (8.26)	4.62* (9.80)	8.16* (13.98)
Bihar	10.40* (22.63)	12.16* (11.40)	12.40* (14.29)	5.41* (5.12)	7.05* (4.64)	12.12* (7.46)
Gujarat	8.61* (17.98)	9.83* (10.99)	9.53* (6.78)	4.67* (9.66)	5.36* (9.21)	7.66* (10.85)
Haryana	11.77* (17.20)	17.70* (16.50)	9.36* (4.47)	3.67* (24.56)	4.74* (14.77)	17.84* (9.84)
Himachal Pradesh	9.67* (17.79)	6.07* (7.79)	9.41* (5.72)	1.49* (7.66)	6.03* (7.36)	7.17* (9.05)
Karnataka	9.19* (24.01)	11.59* (22.07)	12.53* (10.93)	4.07* (10.38)	5.56* (7.36)	6.14* (10.12)
Kerala	5.33* (17.96)	5.62* (11.20)	7.70* (13.72)	2.54* (6.51)	3.19* (7.89)	2.10* (4.63)
Madhya Pradesh	12.51* (16.55)	14.71* (17.58)	13.95* (15.71)	3.10* (4.09)	4.40* (6.46)	6.30* (6.52)
Maharashtra	9.06* (9.69)	9.74* (14.96)	13.57* (5.88)	3.46* (9.69)	6.21* (12.26)	7.14* (9.99)
Orissa	8.70* (15.06)	10.53* (21.11)	12.40* (18.46)	3.90* (9.69)	7.61* (14.89)	6.29* (10.15)
Punjab	10.58* (15.70)	14.68* (12.41)	7.34* (3.22)	2.19* (15.37)	2.87* (8.39)	8.92* (12.19)
Rajasthan	9.20* (19.39)	12.54* (19.76)	8.11* (6.27)	4.24* (17.65)	5.43* (10.53)	7.94* (8.85)
Tamil Nadu	6.18* (11.85)	6.59* (11.43)	8.58* (17.16)	1.93* (8.93)	3.12* (6.44)	2.09* (3.60)
Uttar Pradesh	10.43* (13.61)	11.14* (8.62)	7.60* (4.41)	2.51* (13.96)	5.36* (14.02)	7.90* (9.36)
West Bengal	12.27 (30.00)	16.03* (18.89)	15.82* (7.90)	2.51* (12.98)	4.83* (13.68)	6.15* (11.46)
India	9.22* (23.58)	10.22* (18.92)	9.17* (15.63)	3.26* (15.19)	4.24* (9.73)	5.67* (8.44)

*Source: Source: Ministry of Agriculture and Farmers Welfare, Government of India, [4]. Note Parenthesis value are t-statistics, *, ** & *** indicates one, five & ten percent level of significance*

Table 12. Selected state wise consumption and ratio of nitrogen, phosphorus and potassium during PGRP and ERP

State	NPK Ratio (PGRP)	NPK Ratio (ERP)
Andhra Pradesh	9:3:1	5:2:1
Bihar	8:2:1	9:2:1
Gujarat	8:4:1	8:3:1
Haryana	32:7:1	42:13:1
Himachal Pradesh	7:1:1	4:1:1
Karnataka	3:1:1	3:2:1
Kerala	1:1:1	1:1:1
Madhya Pradesh	10:6:1	12:7:1
Maharashtra	3:2:1	3:2:1
Orissa	5:2:1	5:2:1
Punjab	19:7:1	32:9:1
Rajasthan	21:7:1	32:13:1
Tamil Nadu	3:1:1	2:1:1
Uttar Pradesh	11:3:1	17:5:1
West Bengal	4:1:1	2:1:1
India	7:2:1	6:2:1

Source: Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture, Government of India, [4]. Ratios has calculated by k = 1, for Potassium, N = N/K for Nitrogen and P = P/K for Phosphorus

Table 13. Selected state wise compound annual growth rate of number of tractors during PGRP and ERP

State	PGRP	ERP
Andhra Pradesh	10.79*	2.03*
	(49.09)	(6.74)
Bihar	12.84*	4.39*
	(35.93)	(9.22)
Gujarat	8.14*	5.14*
	(15.29)	(9.04)
Haryana	10.50*	0.39*
	(60.01)	(0.77)
Himachal Pradesh	-2.08*	05.84*
	(-0.93)	(10.39)
Karnataka	7.04*	1.53*
	(9.98)	(2.70)
Kerala	2.57*	8.63**
	(5.91)	(2.14)
Madhya Pradesh	15.66*	2.40*
	(15.52)	(4.29)
Orissa	3.23*	7.37*
	(5.30)	(8.26)
Punjab	12.30*	5.18*
	(-0.77)	(1.60)
Rajasthan	13.84*	4.02*
	(47.14)	(9.43)
Tamil Nadu	7.77*	10.49**
	(12.16)	(2.37)
Uttar Pradesh	13.03*	4.18*
	(46.77)	(11.15)
West Bengal	-7.11**	2.04*
	(-2.13)	(6.32)

*Source: Estimated from ICRISAT Database. Note: parenthesis value are t-statistics, *, ** & *** indicates one, five & ten percent level of significance*

Table 14. Change in annual and monsoon rainfall in selected states during PGRP and ERP

State	Annual rainfall PGRP			Monsoon rainfall ERP		
	1966-90	1991-2012	∆ (in M.M.)	1966-90	1991-2012	∆ (in M.M.)
Andhra Pradesh	978	962	-16	505	489	-16
Bihar	1221	1051	-170	779	671	-108
Gujarat	1536	1649	113	1228	1331	103
Haryana	603	581	-22	415	379	-36
Himachal Pradesh	1236	1182	-54	692	679	-13
Karnataka	1292	1363	71	770	813	43
Kerala	2575	2837	262	1620	1611	-9
Madhya Pradesh	1051	1017	-34	804	756	-48
Maharashtra	1234	1251	17	898	918	20
Orissa	1306	1457	151	835	928	93
Punjab	642	532	-110	419	353	-66
Rajasthan	582	569	-13	448	441	-7
Tamil Nadu	1025	1029	4	246	227	-19
Uttar Pradesh	979	747	-232	651	496	-155
West Bengal	1220	1308	88	716	779	63
India	1170	1169	1	835	825	-10

Source: Indian Meteorological Department of India, 2013. Note: for the estimation of State level rainfall distribution, geographical location of the meteorological stations has comprised. ∆ indicates change in rainfall distribution. Values are in millimeters

Table 15. Selected state wise change in mean minimum and maximum temperature during PGRP and ERP

State	PGRP		ERP	
	Minimum temperature	Minimum temperature	Maximum temperature	Maximum temperature
Andhra Pradesh	21.96	21.85	32.99	32.58
Bihar	19.62	19.44	27.67	27.50
Gujarat	19.76	19.93	26.70	26.85
Haryana	18.14	18.56	31.56	31.85
Himachal Pradesh	13.03	13.75	22.54	23.02
Karnataka	20.32	20.62	25.67	25.93
Madhya Pradesh	19.00	19.26	32.40	30.49
Maharashtra	20.23	20.41	27.75	27.91
Orissa	20.68	19.70	28.49	27.47
Punjab	17.86	18.37	28.65	29.01
Rajasthan	18.82	19.30	31.16	31.61
Tamil Nadu	22.48	22.91	21.63	21.94
Uttar Pradesh	18.78	19.23	32.17	32.51
West Bengal	20.29	20.81	31.00	31.05
India	19.36	19.58	28.60	28.55

Source: Indian Meteorological Department of India, 2013. Note: for the estimation of State level rainfall distribution, geographical location of the meteorological stations has comprised. Values are in degree centigrade

monsoon rainfall pattern [13]. They also observed that rainfall in early Rabi cropping season adversely affected to the Rabi crop, such as wheat. Further, the frequency of heavy and very heavy rain events in central India increased by nearly 50 percent and more than 100 percent during 1951-2000. All India annual rainfall distribution shows that regional variations not only in the monsoon period have increased but it also increased in the annual distribution.

3.5.4.2 Change in day and night temperature

Table 15 indicates the change in day and night temperature. It was observed that states like Gujarat, Haryana, Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Orissa and West Bengal shows that night (minimum) temperature has increased during 1966-90 to 1991-2012. On the other hand, night temperature in states like, Bihar, Rajasthan and Uttar Pradesh has declined

during the same period. Further, day (maximum) temperature is important for the vegetative growth of the plants reflects regional variations. It has increased in the states, viz., Gujarat, Himachal Pradesh, Karnataka, Kerala, Maharashtra, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal during 1966-90 to 1991-2012, while it has declined in Andhra Pradesh and Bihar. Current findings are match from the Kaur and Kaur [15] study. By using simulation method, his study projected about wheat crop that in Northern India State such as Uttar Pradesh, Punjab, Haryana, Uttarkhand and Himachal Pradesh affected by increasing trends of temperature. Wheat output could plunge by 6 million tons with every 1°C rise in day temperature.

4. CONCLUSION AND POLICY RECOMMENDATION

The present study start begin question of performance of Indian agriculture, sustainable farm practices, food security and how well Indian farmers dealing with climate change. By using large-scale data at national and state-level, input-output analysis was carried out in two periods, viz., post- green revolution period and economic reform periods. The results show that production of food and non-food crops has tremendously increased over the period and nowadays India has surplus food stock to deal with any future food crisis. However, the dark side of the green revolution also observed. First, technological change in the mid-eighties caused significantly shift in land utilization in favor of food grain crops such as wheat and rice at the cost of the area under coarse cereals, pulses and oilseeds. This shift was combined effect of differential rate of technological change among the crops. Second, irrigation bias of new technology causing shift, of land away from dry crops in favor of irrigated crops and the associated policy price- support system as well as market intervention by the government for certain crops [16]. Third, distortions in cropping pattern were reflected in the relatively abundant supply of the same crops (like wheat of which government has surplus stock) and acute shortages of others (like pulses and oilseeds which had to be imported at the huge cost in terms of foreign exchange). Fourth, the input cost has increased many folds [17]. High yielding food grain technology along with fertilizer and irrigation needs more investment in agriculture. With least coverage of institutional credit sources, green revolution pushed in poverty and credit trap to the marginalized Indian farmers. Fifth, emphasis on the agricultural development policy (green revolution) was more on raising the yield of a particular crop per unit of land rather than increasing the total output per unit of land from all crops growth in a year [18]. Sixth, change in land use pattern. Sharma [19] examined the inter-state disparities in cropping pattern and agriculture growth. Study found that size of land holding has basic factor affecting the structure of cropping pattern across the states. The state with higher agricultural growth rates was having a relatively higher average size of holding except Uttar Pradesh, Punjab and Haryana. Lastly, shift from traditional to unsustainable farm practices. Das [20] argued that traditionally, Indian farmers were small plots of land protected by windbreaks and tree cover. The practices of crop rotation and leaving the field fallow for long periods of time allowed the soil to retain nutrients. However, farmers were then influenced by the green revolution and large farmer who had changed to modern method, such as mono-cropping, in which they cultivated only one type of crop rather than multiple crops, as is done in traditional farming. While mono-cropping allows farmers to grow more of a certain crop that usually of higher market value. It has negative effects on the soil as well. A farmer who applies a mono-cropping system tend to leave their fields fallow for a shorter period of time. Thus, the soil cannot replenish its nutrients. Moreover, farmers that employ mono-cropping methods need higher inputs such as chemical fertilizers, pesticides and improved irrigation facilities.

Though, from the early years of the green revolution period, farmers have adopted intensive chemical fertilization, which was much higher from the recommended ratio. But Chand and Pavithra [7] criticized that validity of this ideal ratio. They argued that this ratio ignored two important factors. First, during the green revolution period, farmers applied farm-yard manure (bio-fertilizers) and the native soil were rich in phosphorus and potassium content. Second, the response to applied phosphorus and potassium fertilizers was much higher in red and lateritic soils, which clearly indicate that the ratio of NPK would vary for different soil types. Further, the fertilizer norm for a state or country depends upon the cropping pattern, yield levels, crop variety and soil-specific

characteristics which have undergone a sea change over the years. The farm trails conducted in the post-green revolution period confirmed that the response of rice crop to the applied phosphorus was as good as to that of nitrogen and in fact it was higher in the case of improved varieties of wheat. This finding along with the popularization of improved wheat varieties encouraged the use of Phosphate fertilizers during the post green revolution period [7]. However, use of fertilizer in India remained skewed towards Nitrogen based fertilizers. They suggested that the ideal ratio in India based on the current crop pattern and recommendations of SAUs and ICAR institutions were found to be 2.6:1.4:1. This norm implies that N should comprise 52 percent and P and K should constitute 28 and 20 percent, respectively, of the total fertilizer applied in India. These shares are quite different from the share based on the ratio of 4:2:1, which implies that N should constitute 57.8 percent, and P and K should constitute 28.6 & 14 Percent respectively [21].

COMPETING INTERESTS

Author has declared that no competing interests exist.

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