EXPLORING POSSIBILITIES OF ACHIEVING FOUR PERCENT GROWTH RATE IN INDIAN AGRICULTURE

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I
INTRODUCTION

Performance of agriculture sector in the country in the recent years has turned out to be quite dissatisfactory because of sharp deceleration in growth rate of agricultural output. Ministry of Finance, Planning Commission, and office of Prime Minister are emphasising concerted measures to address poor growth rate in agriculture, partly because poor growth rate has serious implications for large percent of India's population that depends upon agriculture for livelihood, and partly because poor growth of agriculture affects growth of overall economy. There are apprehensions that high growth rate in non agriculture sector alone would not help India to realise high growth rate in total economy if agriculture continues to remain in low growth trap. Thus, there is lot of concern to raise growth rate in agriculture.

What is the growth rate in agriculture that India is aiming for? In official quarters it is 4 percent annual growth rate. Both, National Agriculture Policy 2000 and 10th Five Year Plan, aim at this growth rate. This paper examines the feasibility of attaining four percent growth in agriculture. How does this growth rate fare with historical growth rate in Indian agriculture? What are the sources of growth rate in agriculture? Why growth rate has decelerated in recent years? When and where this deceleration started? These are the other questions addressed in the paper.

The remaining paper is organized into four sections. The Second section comments on some methodological issues concerning growth rates in agriculture. The Third section discusses growth experience since 1950-51 and examines if there is deceleration in growth rate in the recent years. The Fourth section analyses the prospects for realising 4 percent growth rate in Indian agriculture.

* Some of the material used in this paper is taken from Demand For Urea Towards 2011, Research Report NCAP (01)/2005, September 2005, by Ramesh Chand, NCAP, New Delhi.

II
METHODOLOGICAL ISSUES

Lot of confusion and disagreement about growth rate of agriculture results from definition of agriculture followed by various researchers. Agriculture sector in India at broad level is taken to include crop, livestock, fisheries and forestry. Out of these, crop and livestock together are often termed as agriculture or agriculture proper. Some researchers use broad definition of agriculture, some include only crop and livestock in agriculture while some use index of production of principal crops to designate agriculture. There is a need to bring some clarity in relation to use of different concepts of output to have proper understanding about growth of agriculture.

Index number of principal crops prepared by Directorate of Economics and Statistics has been widely used to represent growth rate in agriculture though it clearly and explicitly implies that livestock output, whose share has continuously risen in the agriculture output for quite long, is not included in it. This index has turned inadequate for representing even crop sector. The reason is that 46 crops covered in the index do not include large segment of fruits and vegetables. While potato, onion, banana, cashewnut, tapioca and sweet potato are included, the index excludes all fresh vegetables and fruits, except banana, which represent dynamic horticulture sector of India. It is worth mentioning that during 1990-91 to 2000-01 share of fruits and vegetables in value of crop output has increased from 18 percent to 23 percent. Therefore exclusion of important fruits and vegetables, as is the case with the index number of principal crops, results in under-estimation of growth rate of crop sector in the said period. One way to overcome this limitation is to use data on value of crop sector at constant prices as that includes value of output of fruits and vegetables also.

Another limitation of agriculture output data is that due to use of common input in crop and livestock activities separate estimates of value added or GDP in crop sector and that in livestock sector are not available. Thus, separate growth rate for these two sub sectors can be obtained only in respect of value of output and not for value added output.

Keeping these characteristics of data in mind this paper computes all India growth rate for (a) GDP agriculture which includes crop and livestock (b) GDP fishery (c) Value

of output of crops, livestock, horticulture crops and non horticultural crops and (d) physical production of important crops/groups.

Sources and Feasibility of Attaining Four Percent Growth

It is hypothesized that in the medium term there are four sources of output growth as follows:

(1) Fertiliser

(2) Irrigation

(3) Crop diversification from foodgrains to high value crops

(4) Total factor productivity (representing effects of technology, infrastructure, better management etc.).

Considering output as a function of above four factors output growth equation was expressed as:

$$\frac{dY}{Y} = E_Y^F \frac{dF}{F} + E_Y^I \frac{dI}{I} + E_Y^D \frac{d(YD)}{Y} + \dot{TFP} \qquad \ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where

$\frac{dY}{Y}$ = Rate of growth in output

E_Y^F = Elasticity of crop output with respect to fertilizer

E_y^I = Elasticity of crop output with respect to irrigation

E_Y^D = Elasticity of crop output with respect to diversification of area away from foodgrains

$\frac{df}{f}$ = Rate of growth in fertilizer

$\frac{dI}{I}$ = Rate of growth in irrigation

$\frac{d(YD)}{YD}$ = Rate of growth in output due to area shift

$\dot{TFP}$ = Growth rate in TFP

Equation 1 can be re-expressed to know what growth in specific factors would be needed to attain specified level of growth rate in output. For instance, using empirical estimates or scenario estimate for growth that is feasible through irrigation, TFP and diversification one can compute required growth in fertilizer that would achieve specified growth in output, as follows:

$$\frac{dF}{F} = \left[\frac{dY}{Y} - E_Y^I \frac{dI}{I} - E_Y^D \frac{dYD}{Y} - \dot{TFP} \right] / E_Y^F \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

Similarly, equation (2) can be used to construct other scenarios for growth required in irrigation or TFP or diversification to attain 4 percent output growth per year. To arrive at that the study estimated growth rate in output achievable through various factors and by multiplying elasticity of crop output with respect to the concerned variables with plausible growth rate in that variable.

As mentioned above the exercise involves estimation of elasticities, future growth in irrigation, diversification and TFP. Elasticities of crop output with respect to irrigation and fertilizer were obtained from estimated production function. The production function was estimated for each state using time series data on value of crop output expressed in 1993-94 prices, fertilizer expressed in quantity of NPK, area under irrigation, rainfall and some other variables considered relevant. Value of crop output was used as dependent variables and all production functions were estimated after log linear transformation of raw data. Only statistically significant coefficients were used to choose coefficients of elasticities.

As it is well known, Indian agriculture has tremendous diversity across regions in terms of productivity levels already attained, growth potential, irrigation potential and resource endowment. Because of these vast regional variations, national level exercise on sources of growth does not take into account region specific characteristics. Therefore, output growth exercise was carried out at state level with a view to find feasible growth at state level to attain 4 percent growth at national level.

III
HISTORICAL AND RECENT GROWTH RATES AT NATIONAL LEVEL

Agricultural production over time is affected by interacting influences of technological, infrastructural, and policy factors. After mid 1960s, Indian government started intervening in agriculture sector to create favourable environment for exploitation of technological potential. This was done by creating enabling infrastructure through public investments and by policy changes affecting agricultural marketing, production, processing and trade. During the decade of 1980s public investments in agriculture started falling. Despite this decline, output of agriculture sector showed higher growth rate compared to the previous three decades (Table 1). This could be made possible by spread of modern technology to wider areas, increase in crop intensity, crop diversification, increased use of technology enhancing input use driven by market forces and policy support. The decade also witnessed some improvement in terms of trade in favour of agriculture.

During the decade of 1990s declining trend in public sector investment that set in year 1979-80 continued for most part of the decade. However, terms of trade were kept favourable to agriculture sector during 1990s by hiking level of cereal prices through government support, trade liberalization, exchange rate devaluation and disprotection to industry. Several researchers felt that as economic reforms focused mainly on price factor and ignored infrastructure and institutional changes the overall impact on growth of agricultural sector has not been favourable. This argument is supported by citing deceleration in output of agriculture sector after reforms were started in the year 1991 (Mujumdar 2002, Bhalla 2002, Kumar 2002). There is a particular concern about the decline in public sector investments in agriculture, as can be seen from the data presented in Annexure I. Several studies have shown public investments have strong effect on agricultural productivity and growth in India (Chand 2001; Gulati and Bathla 2001; Shangen et. al. 1999).

Our estimates for decadal growth rates showed that total and agricultural and non agricultural GDP followed acceleration during the reform decade (Table 1). The increase was modest for agricultural sector but quite large for non agricultural sector. Within

agriculture, output of crop sector showed better growth during reform whereas output of livestock showed deterioration. Further, within crop sector, growth rate of output of horticulture sector (fruits and vegetables) during the decade of economic reforms turned out to be more than double as compared to the pre reform decade. It is worth noting that during the reforms output of horticultural sector increased annually by about 6 percent which is double the growth rate in total crop output. Excluding fruit and vegetables, output of crop sector showed a decline in growth rate to the level of 2.26 percent during 1990s as compared to 2.48 percent during 1980s. Likewise, GDP of fishery sector also witnessed setback in growth rate during the reforms.

Table 1: Growth rates in output of economy and agriculture sub sectors at 1993-94 prices

	GDP				Value of output			
Period	Total	Non agriculture	Agri-Culture	Fishing	Live-stock	Crop sector	Fruit/ Veg	Crops other than fruit/veg
1950-51 to 1959-60	3.68	4.91	2.93	5.79	1.42	3.06	0.56	3.44
1960-61 to 1969-70	3.29	5.00	1.27	4.00	0.41	1.70	5.82	1.09
1970-71 to 1979-80	3.45	4.72	1.94	2.90	3.92	1.79	2.88	1.55
1980/81 to 1989-90	5.38	6.78	3.13	5.82	4.99	2.47	2.36	2.48
1990/91 to 1999/00	6.19	7.40	3.28	5.46	3.82	2.99	5.97	2.26
1990/91 to 1995/96	5.56	6.63	3.16	7.49	4.25	2.65	4.93	2.13
1996/97 to 2001/02	5.53	6.85	1.75	2.72	3.47	1.28	4.55	0.34

Though agricultural growth rates during 1990s by and large present favourable situation there have been frequent protests by farmers groups and reports of distress from the countryside about adverse impact of WTO on agriculture. It is possible that decadal growth rates conceals the true picture of growth experienced in pre and post WTO period. This was investigated by estimating separate growth rates for the two sub periods viz. 1990-91 to 1995-96 and 1996-97 to 2001-02, former representing domestic reforms before WTO and latter representing liberalisation following WTO. Growth rates for these two sub periods reveal a totally different story than what is seen from the decadal data.

As it can be seen from Table 1, growth experience of Indian agriculture after mid 1990s was totally different than the experience before mid 1990s. GDP of agriculture sector showed annual growth rate of 3.16 percent during 1990-91 to 1995-96, after which it declined to 1.75 percent. Growth rate of fishery between the pre and post WTO periods declined from 7.49 percent to 2.72 percent. Growth rate in output of livestock sector decelerated from 4.25 percent to 3.47 percent. Likewise, growth rate in output of crop

sector after 1996-97 plummeted to less than half of what it was during 1990-91 to 1995-96. As a result, crop sector, which forms largest segment of agriculture, showed poorest growth during post WTO period in the history of post Independence India. Further, within crop sector, output of fruits and vegetables, which showed spectacular growth during 1990s, also followed deceleration in the recent years. Post WTO period turns out to be highly adverse to crop sector excluding fruits and vegetable as their output did not increase even at 0.5 percent per annum. These results indicate that initial years of reforms were somewhat favourable for raising growth of agriculture sector but after 1995-96 the sector showed very poor growth rate.

In order to see precisely in which year deceleration in agricultural growth started, the growth rates were estimated between fixed base 1990-91 and extending the terminal year from 1995-96 onwards. These results are presented in Table 2 which show that growth rate of agriculture sector reached peak by 1996-97 and slowed down after that. There is a continuous deceleration in the growth rate of livestock output after 1995-96. Growth rate in output of horticultural crops kept increasing till 1998-99 after which slowdown set in.

Table 2: Identification of the year showing deceleration in growth rates in GDP of economy and agriculture sub sectors at 1993-94 prices

	GDP				Value of output			
Period	Total	Non agriculture	Agri-Culture	Fishing	Live-stock	Crop sector	Fruit/ veg	Crops other than fruit/veg
1990/91 to 1995/96	5.56	6.63	3.16	7.49	**4.25**	2.65	4.93	2.13
1990/91 to 1996/97	6.01	7.04	**3.69**	**7.41**	4.12	**3.22**	5.92	**2.59**
1990/91 to 1997/98	6.09	7.26	3.35	6.90	3.95	2.92	5.91	2.21
1990/91 to 1998/99	6.16	7.33	3.43	5.90	3.89	3.10	**6.14**	2.36
1990/91 to 1999/00	**6.19**	**7.40**	3.28	5.46	3.82	2.99	5.97	2.26
1990/91 to 2000/01	6.12	7.38	3.01	5.07	3.76	2.66	5.88	1.84
1990/91 to 2001/02	6.06	7.29	2.95	4.96	3.73	2.58	5.78	1.76

The slowdown in agriculture growth rate after mid 1990s seems to have resulted from couple of factors. One, there is deterioration in terms of trade for agriculture towards late 1990s and beyond, mainly due to impact of depressed international prices of most of agricultural commodities on domestic prices (see Table 3). Two, output price intervention remained confined to already developed regions where crop yields have approached plateau and prices have little scope to improve supply response. Agriculturally underdeveloped regions which have potential for raising productivity and

production did not have favourable output price environment. Three, despite lot of concern public investments in agriculture did not increase to keep pace with the needs and output growth (see Table 3). Four, adoption of new and improved technology remained slow. Five, large scale imports of some commodities in post WTO period caused adverse affect on their output. These are the probable causes. There is a need for quantitative study to establish exact role of these and other factors in influencing India's agriculture growth.

Table 3: Public sector investments in agriculture and index of terms of trade between agriculture and non agriculture sectors

Year	Public sector Gross Fixed Capital Formation	Public sector GFCF as % of GDP agriculture	Index of terms of trade Base triennium ending 1990-91=100
1960-61	2400	2.20	--
1970-71	3216	2.34	--
1980-81	7358	4.62	--
1981-82	6998	4.17	88.7
1982-83	7020	4.21	91.4
1983-84	7089	3.88	91.6
1984-85	6699	3.62	93.9
1985-86	6005	3.22	93.6
1986-87	5738	3.10	95.7
1987-88	6004	3.28	97.4
1988-89	5733	2.71	98.3
1989-90	4911	2.29	99.4
1990-91	4871	2.18	101.9
1991-92	4400	2.00	105.6
1992-93	4549	1.96	103.9
1993-94	4996	2.06	103.9
1994-95	5406	2.13	106.6
1995-96	5318	2.11	105.3
1996-97	4942	1.79	103.1
1997-98	4467	1.66	105.6
1998-99	4459	1.55	105.2
1999-00	4764	1.67	102.7
2000-01	4468	1.48	102.8
2001-02	--	--	102.3

IV
SOURCES AND GROWTH PROSPECTS AT STATE LEVEL

Estimation of growth in output in this chapter refers to crop sector only and excludes livestock sector. The reason for this exclusion is that livestock sector still continues to grow at close to 4 percent annual rate and the real problem of slowdown of agriculture sector resulted from slowdown in output of crop sector which accounts for three-fourth of total output of crops and livestock.

Estimation of growth prospects involves several steps as discussed in section I. The exercise involved estimation of output elasticity with respect to fertilizer and irrigation, scope of irrigation expansion and increase in fertilizer use, scope of diversification through high value crops, improvement in TFP, and then estimation of prospects of output growth through expansion of irrigation, increase in application of fertiliser, diversification and growth in TFP.

After mid 1960s expansion of irrigation and increased use of fertilizer have played primary role in exploiting production potential of any crop production technology that became available and in raising output. It is therefore instructive to look at change in output associated with changes in these two important inputs in different periods. The information for 1980s, 1990s and for recent five years for which data was available is presented in Table 4.

As can be seen from the Table 4 about half of the states show decline in area under irrigation and fertilizer use and 9 out of 16 states show negative growth in crop output in the recent period. This shows importance of fertilizer and irrigation in raising agricultural output. However exact response of output to these two modern inputs can be seen from elasticities of crop output with respect to changes in fertilizer and irrigation presented in following section.

Table 4: Statewise growth rate in irrigation, fertilizer use and output since 1980-81

State	Output			Fertilizers			GIA		
	1980-81 to 1989-90	1990-91 to 1999-00	1998-99 to 2002-03	1980-81 to 1989-90	1990-91 to 1999-00	1998-99 to 2002-03	1980-81 to 1989-90	1990-91 to 1999-00	1998-99 to 2002-03
Andhra Pradesh	2.26	1.41	-2.65	9.63	3.15	-4.35	1.45	1.22	-6.06
Assam	1.85	2.19	3.02	10.89	13.88	22.44	NA	NA	NA
Bihar	2.13	4.73	-0.68	14.98	5.11	-1.58	2.14	1.92	0.23
Gujarat	-3.1	4.19	-5.9	5.79	4.61	-5.52	0.47	3.25	-1.15
Haryana	3.54	2.63	0.69	9.65	4.83	2.86	2.55	2.04	0.9
Himachal Pradesh	1.52	2.41	0.74	8.51	1.75	1.29	1.31	0.75	-0.11
Karnataka	3	2.86	-0.22	9.43	4.61	-1.05	5.03	1.54	-0.44
Kerala	2.21	2.61	2.24	10.26	-1.34	0.62	0.6	2.12	1.41
Madhya Pradesh	2.84	3.62	-6.71	15.51	3.39	-8.35	5.19	2.42	-4.2
Maharashtra	1.79	3.82	-0.24	9.55	4.59	-1.47	1.57	2.1	0.29
Orissa	2.89	-0.82	-4.08	10.2	6.98	-0.96	4.53	-1.49	-3.67
Punjab	4.59	1.1	1.4	4.59	1.74	0.26	1.95	0.73	0.73
Rajasthan	2.8	3.58	-8.4	9.43	8.88	-5.76	1.72	4.35	-3.25
Tamil Nadu	3.83	3.67	-9.3	5.81	2.28	-5.9	-1.23	1.59	-6.79
Uttar Pradesh	3.14	2.68	0.62	5.91	4.39	2.79	2.67	2.22	1.15
West Bengal	5.3	4.46	3.52	12.13	5.19	3.45	1.64	3.43	9.48

Output Response to Fertilizer and Irrigation

A set of production function was estimated for all the major states using crop output at 1993-94 prices as dependent variable and level of fertilizer, irrigation and some other variables considered as explanatory variables. These estimation were based on time series data for the period 1980-81 to 2000-01. For each state very large number of regression equations were estimated to arrive at credible estimates of output elasticity. There were serious problem of multi-collinearity among dependent variables because of which different specifications of variables were tried. Final estimates of output response to fertilizer and irrigation in terms of elasticity are presented in Table 5. The figures reported in table 1 indicate percent change in crop output resulting from 1 percent change in irrigation or fertilizer, as the case may be.

In the case of Andhra Pradesh one percent change in fertilizer resulted in 0.36 percent change in crop output. The impact of irrigation was almost double the impact of fertilizer. In the case of Assam, data on area under irrigation was missing for most of the years. Because of this area under irrigation could not be included in the regression

equation. Ultimately, average output response to irrigation in neighboring states of Orissa and West Bengal was used as a proxy of irrigation impact in Assam. Output response to fertilizer reveals that ten percent increase in use of inorganic fertilizer results in about two percent growth in crop output.

Table 5: Elasticity of crop output with respect to fertilizer and irrigation

State	Fertiliser	Irrigation
Andhra Pradesh	0.363	0.714
Assam	0.192	0.472#
Bihar	0.167	0.690
Gujarat	0.389	0.480
Haryana	0.283	0.660
Himachal Pradesh	0.398	0.965
Jammu and Kashmir*	0.398	0.965
Karnataka	0.251	0.942
Kerala	0.316	0.777
Madhya Pradesh	0.183	0.418
Maharashtra	0.294	0.585
Orissa	0.134	0.472
Punjab	0.231	1.382
Rajasthan	0.363	0.950
Tamil Nadu	0.700	1.004
Uttar Pradesh	0.330	0.826
West Bengal	0.450	0.303

#Refer to estimate for Orissa
* Refer to Himachal Pradesh

Crop output in Bihar was highly responsive to use of irrigation and fertilization. One percent increase in irrigation brought 1.2 percent increase in crop output. Similarly, one percent increase in fertilizer resulted in 0.53 percent increase in value of crop output. In Gujarat, unit increase in irrigation percent raised crop output by 0.5 percent. The impact of fertilizer was 0.4 percent. Crop output in Haryana increased by 0.28 and 0.66 percent in relation to one percent increase in fertilizer and irrigation.

In the case of Himachal Pradesh impact of irrigation was much stronger than that of fertilizer. For the state of Jammu and Kashmir adequate data was not available to estimate response of crop output to selected variables. Therefore elasticity variable pertaining to Himachal Pradesh, which is a neighboring state having similar topography were used. Crop output in Karnataka responded by 0.25 and 0.94 percent in response to

one percent change in fertilizer and irrigation. Response in neighboring Kerala was slightly higher for fertilizer and slightly lower for irrigation.

Crop output in Madhya Pradesh shows moderate response to plant nutrient and application of water. A ten percent increase in fertilizer and irrigation in Madhya Pradesh raised output by 1.83 and 4.18 percent. The response in Maharashtra was 2.94 and 5.85 percent corresponding to ten percent change in plant nutrient and irrigation.

It was very difficulty to track impact of fertilizer on output in the case of Orissa, due to unmanageable problem of multicollinearity between fertilizer and irrigation. Ultimately, two separate production functions were estimated for this state including fertilizer and irrigation turn wise. These functions show output elasticity with respect to fertilizer as 0.134 and with respect to irrigation 0.472. Exactly similar problem was encountered in the case of Rajasthan where irrigation and fertilizer defined in various forms show strong and detrimental multicollinearity. Crop intensity was used as another variable in different specification to represent irrigation and or fertilizer. Output elasticity from these specifications turned out to be 0.363 for fertilizer and 0.95 for irrigation.

Crop output in Punjab show moderate response to fertilizer but very high response to irrigation. Highest response to fertilizer was obtained in the case of Tamil Nadu where one percent increase in fertilizer brought 0.7 percent increase in output. Elasticity of crop output with respect to irrigation was one. Crop output in Uttar Pradesh increased by 0.33 and 0.826 percent in response to one percent increase in fertilizer and irrigation. Compare to this response to fertilizer was much higher and response to irrigation was much lower in the case of West Bengal.

Above estimates of elasticity were used in estimating output growth that can be achieved to various sources and for making projection about quantity of fertilizer needed to achieve specified growth rate in crop output.

Scope of Irrigation Expansion and Resulting Output Growth

As it is well know and as it would be found from above discussion irrigation is a very important source of growth in crop output. The possibility of irrigation expansion in various states in presented in Table 6. The table presents three kinds of growth rate in irrigation. The first set presents annual rate of growth in irrigation if irrigation potential

of the state is fully utilized by the year 2020. The irrigation potential refers to sum of major, medium and minor sources of irrigation. In other words, it includes total potential of surface and groundwater irrigation. The second set of growth rates represents actual achievements in creating irrigation during 1990/91 to 2000/01. This reflects the actual effect of efforts made in the recent past in expanding irrigation. The third set of growth rate named as "feasible growth rate" indicate the likely growth or future expansion of irrigation. This is taken as the potential growth rate corresponding to full exploitation of irrigation by the year 2020 except for the state of Punjab, Haryana and Rajasthan and Kerala. The former states have over exploited their irrigation potential and actual area under irrigation in these states is more than the potential. These states are treated as having no scope for further expansion of irrigation. In Kerala, actual utilization of irrigation potential is less than one fourth of the potential. Because of this Kerala requires 8.01 percent annual increase in area under irrigation to fully exploit the potential. But this growth rate seems very unlikely given the past performance of the state. Therefore, to have a modest estimate it is assumed that Kerala would exploit its irrigation potential at the same rate as the average of the country – which again is 50% higher than Kerala's achievement in irrigation in the past.

Table 6: Scope for Irrigation expansion and its impact on output growth

State	Irrigated area: 000 ha		Ultimate Potential	Growth rate to exploit potential in 20 years	Growth in recent 10 years	Feasible growth rate	Output growth achievable with irrigation growth
	TE 1990-91	TE 2000-01					
Andhra Pradesh	5421	5918	9500	2.39	0.88	2.39	1.71
Assam			2670			3.00	1.42
Bihar	4186	4789	12400	4.87	1.35	4.87	3.36
Gujarat	2639	3698	4847	1.36	3.43	1.36	0.65
Haryana	4188	5130	4550	-0.60	2.05	0.00	0.00
Himachal Pradesh	171	181	335	3.13	0.57	3.13	3.02
Jammu and Kashmir	434	445	800	2.98	0.25	2.98	2.88
Karnataka	2594	3185	4600	1.86	2.07	1.86	1.75
Kerala	395	450	2100	8.01	1.31	1.98	1.54
Madhya Pradesh	3985	5227	11200	3.88	2.75	3.88	1.62
Maharashtra	3203	3781	7300	3.34	1.67	3.34	1.95
Orissa	2865	2332	6100	4.93	-2.04	4.93	2.33
Punjab	6937	7516	6550	-0.69	0.80	0.00	0.00
Rajasthan	4493	6626	5350	-1.06	3.96	0.00	0.00
Tamil Nadu	2937	3570	4200	0.82	1.97	0.82	0.82
Uttar Pradesh	14420	18000	25700	1.80	2.24	1.80	1.49
West Bengal	2491	3369	6110	4.01	3.07	4.01	1.22
All India	62060	75810	115615	2.13	2.02	1.95	1.43

Among all states Orissa is the only state which shows decline in area under irrigation during last 10 years. The rate of decline is more than two percent per annum. This has happened despite the fact that Orissa has not yet exploited even 40 percent of its irrigation potential. It is feasible to expand area under irrigation in Orissa by close to 5 percent for almost two decades before reaching the level of potential. Bihar also has similar potential. Area under irrigation can be expanded by more than 3 percent per annum in the states of Himachal Pradesh, Madhya Pradesh, Maharashtra and West Bengal. The scope for irrigation expansion in Uttar Pradesh and Karnataka is 1.67 and 1.80 percent per annum respectively.

This expansion in irrigation translates to 1.43% growth in crop output at national level. Because it is not feasible to expand irrigation in Punjab, Haryana and Rajasthan, therefore, no contribution of irrigation towards output growth is visualized in these states. Irrigation has highest potential for output growth in the state of Bihar. The state can achieve 3.36% annual growth in output through irrigation alone till year 2020. Himachal Pradesh also shows potential of raising output by 3% through exploitation of irrigation. Jammu and Kashmir and Orissa shows high potential for output growth through irrigation expansion. The scope is 1.71% in Andhra Pradesh 1.49% in U.P and 1.22% in West Bengal, Gujarat and Tamil Nadu indicate scope to raise output by 0.65 and 0.82% per annum through irrigation.

Agriculture Growth through Crop Diversification

With serious constrains on area expansion and declining scope of other sources of growth of agriculture output, lot of emphasis is being placed on crop diversification as a source of output growth. In our exercise we have prepared estimates of output growth that can be achieved with one percent shift in area from food grain to non-food grain crops. This is done based on productivity of food grain and non-food grain and projected change in share of food grain and non-food grain in total cropped area. The results are presented in Table 7. The Table shows that at All India Level per hectare productivity of foodgrain at 1993-94 price was Rs 7744 where as per hectare productivity of non foodgrain crops was Rs. 21722. There is lot of variation in productivity of food grain and

non food grain across states. Per hectare output of foodgrain was less than Rs. 5000 in Rajasthan and Maharashtra. In contrast to this foodgrain productivity was more than Rs. 10000 in Andhra Pradesh, Tamil Nadu, West Bengal, Kerala, Haryana and Punjab. Similar variations exists in productivity of non food grain across States. Rajasthan is the only State where per hectare productivity of non-foodgrain was below Rs. 10000. Highest productivity of non food grain was observed in Himachal Pradesh where output of non-foodgrain was valued at Rs. 79378 per hectare. Punjab, which ranked at the top in terms of productivity of foodgrain, did not have high productivity of non-food-grain. Productiivity of non-foodgrain in the case of Punjab was less than national average. In other states the difference between productivity of foodgrain and non-foodgrain is quite high.

Table 7: Potential of diversification towards non foodgrains and its impact on output growth

State	Productivity Rs/ha			Area share % of Non Foodgrain				Output increase due to one % area shift	
	FG	Non FG	Average	TE 1982	TE 1991	TE 2001	2011	Rs./ha	Percent
Andhra Pradesh	11119	17331	13937	29.8	39.8	45.4	50.9	62	0.45
Assam	7231	30271	14346	27.3	29.2	30.9	32.6	230	1.61
Bihar	7782	32954	10426	10.4	9.8	10.5	11.2	252	2.41
Gujarat	5993	13630	11115	57.2	55.7	67.1	67.1	76	0.69
Haryana	12142	21952	14982	27.0	30.8	29.0	34.0	98	0.65
Himachal Pradesh	6390	79378	15416	9.5	10.9	12.4	13.8	730	4.73
Jammu & Kashmir	7844	71602	20044	14.5	16.3	19.1	22.0	638	3.18
Karnataka	5620	29437	14634	35.0	39.0	37.8	39.0	238	1.63
Kerala	12770	27664	25756	70.7	79.9	87.2	87.2	--	--
Madhya Pradesh	5414	12046	7535	17.6	23.5	32.0	40.5	66	0.88
Maharashtra	4376	20462	10806	30.9	33.5	40.2	46.8	161	1.49
Orissa	5377	16344	9233	22.6	26.3	35.1	44.0	110	1.19
Punjab	16008	21952	17463	28.0	25.3	24.5	29.5	59	0.34
Rajasthan	4562	9221	6438	29.8	34.0	40.4	46.8	47	0.72
Tamil Nadu	11968	35544	21901	34.8	38.4	42.1	45.9	236	1.08
Uttar Pradesh	8799	32954	13950	18.0	19.2	21.3	23.5	242	1.73
West Bengal	11150	37848	19124	19.8	24.3	29.9	35.5	267	1.40
All India	7744	21722	12656	27.2	30.4	35.1	39.9	140	1.10

The current status of diversification can be seen from share of area under foodgrain and non-foodgrain in total cropped area. Share of foodgrain in total area was more than 70 percent in Bihar, West Bengal and Northern States except Rajasthan. Least Diversified state is Bihar where close to 90 percent area is under food grain. This is followed by Himachal Pradesh where about 88 percent area is allocated to foodgrain.

Kerala, which is known for production of plantation crops, allocated less than 13 percent area to foodgrain. Crop Pattern shows much higher diversification towards non-foodgrain crops in all Southern States. These states alongwith Maharashtra and Rajasthan allocated more than 40 per cent area to non-foodgrain crops.

Projections on growth in output due to diversification towards non food-grain crops were based on difference in productivity and prospects of area shift. The prospects of area shift were based largely on the experience between TE 1991-92 and TE 2001-02. These estimation shows that highest diversification took palace in the state of Gujarat, Orissa and Madhya Pradesh. Gujarat has already allocated more than two third area to non foodgrains. Similarly, in Kerala more than 87 percent area is under non foodgrain crops. Based on discussion with the state level experts our assumption is that Kerala would not be able to further shift area away from food grains at state level. It is projected that in next 10 years area under non-foodgrain crops would increase by about 9 percent in Orissa and Madhya Pradesh as has been the experience during 1990s. Our projections show that annual shift in area from foodgrain to non-foodgrain would be 0.66 percent in Maharashtra, 0.69 percent in Rajasthan, 0.56 percent in West Bengal and Andhra Pradesh. Based on the past experience diversification is expected to be very low in Bihar.

Three states, namely, Karnataka, Punjab and Haryana show increase in area under foodgrain during 1990s. As serious attempts are being made in the State of Punjab and Haryana for diversification of their agriculture, we are presuming that these efforts would meet some, albeit small, success. Based on the discussions with experts of these two states it was found that it is reasonable to expect 5 percent shift in area away from food grains in next 10 years. This estimate is close to All India Average of 0.47 percent.

Due to variation in productivity per unit of area it is estimated that shift of one percent are from food grain to non-food grain would increase crop output by 1.10 percent at All India Level. The scope to raise output through diversification depend upon two factors. One difference in productivity and two base level area share. In Himachal Pradesh and Jammu & Kashmir scope to raise output through diversification is highest as one percent shift in area entails more than 3 percent growth rate in crop output at state level. Shift in one percent area from foodgrain to non foodgrain offers scope to raise crop output by 1.73 percent in Uttar Pradesh 1.6 percent in Karnataka and Assam, 2.4

percent in Bihar 1.5 percent in Maharashtra, 1.4 Percent in West Bengal, 1.2 percent in Orissa and 1.1 percent in Tamil Nadu.

Scope to Raise Output through TFP Growth

Up to date information on state-wise estimates of TFP of crop sector is not available for all the states. However, some scattered evidence for different states and for different periods were available. These were collated and pieced together to arrive at some credible estimates of TFP growth. One source is study by Kumar et al (2003) which provides estimates of TFP growth for the period 1981-96 for the states in Indo-Gangetic region. Another study by Desai (1997) provides estimates for TFP for different periods upto 1989-90 at All India level. These two studies also provide information about share of TFP in output growth of crop sector. These shares were used to estimate out put growth through improvement in TFP for the period 1991-92 to 20002-03. For some of the states for which TFP estimates were not available either a proxy was used or estimate of TFP in the states having similar resources endowment and agro climatic features was used. These estimates are shown in Table 8.

Table 8: Prospects of crop output growth through improvement in TFP

State	Output growth rates 1991/92-2002/03	Share of TFP %	Source	Output growth From TFP
Andhra Pradesh	1.36	29.62	Desai All India	0.40
Assam	2.57	34.22	Same as WB	0.88
Bihar	3.98	56.45	Kumar	2.24
Gujarat	1.26	37.17	Arid	0.47
Haryana	2.21	29.56	Kumar	0.65
Himachal Pradesh	2.98	36.21	Kumar	1.08
Jammu and Kashmir	1.16	36.21	Kumar	0.42
Karnataka	2.91	29.62	Desai All India	0.86
Kerala	2.03	29.62	Desai All India	0.60
Madhya Pradesh	0.89	29.62	Desai All India	0.26
Maharashtra	2.98	29.62	Desai All India	0.88
Orissa	0.46#	29.62	Desai All India	0.14
Punjab	1.23	29.56	Kumar	0.36
Rajasthan	0.68	37.17	Kumar	0.25
Tamil Nadu	1.18	29.62	Desai All India	0.35
Uttar Pradesh	2.32	25.81	Kumar	0.60
West Bengal	3.39	34.22	Kumar	1.16
All India	2.08	29.62	Desai All India	0.62

Growth rate during 1980-81 to 2002-03

Contribution of TFP to output growth was found to be as high as 56% in Bihar and as low as 26% in Uttar Pradesh. In agriculturally advanced states of Punjab and Haryana TFP contributed around 35% of out put growth.

Based on share of TFP in output growth and rate of growth of crop output during 1991/92 to 2002/03 it is estimated that improvement in TFP would make highest contribution to output growth in the state of Bihar. Here TFP would help in getting annual growth rate of 2.24% in crop output. Contribution of TFP of output growth is expected to be more than 1% in the states of Himachal Pradesh and West Bengal. In the case of Orissa output growth during 1991-92 to 2002-03 was negative. In order to compute TFP contribution historic growth of agriculture in Orissa was used which reveals 0.14% annual growth in crop output through improvement in TFP.

Scope to Raise Output through Growth in Fertiliser

Like irrigation, fertiliser has played an important role to tap potential of improved technology and to raise crop output. As can be seen from Table 9 fertilizer consumption witnessed sharp increase during the decade of 1980s. Consumption of fertilizer in the country increased from 32 kg / ha of net sown area in 1980-81 to 67 kg during 1990-91. Average annual growth in fertilizer use in this decade was 8.47 percent. This has been a major factor for reasonably high growth in agricultural production during the 1980s which exceeded average annual growth rate of 5 percent.

Table 9 : Growth in fertilizer use and crop output during 1980-81 to 2003-04

Period	Average annual rate of growth in		Average level of fertilizer use NPK/Ha of GCA
	Index of agricultural production	Fertilizer use	
1980-81 to 1990-91	5.07	8.47	32-67
1990-91 to 1999-00	2.26	4.67	67-95
1995-96 to 2003-04	1.40	2.60	75-90
2000-01 to 2003-04	1.21	-1.63	

Note : Growth rates are average of annual rate of increase in the given period

Fertilizer growth during 1990s turned out to be 4.40 percent as against 8.08 percent during 1980s for the whole country. One of the reasons for high growth in fertilizer was low base as fertilizer use in early 1980s was only 32 Kg/ha. Thus, though growth rate in fertilizer use during 1990 was relatively lower but still at 4.40 percent it was reasonable. This growth helped India to raise per hectare use of fertilizer to 95 Kg

during 1999-00. Average fertilizer use in the recent three years covering 2001-02, 2002-03 and 2003-04 turned out to be 88 kg which is 7 percent lower than the record level reached in 1999-00.

Among different states variation in use of fertilizer is very wide – the ratio of lowest to highest state is 1 : 5.38. This indicates immense potential to promote fertilizer use in various states. Moreover, within the states there are wide inter-district variations in fertilizer use which further underscores the scope for increasing fertilizer use. Even in agriculturally most developed state of Punjab district wise use of fertilizer shows a large range. This indicates that both categories of states, using low fertilizer and those using high level of fertilizer, there is a scope to raise fertilizer use and through that agricultural output.

As pointed out earlier, stagnation in irrigation and fertilizer use are the major factors for sharp deceleration in agricultural output in the recent years. Our exercise reveals that if fertilizer use is increased at about the same rate as witnessed during the decade of 1990s it would help India to annually increase its agricultural output by 1.32 percent. This growth rate in fertilizer is not ambitions or difficult to achieve as it involves raising fertilizer use in the country from 88 kg, as of now (TE 2003-04), to 147 Kg by the year 2014-15.

Application of fertilizer in most of the states in the recent years remained either stagnant or declined. This happened despite the fact that level of fertilizer in most of the states is low. The level of fertilizer use and its growth in different time periods is presented in Table 10.

At state level feasible growth rates in fertilizer in future may be more or less the same as were achieved during 1990s, depending upon scope to expand irrigation and existing level of fertilizer use. Accordingly, growth rates in fertilizer considered feasible for various states are presented in Table 10. It seems likely that Andhra Pradesh, Bihar, Gujarat, Himachal Pradesh, Jammu and Kashmir, Karnataka, Maharashtra, Orissa, Punjab, Tamil Nadu, U.P and West Bengal are in a position to increase fertilizer use by same rate as witnessed during 1990s. Rajasthan and Haryana seem to be in a situation to attain half the growth rate seen during 1990s as opportunities for expanding irrigation, which is an important factor for promoting fertilizer use, in these two states are

constrained by the potential. Assam is also presumed to achieve half the growth rate of 1990s which was on a very high side. Fertilizer consumption in Kerala declined during 1990s. as there is considerable scope to increase are under irrigation in Kerala, the state has potential to increase fertilizer at the same rate as its neighboring state Karnataka. Despite lowest level of fertilizer use Madhya Pradesh recorded below average growth in fertilizer use during 1990s. It is presumed the MP would be able to increase fertilizer use at least by national average growth of 1990s.

Table 10: Fertiliser use and Scope to increase output through increase in fertiliser

	Growth rate			Fertiliser use Kg/ha		
State	1980/81 to 89/90	1990/91 to 99/00	Feasible growth rate	TE 2003-04	2014-15	Output growth from increase in fertiliser
Andhra Pradesh	9.63	3.15	3.15	144	210	1.14
Assam	10.89	13.88	6.94	39	87	1.33
Bihar	14.98	5.11	5.11	82	149	0.85
Gujarat	5.79	4.61	4.61	77	132	1.79
Haryana	9.65	4.83	2.42	154	205	0.68
Himachal Pradesh	8.51	1.75	1.75	40	50	0.70
Jammu & Kashmir	9.97	5.11	5.11	61	111	2.03
Karnataka	9.43	4.61	4.61	101	173	1.16
Kerala	10.26	-1.34	4.61	62	107	1.46
Madhya Pradesh	15.51	3.39	4.40	32	54	0.81
Maharashtra	9.55	4.59	4.59	75	129	1.35
Orissa	10.20	6.98	6.89	38	86	0.92
Punjab	4.59	1.74	1.74	172	212	0.40
Rajasthan	9.43	8.88	4.44	33	56	1.61
Tamil Nadu	5.81	2.28	2.28	136	178	1.60
Uttar Pradesh	5.91	4.39	4.39	126	211	1.45
West Bengal	12.13	5.19	5.19	123	225	2.34
All India	8.08	4.40	4.35	88	147	1.32

The above mentioned increase in use of fertilizer would enable most of the states to achieve annual growth rate in output in the range of 1-2 percent. Feasible growth rate in output through increase in fertilizer would be minimum in Punjab - 0.40 percent. Haryana, Himachal Pradesh and Bihar are also projected to attain less than 1 percent annual growth in output through fertilizer. West Bengal and Jammu and Kashmir have potential to realize more than 2 percent annual growth in output by increasing application of plant nutrients.

Output Growth from All Sources

Expansion of area under irrigation, improvement in total factor productivity, resource shift towards high value enterprises and increase in application of fertilizer are the four sources of growth in agriculture. Crop intensity is another source for output growth but in our exercise its impact on output is captured by impact of irrigation on output. Scope to raise agricultural output through various sources in different states is summarized in Table 11.

Feasible growth rate in Punjab through all the four sources turns out to be lowest and less than 1 percent. Bihar has the scope to raise crop output annually by 6.64 percent in medium term which is highest among all the states. Growth prospects seem to be low in Haryana and Rajasthan which are projected to achieve 1.66 and 2.33 percent growth in crop output. Maharashtra, Himachal Pradesh and West Bengal possess potential for more than 5 percent growth rate. Growth prospects are also high for Orissa. Output growth rate in the remaining states is projected to be between 3-4 percent.

Table 11 : Output growth towards 2011 through various sources

State	Diversification	Irrigation	TFP	Fertiliser	Total
Andhra Pradesh	0.25	1.71	0.40	1.14	3.50
Assam	0.27	1.42	0.88	1.33	3.89
Bihar	0.18	3.36	2.24	0.85	6.64
Gujarat	0.78	0.65	0.47	1.79	3.69
Haryana	0.33	0.00	0.65	0.68	1.66
Himachal Pradesh	0.69	3.02	1.08	0.70	5.49
Jammu & Kashmir	0.90	2.88	0.42	2.03	6.23
Karnataka	0.19	1.75	0.86	1.16	3.96
Kerala	0.00	1.54	0.60	1.46	3.60
Madhya Pradesh	0.75	1.62	0.26	0.81	3.44
Maharashtra	0.99	1.95	0.88	1.35	5.18
Orissa	1.05	2.33	0.14	0.92	4.44
Punjab	0.17	0.00	0.36	0.40	0.94
Rajasthan	0.46	0.00	0.25	1.61	2.33
Tamil Nadu	0.40	0.82	0.35	1.60	3.17
Uttar Pradesh	0.37	1.49	0.60	1.45	3.90
West Bengal	0.78	1.22	1.16	2.34	5.49
All India	0.49	1.43	0.72	1.32	3.96

As it is obvious above growth rates are to be achieved by expanding irrigation, promoting fertilizer, crop diversification and growth in TFP. Actual growth rates required in fertilizer, irrigation, area under non foodgrain crops and TFP to achieve 4 percent growth rate in output are summarized in Table 12.

Table 12: Statewise growth in various factors needed to achieve 4 % output growth at national level

State	Fertiliser	Irrrigation	Area shift to non foodgrain	TFP
Andhra Pradesh	3.15	2.39	0.555	0.40
Assam	6.94	3.00	0.166	0.88
Bihar	5.11	4.87	0.074	2.24
Gujarat	4.61	1.36	1.136	0.47
Haryana	2.42	0.00	0.500	0.65
Himachal Pradesh	1.75	3.13	0.146	1.08
Jammu & Kashmir	5.11	2.98	0.283	0.42
Karnataka	4.61	1.86	0.116	0.86
Kerala	4.61	1.98	0.000	0.60
Madhya Pradesh	4.40	3.88	0.854	0.26
Maharashtra	4.59	3.34	0.664	0.88
Orissa	6.89	4.93	0.884	0.14
Punjab	1.74	0.00	0.500	0.36
Rajasthan	4.44	0.00	0.640	0.25
Tamil Nadu	2.28	0.82	0.374	0.35
Uttar Pradesh	4.39	1.80	0.213	0.60
West Bengal	5.19	4.01	0.559	1.16
All India	4.35	1.95	0.497	0.72

India need to increase fertilizer consumption in agriculture by 4.35 percent and area under irrigation is required to be increased annually by 1.95 percent in order to contribute towards goal of achieving 4% output growth. Further, there is a need to shift about 0.5 percent area from foodgrains to non-foodgrains every year. Achieving these is quite feasible in the light of achievements in these factors in the past and in the light of available potential. Growth in TFP in India is projected to be 0.72 % per year at all India level. Here it needs to be mentioned that TFP consists of contribution of several factors. The most important among these is technology and its dissemination. Improvement in infrastructure and farmer's knowledge and skill applied to farming are other contributions to TFP.

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