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Constraints to Growth in Indian Agriculture: Needed Technology, Resource Management and Trade Strategies*

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At the outset, I would immensely thank the Society for selecting me as President for the 63rd Annual Conference and I think this annual meet provides a greater opportunity to bring together the members of agricultural economics tribe in this country to meet, know each other, take stock of the developments in the profession, motivate the young agricultural economists to actively participate in professional activities and explore the scope to nurture the profession. Indian agriculture is fast changing as a result of new developments in natural resource supplies and demand, emerging economic opportunities due to transformation taking place both within the national border and outside, and to meet the challenges of persistence of socio-economic problems such as poverty, unemployment, gender bias, worsening income distribution, etc. I take this opportunity, so generously given to me by the members of the Society to place before you, my understanding of the current problems plaguing Indian agriculture. In this address, I am not attempting to propose solutions for the issues, but venture to place before you a collection of wisdom of leading researchers and eminent economists working on the issues of agricultural development in this country. I also, with all humility, make an attempt to throw some light on complex relationships, which exist among the socio-economic and technological variables, which have significant implications for agricultural development and for the welfare of the people who are dependent on agriculture so that this learned and high profile audience can continue to debate, discern out issues and propose framework for designing policies and programmes and for their implementation.

I

CHALLENGES

Agricultural technologies generated adequate margin of returns over costs in the early phases of green revolution. Widespread adoption of yield boosting agricultural technologies particularly in the irrigated areas coupled with development of rural infrastructure such as rural markets, irrigation, roads and electrification were

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responsible for higher growth in agriculture. Public investment on agricultural research and extension along with better crop production strategies also stimulated agricultural growth in India (Kumar and Rosegrant, 1994). However, the gains from the green revolution areas have been plateauing due to decline in land and factor productivity. Apparently, growth rate in production of many crops has come to stagnate in recent years due to many constraints with almost no hope for increasing area under cultivation.

Growing population in India outstrips agricultural growth as a result incremental gain is divided proportionately by more people. So desired goals of poverty reduction and food security are not realised within the defined time horizon. Growing population puts enormous pressure on the available natural resources and infrastructure, which become more and more fragile. Grain harvested area per person, which was 0.22 per ha during 1950 in India declined to 0.10 ha during 2000 and it is projected to be 0.06 ha in 2050 (USDA, 2002). We have the world's largest concentration of the poorest of the poor. Widespread poverty is a terrible anachronism and that traditional ways of alleviating poverty have not worked. Then how to pull the 260 million people in the country out of poverty? What would be the imaginative and innovative approaches, which could be contemplated in the context of technological stagnation, resource degradation and declining public investment in agriculture? And trade liberalisation has also thrown up new challenges opening up more opportunities for agricultural exports and possibly surging imports.

A perceptible decline in the contribution of the agricultural sector to the overall gross domestic product (GDP) growth and the emergence of the services sector as the prime mover of the economy indicates that the real income generation is not taking place in the agricultural sector. No doubt, high growth in agriculture is essential to reduce poverty and attain various social objectives. A growth rate of four to five per cent in agriculture is targeted to achieve the set objectives. The question before us is how best the country could formulate and implement appropriate policies and programmes to achieve the desired socio-economic goals. The country has comparative advantages in certain crops. How to gain more out of the freer trade regime? 'So far what are our experiences' and 'what should be India's future agenda to keep the pace of growth in agriculture' are explored in this address.

II

CONSTRAINTS TO GROWTH

Technological Constraints

(i) *Modern Varieties*

Technology that heralded the process of green revolution during 1970s and 1980s started showing signs of deceleration during 1990s. In the 1970s, agricultural production growth was comparatively low, growing at an average annual rate of 1.95 per cent. In the 1980s, it grew at 3.82 per cent per annum. Since 1990, production growth has slowed, growing at only 2.09 per cent per annum (Fan, 2002). To obtain important insights about the technological stagnation, contribution of technological change to the increase in agricultural production was estimated by following the method of Intriligator (1978).[1] The results provide evidences that the contribution of technological change to agriculture declined over the period (Tables 1 and 2). The output elasticities show that these were positive and high in the case of land. The very low and negative elasticity of production with respect to institutional credit is also understandable in the early years that institutional credit has not made a big dent in the agricultural sector but in the later years its contribution is felt.

TABLE 1. TECHNOLOGICAL CHANGES IN AGRICULTURE-ALL INDIA (REGRESSION ESTIMATES)

Particulars (1)	Coefficients (2)	t- value (3)
1970s		
Constant	0.983	0.808
Cropped area	1.103	7.781
Agricultural labour	-0.074	-0.795
Credit	-0.120	-1.389
1980s		
Constant	-0.860	-0.781
Cropped area	1.144	7.794
Agricultural labour	-0.044	-0.503
Credit	-0.080	-0.954
1990s		
Constant	-14.53	-4.684
Cropped area	1.991	4.254
Agricultural labour	- 0.304	-0.863
Credit	0.297	1.209
Overall		
Constant	0.556	0.511
Cropped area	0.832	3.633
Agricultural labour	0.111	0.671
Credit	0.034	0.372

R^2: 94 F: 44.66 (1970s) R^2: 0.94, F = 85.54 (Overall),
R^2 : 96, F: 94.34 (1980s) R^2 : 92, F: 48.80 (1990s).

TABLE 2. OUTPUT ELASTICITIES AND RATES OF TECHNOLOGICAL CHANGE FOR INDIAN AGRICULTURE, 1970-71 TO 2001-2002

Period	Elasticity with respect to			Rate of technological change
	Land	Labour	Credit	
(1)	(2)	(3)	(4)	(5)
1970s	1.103	-0.074	-0.120	0.011
1980s	1.144	-0.044	-0.080	0.006
1990s	1.991	-0.304	0.297	-0.050
Overall	0.832	0.111	0.034	0.010

Technological stagnation is supported by an increasing evidence of stagnating levels of productivity growth of crops even in many potential areas as the trend in productivity is not consistently upward in many states of India (Annexures 1 and 2). The growth has been flat and has started declining in some of the progressive states and reversing the trend will not be easy. This is due to differential levels of adoption of new technologies, varying degrees of water control, imbalances in infrastructure development and a host of other factors. Differential levels of adoption of modern varieties are also one of the causes for stagnation in yield levels. Adoption of modern varieties of major crops even now met with only partial success

(Asaduzzaman, 1979; Shotelersuk-vivat, 1981; Agarwal, 1985; Thapa, 1989; Fugile, 1989; Hossain, 1990; Azam, 1995; Hossain, 1996) as the area under high-yielding varieties (HYVs) is still low. About 40 per cent of the cropped areas in the country are under HYVs in 1996-97 and it increased from 21 per cent in 1970. The area under HYVs of crops ranged between 2 per cent and 69 per cent across the states and this differential adoption rate accentuates the income disparities among the region. The estimated Gini coefficient of 0.60 implies that there is wide variation among the states in the adoption of HYV of crops (Ramasamy and Selvaraj, 2001).

The lackadaisical pace of growth was witnessed even in rice. India is still amongst the countries with the lowest rice yields. Seventy per cent of the 414 rice-growing districts report yields lower than the national average, clearly indicating that well after the advent of high yielding technology, a sizable area is categorised as low producing. Sixty per cent of the low productivity rice areas are in Bihar, Orissa, Assam, West Bengal and Uttar Pradesh. Surprisingly 32 per cent of the irrigated rice areas produce low yields (www.math.tau.ac.il). Yield gap analysis further reveals that 30 to 40 per cent of the potential yield is yet to be tapped with the available high-yielding varieties sown on highly productive irrigated soils. After a long period of technological breakthroughs and adoption, yield gap still exists in many of the States as could be seen from the Table 3. In the country more than 50 per cent of the potential yield even in the case rice is not realised yet.

TABLE 3. YIELD GAP IN PADDY IN MAJOR RICE GROWING STATES, 1990-91 TO 1997-98

(kg/ha)

Zone/ State	State average	Experimental plot average*	Yield difference	Gap - State average vs experimental average (per cent)
(1)	(2)	(3)	(4)	(5)
South Zone				
Tamil Nadu	4,460	5,286	826	15.6
Andhra Pradesh	3,767	5,882	2,115	36.0
Karnataka	3,456	5,250	1,794	34.2
Kerala	2,857	5,690	2,853	49.8
North Zone				
Punjab	5,042	6,460	1,418	22.0
Haryana	4,074	7,396	3,322	44.9
Uttar Pradesh	2,870	6,598	3,728	56.5
East Zone				
West Bengal	3,147	5,003	1,856	37.1
Orissa	1,993	5,620	3,627	64.5
Bihar	1,811	6,083	4,272	70.2
Assam	1,954	6,437	4,483	69.6
East Uttar Pradesh	1,881	6,598	4,717	71.5
Manipur	3,233	7,619	4,386	57.3
West Zone				
Maharashtra	2,380	4,501	2,121	47.1
Gujarat	2,146	5,557	3,411	61.4
Madhya Pradesh	1,581	4,710	3,129	66.4
Rajasthan	1,582	6,485	4,903	75.6
North West Hills				
Jammu and Kashmir	2,774	7,254	4,480	61.8
Himachal Pradesh	1,976	5,003	3,027	60.5
India	2,759	5,781	3,022	52.3

* Mean yield of best entries from AICRIP test locations over 7 years period. *Source*: Siddiq (2000).

Non-price prerequisite for sustaining the agricultural production, namely, the technology receded in the later periods and its bearing on the profitability of crops is also reflected in the output-input ratios of the many crops. The surplus production of rice and wheat could not be exported profitably as the ruling prices in the international markets remained far below the cost of procurement. Consequently with mounting stocks, the prices of the commodities in the domestic market fell far below the cost of production. In the case of paddy a proportionate increase in the cost of production was more than the increase in income (Tables 4 and 5) and as a result, the benefit-cost ratio declined to 1.41 during 2000-01 from 2.45 per cent in 1973-74. The benefit-cost ratios for majority of the crops in many of the states declined over the years due to various factors. This has reflected in declining Total Factor Productivity (TFP). It grew at an average annual rate of 1.37 per cent per annum in the 1970s and grew faster in the 1980s, at 1.99 per cent per annum. Since 1990, TFP growth in Indian agriculture slided downwards, at the rate of –0.9 per cent per annum (Fan, 2002).

TABLE 4. TREND IN COST AND INCOME IN RICE PRODUCTION

(per cent)

Year (1)	Cost (2)	Income (3)
1983-84 over 1973-74	232.51	215.35
1992-93 over 1983-84	254.89	125.67
1997-98 over 1992-93	317.46	47.95
1998-99 over 1997-98	6.92	5.90
1999-00 over 1998-99	6.73	9.33

Source: Scheme on "Cost of Cultivation of Principal Crops", Ministry of Agriculture, Government of India; data relate to Tamil Nadu.

TABLE 5. BENEFIT-COST RATIO IN RICE PRODUCTION

Year (1)	Total operational cost (Rs./ha) (2)	Total income (Rs./ha) (3)	Benefit-Cost ratio (4)
1973-74	1,012	2,482	2.45
1983-84	3,365	7,827	2.33
1992-93	11,942	17,663	1.48
1997-98	18,107	26,132	1.34
1998-99	19,360	27,674	1.42
1999-00	20,662	30,255	1.46
2000-01	20,142	28,435	1.41

Source: Scheme on "Cost of Cultivation of Principal Crops", Ministry of Agriculture, Government of India; data relate to Tamil Nadu.

Decline in factor productivity and output-input ratios clearly substantiate that the returns to investment in agriculture seem to have been declining. Farmers may have been able to maintain yields of modern varieties through the application of higher amounts of non-land inputs, which means a declining trend in TFP and profitability in farming. Without impressive growth in the productivity of crops, the farmers are forced to extend cultivation to marginal lands due to low profitability and this aggravates the problem of sustaining the natural resource base. Therefore, potential for increasing production of crops through adoption of wide range of modern technologies has remained unexploited in many parts of the country because of unfavourable output-input prices.

(ii) *Agro-Chemical Use*

Commercialisation of agricultural sector, changes in product mix and declining labour productivity and labour use are the major factors that drive the intensive use of fertilisers, pesticides and herbicides. There are indications that overuse and unbalanced use of fertilisers in the assured areas of irrigation is leading to declining output-input ratio, increasing micronutrient deficiency and declining soil quality and rise in groundwater pollution. A calculation has shown that fertiliser use efficiency was 17.1 in 1970-71, but decreased to 10.3 in 1980-81 and 8.1 in 1988-89 and expected to decline to 6.5 in 2000 as judged by the additional food grains produced and attributable to fertilisers (Sankaran, 1990). The declining efficiency coupled with increasing price of fertilisers is causing great concern as it is reducing the economics of fertiliser use. The imbalances in the fertiliser use are reflected in the deviation of NPK ratio from the recommended level of 4:2:1, which deteriorated the quality of soils. Imbalances in the fertiliser use were found in all the periods and the states (Annexure 3). Fertiliser consumption was 25.75 kg per ha during 1970s and it increased to 78.43 kg per ha during 1990s registering a growth rate of 3.94 per cent between 1990-91 and 2000-01. There was however notable disparity in fertiliser use among the States during 1970s and 1980s and the variation has declined marginally during 1990s (Gini ratio is 0.46, 0.49 and 0.43 during 1970s, 1980s and 1990s, respectively).

The pesticide use is declining in quantitative terms, due to the increased use of bio-pesticides, cultivation of more pest-resistant varieties and improved pesticide application efficiency (Birthal *et al.,* 2000). The use of herbicides is increasing and it is likely to increase in the future with decline in labour use and the release of herbicide-tolerant crop varieties such as Roundup Ready Soybean. More specialisation in product mix towards production of fruits and vegetables for competitive markets is also likely to increase the use of agro-chemicals. It is more likely that a number of pesticides will go obsolete as pests develop genetic resistance. Irrational use of pesticides has led to serious problems and in some crops, like rice in Asia. The costs of pesticide use are already higher than the benefits once if the environmental costs are included (Rola and Pingali, 1993). Ever since the landmark study by Carson (1962), many researchers have reported increasingly convincing evidences for pesticide residues in food chain and its consequences on human health.

(iii) *Mechanisation*

Mechanisation complements modern varieties to realise the production potential (David and Otsuka, 1994). The spread of modern varieties induced labour saving technologies such as use of tractors, threshers and farm equipments, and their easy availability due to custom hiring facilitated even small farmers to adopt these technologies. The preposition that the labour saving technologies like tractors had expanded rapidly and they were substituted for human and bullock labour is partially supported by statistical evidences. The share of human labour cost in paddy production remained almost constant; decreasing in recent years over the three decades ending 2001. The use of bullock labour in both small and large farms has sharply declined. The machine labour's share in the total cost of production of both small and large farms has risen sharply in the same period. Growth rates in labour use confirm the results churned out from cost analysis (Table 6).

TABLE 6. RATE OF GROWTH IN LABOUR UTILISATION, 1972-73 TO 1999-2000

(per cent per ha)

Particulars (1)	Growth rate (2)
Human labour	-1.70
Animal labour	-12.17
Machine labour	2.60

Source: Scheme on "Cost of Cultivation of Principal Crops", Ministry of Agriculture, Government of India; the estimates are for Tamil Nadu.

Labour cost saving mechanical technologies with less drudgery and higher burden of maintenance of draught animals were the factors responsible for decline in use of animal labour. The rate of machine labour utilisation per hectare has grown at the rate of 2.6 per cent per annum. Much of growth in the use of tractors in land preparation was attributed to the availability of competitive rates with lesser variation in hiring rates. The other factors that influenced use of tractors are ease of land preparation, timeliness and quality of work done. Despite decrease in use of human and animal labour, there was a rapid rise in wage rates for human labour and animal labour. Estimated labour demand equations confirm the above results as the wage rates did not influence human labour employment but competitive machine labour rates led to its rational application (Table 7). Thus the human labour market is more distorted with more unequal distribution of total wages.

TABLE 7. PRICE ELASTICITY OF LABOUR DEMAND

Labour (1)	Elasticity (2)
Human	0.1431
	(1.424)
Animal	- 0.4028**
	(- 2.083)
Machine	- 0.1011***
	(- 6.9077)

Figures in parentheses denote ‘t’ ratios.
** and *** Significant at 5 and 1 per cent level of probability (two-tailed test).

The elasticity of machine labour with respect to farm size reveals that the magnitude of elasticity is not uniform over the years both in small and large farms. This means, complementarity between machine labour use and farm size was not an universal phenomenon and scale neutrality of adoption of mechanical technologies is confirmed (Table 8).

TABLE 8. ELASTICITY OF MACHINE LABOUR DEMAND WITH RESPECT TO FARM SIZE IN PADDY PRODUCTION

Year (1)	Small farms (2)	Large farms (3)
1972-73	0.23	0.15
	(0.61)	(0.39)
1981-82	0.75	-0.51
	(1.66)	(0.67)
1992-93	-0.006	0.02
	(-0.53)	(0.07)
1999-00	0.20	-0.03
	(1.18)	(-0.28)

Figures in parentheses are t ratios. The estimates are for Tamil Nadu using CCPC data.

The possible effect of mechanisation on rice yield was examined by estimating the marginal productivity of labour. The marginal productivity of machine labour was positive and significant in most of the crops (Table 9), while marginal productivities of animal labour and human labour were negative indicating that there would be significant yield advantages by the adoption of mechanisation and reduction in human labour employment. Of all the modern agricultural technologies introduced, mechanisation was subject to more debate. Mechanisation has been blamed for exacerbating rural unemployment. Agricultural labour households' level of income largely depends on the availability of wage employment and real wage rate. The results reveal that labour absorption in agriculture must have a significant impact on agricultural productivity for income generation, for labour households. According to Bhalla (1987), labour productivity has not increased proportionately with increase in labour absorption in agriculture. Hence it is paradoxical that can mechanisation be promoted? And in what way? The proper selection, utilisation and management of farm power resources are crucial. Since the efficiency in rice production is crucial given the demand for low prices of food grains to ensure food security for the poor, and also the export demand for rice in the world market, it is advisable to continue to promote mechanisation in agriculture. Concurrently, policies and programmes which could offer alternative employment for the rural poor in rural non-farm sector and in building rural infrastructure must be designed and implemented to minimise the problem of unemployment in the rural areas.

TABLE 9. MARGINAL PHYSICAL PRODUCTIVITY OF LABOUR IN PADDY PRODUCTION

Type of labour (1)	Marginal Physical Productivity (2)
Human labour	-0.0124
	(-1.235)
Animal labour	-0.0518**
	(-3.483)
Machine labour	0.0575*
	(1.752)

Figures in parentheses denote t ratios; ** and * Significant at 5 and 10 per cent level of probability. The estimates are for Tamil Nadu using CCPC data.

(iv) *Rainfed Bias*

Policies, so far, have been focused more towards irrigated agriculture to increase agricultural production through public investment. Public investments in agriculture stimulated private investment due to complementarity (Dhawan and Yadav, 1995). Less-favoured areas in India cover 70 per cent of the cropped area, contributing nearly 40 per cent of the total production and account for most of the commodities, which are in short supply (Kanwar, 1991; Rao, 1991). Irrigated areas continue to provide net social returns and they cannot be neglected. But it is argued that the productivity returns to investment leading to economic growth have substantial trickle down benefits for the poor not only in irrigated areas but also those residing in less-favoured areas (Fan and Hazell, 2000).

Large areas of less-favoured regions are characterized by resource-poor, small and marginal farmers and tend to be backward in infrastructure, amenities and supporting services for agriculture and particularly suffer low investments on technology and inputs. Droughts and crop failures are quite common in dry areas, as the soil moisture availability often does not match with evaporative demand. The estimated loss in rainfed rice production in Tamil Nadu due to occurrence of droughts during the last 30 years is to the tune of 30 per cent of rainfed rice production (Ramasamy and Selvaraj, 2003). Loss in employment was 17 per cent which was calculated based on the employment elasticity of 0.6 (Bhalla, 1987).

In the rainfed areas, the productivities of crops are closely linked with the onset and distribution of rainfall. Moreover, cultivation of crops in the marginal lands and absence of major breakthroughs in the development of input responsive and drought tolerant crop varieties are partly responsible for poor productivity growth. Limited irrigation water will continue to be a major constraint for agricultural growth in rainfed areas. The Ministry of Agriculture, Government of India, as a strategy to develop rainfed areas considers watershed development, and it defines rainfed area to be those with less than 30 per cent of their cropped area under irrigation at the time of initiation of the programme.

The rainfed areas are distributed mainly in the semi-arid and sub-humid climatic zones. Though the yield-increasing technologies have been spreading in dry land areas, readiness of the farmers to adopt them when made available is questionable due to lack of sufficient resources for investments, particularly on inputs such as fertilisers and mechanical technologies. Studies suggest that dry land technologies are still inadequate to get small and marginal farmers out of poverty trap in dry land regions. Therefore, further developments in technologies in terms of more input responsive and drought tolerant crop varieties, cost effective crop management practices, more investments on effective rainwater harvesting and storage and improved soil moisture management are critical to increase crop productivity.

The past few decades show a secular rise in area under HYVs in rainfed and dry land areas and has reached a reasonable level (Table 10). However, there is a big productivity gap between irrigated and rainfed areas. The gaps are more pronounced in sorghum, bajra, ragi, groundnut and gingelly. This means with improved resource

TABLE 10. HIGH-YIELDING VARIETIES IN IRRIGATED AND RAINFED PRODUCTION ENVIRONMENTS, SELECTED CROPS

(per cent)

Crops (1)	Irrigated areas (2)	Rainfed areas (3)
Paddy	97.67	85.59
Cholam	66.52	65.34
Cumbu	79.89	72.44
Ragi	84.63	61.45

Source: Based on secondary data for the year 2001-02; average of selected states.

and crop management, part of the gap can be closed. The large gab is because though the HYVs have spread to dry land areas, adoption of associated technologies have been poor. Increase in land productivity cannot be achieved unless soil and moisture conserving and other land-augmenting technologies are adopted concurrently. Under declining public investment in agriculture, it is increasingly important to have a balanced investment, between irrigated and rainfed areas. It is reported that the highest marginal impact on production and poverty alleviation is realised in the rainfed areas as compared to irrigated areas (Fan and Hazell, 2000) and is shown in Table 11. The experiences of watershed programmes indicate the advantage of development of these areas on watershed basis with less investment. Agricultural intensification in rainfed areas really requires better approaches and strategies and higher proportion of investment.

TABLE 11. MARGINAL RETURNS TO INVESTMENT ON INFRASTRUCTURE AND TECHNOLOGY INVESTMENTS IN RURAL INDIA - 1990 PRICES

Particulars (1)	Irrigated areas (2)	High potential rainfed areas (3)	Low potential rainfed areas (4)
Economic returns			
High-yielding varieties (Rs./ha)	63	243	688
Canal irrigation	938	3310	1434
Private irrigation	1000	-2213	4559
Electrification	-546	96	1274
Education	-360	571	102
Poverty reduction (persons/ha)			
High-yielding varieties	-	0.02	0.05
Canal Irrigation	0.01	0.23	0.09
Private irrigation	0.01	-0.15	0.30
Electrification	0.01	0.07	0.10
Education	0.01	0.23	0.01

Source: Fan and Hazell (2000).

Resource Constraints

(i) *Marginalisation of Holdings*

A central issue in agricultural development is the necessity to increase productivity, employment, and income of poor segments of the agricultural population. Among the rural poor, the small farmers constitute a sizeable portion in the developing countries. Studies by FAO have shown that small farms constitute between 60-70 per cent of total farms in developing countries and contribute around 30-35 per cent to total agricultural output (Randhawa and Sundaram, 1990). Liberalisation era began in India when over 40 per cent of the rural households were landless or near landless; and over 96 per cent of the remaining 60 per cent owned holdings but over two-third of the owned land belonged to marginal, small and semi-medium size groups. The decade, 1971-72 to 1991-92, witnessed a marked intensification of the marginalisation process. Small farmers emerged as the size group with the largest share of 33.97 per cent in the total land in 1971-72 which just doubled during the next two decades. As regards the large farmers, they were one per cent of the total owners in 1990-91 but owned nearly 13.83 per cent of the total land. The average size of holding decreased to 1.55 ha during 1990-91. Gini coefficients estimated to examine variation in the average size of holdings across the states showed that marginalisation process has been taking place in all the states simultaneously (Annexure 4). The number of operational holdings increased to 106 millions during 1990-91 from about 70 millions in 1970-71. This trend of marginalisation will continue in the future but at a slower magnitude.

(ii) *Land Degradation*

Natural resource degradation in rural areas is causing serious concern. Sustainable management of land resources is beset with two kinds of problems – managing the quantitative and the qualitative dimensions of land. The quantitative dimension relates to issues such as (i) increasing human and animal population pressure on land and changes in the land use patterns, viz., increase in fallow lands, decline in forest cover, etc. which could be reversed through appropriate technologies and policies, and (ii) erosion and loss of top-soil which is very difficult to reverse. The qualitative dimension relates to the loss of nutrients and the pollution of soil environment by agricultural and non-agricultural activities which are relatively expensive to deal with. Some of these qualitative deteriorations of soil are not reversible even over a fairly long period of time.

There are wide differences among the studies in their estimates of the extent of land degradation due to different reasons. The estimates vary from about 36 million ha to 188 million ha (Table 12). The economic costs of land degradation also show wide differences due to the differences in the estimates of extent of degradation and also due to the methodology followed for estimating the losses. The costs based on experimental data vary between Rs. 25,600 million accounting for 1.4 per cent of GDP and 3.9 per cent of agricultural GDP to as high as Rs. 448,640 million accounting for 5.6 per cent of GDP and 17.11 per cent of agricultural GDP. The costs of degradation based on production function estimates vary from about Rs.10, 000 million (0.45 per cent of GDP) to Rs.56,800 million (2.82 per cent of GDP).

TABLE 12. STATUS OF LAND DEGRADATION IN INDIA

(*million ha*)

Particulars	National Commission on Agriculture, 1976	Bali and Kanwar, 1977	Ministry of Agriculture, Government of India		Sehgal and Abrol,	
			1980	1985	1994	1997
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Erosion	150.00	140.00	150.00	141.20	162.40	167.00
Salinity and alkalinity	7.00	7.00	8.00	9.40	10.10	11.00
Water logging	6.00	-	6.00	8.50	11.60	13.00
Shifting cultivation	-	3.00	4.40	4.90	-	9.00
Total degradation	163.00	150.00	168.40	175.06	174.97	187.80

Source: Bose *et al*., 1997.

However, it is important to note that these estimates on both the extent and economic costs of land degradation do not include the lands affected by various kinds of pollution due to industrialisation and urbanisation. Few studies have documented the impact of fertiliser use and canal water on land degradation. Chopra's study in Punjab shows that fertiliser and canal water use led to increased land degradation, while the number of tubewells decreased land degradation due to salinity and water logging (Chopra, 1989). The various components of land degradation such as salinity, water logging, wind and water erosion are closely associated with water and forest resources while population pressure and poverty are not found to be a major factor affecting land degradation (Reddy, 2003).

The impact of soil degradation is particularly critical for the poor farmers who cultivate annual crops which typically degrade soils more than other crops. They also rely more on common property land and water resources, which suffer to a great extent than privately managed land and water resources (Scherr, 1999). Essentially one must note here that the degradation of land and water resource feed on each other – poor quality or polluted soil resulting in poor quality water and poor quality water leading to soil damages. The economic and environmental impacts of soil degradation will be tremendous assuming that the current rates of soil degradation continue unabated.

(iii) *Water Demand*

There is a tremendous pressure on both quantitative and qualitative dimensions of water resources in the country. This is reflected in the sharp decline in the per capita availability of water by almost one-third over a period of last 50 years from 3107 cu.m/year during 1951 to 1092 cu.m/year in 2000 (Government of India, 2000). The long-term scenario of demand for water reveals increasing competition among various sectors of the economy for water (Table 13). The core sectors of the economy, viz., industry, agriculture and households demand increasing amounts of freshwater and let out effluents that damage the terrestrial environment–air, water and land. Urban water users demand higher quantities of freshwater not only for basic livelihood requirements but also for pollution abatement and other luxury need whose income elasticity of demand is comparatively higher. Urban settlements and industries become concentrated pockets of water demand thus exerting severe pressure on both surface and groundwater in the neighbouring areas thus competing with rural areas. This is already reflected in water-related conflicts and tensions between rural and urban areas both as a consequence of transfer of water from rural to urban areas and also as a result of transport of polluted water from urban to rural areas.

TABLE 13. WATER REQUIREMENT FOR DIFFERENT USES

(*quantity in km*^{3})

Year / Uses (1)	1997-98 (2)	2010 Low (3)	2010 High (4)	2010 Per cent (5)	2025 Low (6)	2025 High (7)	2025 Per cent (8)	2050 Low (9)	2050 High (10)	2050 Per cent (11)
Irrigation	524	543	557	78	561	611	72	628	807	68
Domestic	30	42	43	6	55	62	7	90	11	9
Industries	30	37	37	5	67	67	8	81	81	7
Power	9	18	19	3	31	33	4	63	70	6
Inland navigation	0	7	7	1	10	10	1	15	15	1
Environment and ecological demand	0	5	5	1	10	10	1	20	20	2
Evaporation losses	36	42	42	6	50	50	6	76	76	7
Total	629	694	710	100	784	843	100	973	1180	100

Source: Government of India, 1999.

Agriculture is not only the single largest consumer of water, but also it is increasingly becoming a cause of water quality deterioration. The production of modern crop varieties especially of rice and sugarcane demand larger supply because of expansion in area. Coping with scarce and variable water supplies constitute an intrinsic element of the livelihood uncertainties confronting large section of rural people. A failure to appreciate the complex interrelationship between social, cultural, historical and economic role of water and water management institutions on the one hand and the local institutions on the other has led to simplistic solutions being advanced for solving institutional problems relating to water resource management.

Though drip irrigation could conserve water at the farm level and raise the productivity per unit of water, there is every possibility for groundwater over-exploitation to continue if the farmers go in for perennial crops such as coconut in larger areas. In many parts of the country deepening of existing wells and/or digging of new bore wells continues unabated especially during drought years. Similarly though, biotechnology helps conservation of groundwater resources by enabling more output per unit of groundwater pumped (Arabiyat *et al*., 1999), it has the potential to increase water use intensity if much of the research investments on biotechnology is to be made on commercial crops rather than on crops cultivated in marginal production environments with limited water requirement. Therefore, even though technological solutions have the potential to solve the food problem, they are not sufficient to solve resource problems.

Both equity and efficiency are the critical issues in water resource management given the highly uneven distribution of water resources across different regions of the country as well as the inequalities in access to irrigation water across farms within an area or command. The distribution of water resources potential in the country shows that as against the national per capita annual water availability of water about 1100 cu. m., the average availability in Brahmaputra and Barak basin is as high as 16589 cu m. while it is as low as 360 cu.m. in Sabarmati basin. Brahmaputra and Barak basin with 7.3 per cent of the geographical area and 4.2 per cent of population of the country has 31 per cent of the annual water resources. The annual per capita water availability in most of the east flowing rivers and west flowing rivers in the South is less than 1000 cu. m, which is regarded as scarcity condition. Though these facts provide sufficient justification for inter-basin transfer of water, it is fraught with problems such as huge economic and environmental costs, further complication of inter-state sharing of water resources, etc., which should however be properly reflected in any cost-benefit analysis of the proposed interlinking of rivers.

Inequality in farm-level access to irrigation water is another major issue that requires policy attention, as both surface water and groundwater are distributed (either naturally or through government policies) in direct proportion to the land owned by the household. In addition the existing inequalities in other forms of capital and the higher fragmentation of holdings especially among the smaller farms is likely to further exacerbate the socio-economic inequalities in the rural areas. In many parts of the country the inequality in access to groundwater is becoming more acute than the inequalities between head and tail reach farms in the surface irrigation projects. Though groundwater markets are projected as an important redistributive mechanism, it is also fraught with serious problems (Table 14).

TABLE 14. NUMBER OF DISTRICTS (IN POCKETS) SHOWING FALL IN GROUNDWATER, STATE-WISE

State (1)	Percentage of districts in which the water-table has fallen by more than 4 metres (2)	Percentage of blocks reporting groundwater over-exploitation (3)
Andhra Pradesh	100	1.09
Bihar	5	0.51
Gujarat	68	7.07
Haryana	76	30.58
Karnataka	95	4.00
Kerala	-	0.00
Madhya Pradesh	64	0.44
Maharashtra	83	0.87
Orissa	27	1.27
Punjab	71	52.17
Rajasthan	47	31.36
Tamil Nadu	59	16.67
Uttar Pradesh	34	2.32
West Bengal	31	0.00

Source: Bhalla and Singh (1997).

Capital Constraints

(i) *Agricultural Investment*

Agricultural development in India had to rely heavily on government finance due to presence of externalities, high risks and inadequacies in agricultural institutions (rural credit, input supply, etc.), which discourage investment in agriculture from private sources (FAO, 1987). As a consequence of industrialisation and economic reforms, one could expect government expenditure on agriculture would suffer setbacks relative to other sectors and this could have deleterious effect on the performance of the sector. To keep pace and pattern, the progress of agricultural growth should be further augmented through price policies coupled with other non-price measures such as irrigation, infrastructure and research (Mellor and Ahmed, 1988). This calls for continuing attention and desired emphasis from the government in allocating resources to agriculture. India being primarily an agricultural economy, the desired emphasis has been given to the sector over a period of time. However, there could be reduction in government expenditure on agriculture consequent to industrialisation and implementation of structural adjustment policies like devaluation of exchange rate, cut in import duties, more reliance on the private sectors and curtailment in public investment. Total government expenditure, expenditure on agriculture and allied activities and its percentage share in total expenditure are summarised in Table 15. The share of government expenditure on agriculture to total expenditure has not increased over years but declined and at present agriculture shares only 5.2 per cent of the total public outlay. Falling real public investment in agriculture is a cause for major concern.

TABLE 15. PUBLIC OUTLAY AND EXPENDITURE IN PUBLIC SECTOR- PLAN-WISE

(Rs. in crores)

Five Year Plan	Agriculture and allied sectors*		Total outlay and expenditure		Percentage of agriculture and allied to total	
	Plan outlay	Actual expenditure	Plan outlay	Actual expenditure	Plan outlay	Actual expenditure
(1)	(2)	(3)	(4)	(5)	(6)	(7)
First Plan	354	290	2,378	1,960	14.9	14.8
Second Plan	510	549	4,500	4,672	11.3	11.7
Third Plan	1,086	1,089	7,500	8,577	14.5	12.7
Fourth Plan	2,728	2,320	15,902	15,779	17.2	14.7
Fifth Plan	4,766	4,865	39,322	39,426	12.1	12.3
Sixth Plan	l2,539	15,201	97,500	109,292	12.9	13.9
Seventh Plan	22,233	31,509	180,000	21,870	12.4	14.4
Eighth Plan	63,642	70,146	434,100	4855,456	14.7	14.4
Ninth Plan	42,462	N.A.	859,200	N.A.	4.9	N.A.
Tenth Plan	50,668	N.A.	398,890	N.A.	5.2	N.A.

Source: Planning Commission, Government of India.

* Includes Animal Husbandry and Dairy, Research and Education, Forestry and Wild life, Plantation, Agricultural Marketing and Rural Go downs, Food storage and warehousing, Rural Development, Co-operation, Specia Area Programmes, etc. N.A.-Not Available.

The growth in agriculture is mainly due to planned investment made in agriculture through expansion of irrigation facilities and spread of fertiliser and credit outlets coupled with supportive price policy. The estimated elasticity of the government expenditure is significant at one per cent level of probability. [2] The elasticity of the government expenditure on agriculture indicates that 10 per cent increase in government expenditure would induce 5.3 per cent increase in agricultural growth (Table 16). The results clearly show that government expenditure policies are important determinants of the performance of the agricultural sector.

TABLE 16. IMPACT OF GOVERNMENT EXPENDITURE ON AGRICULTURAL GROWTH

Particulars (1)	Coefficients (2)	t –value (3)	P- Value (4)
Constant	-97.091	-4.180	0.000
Government Ag.expenditure	0.531	3.999	0.000
Cropped area	8.818	4.562	0.000
Agricultural labour	-0.497	-0.961	0.345

R^2: 0.97, F = 273.07.

Instability in government expenditure on agriculture may affect the development of agricultural sector (Lim, 1983). Again uncertainty associated with instability in public expenditure may reduce the level of investment and hence thwart the growth of the sector, if risk averse behaviour characterise the farmers. It might also jeopardize the planning ability of the government and parastatal organisations thereby adversely affecting economic growth. Instability was measured by instability index which is the average absolute percentage deviations from an exponential trend.[3] Instability variable has the expected negative sign but it is not significant (Table 17). However, it is evident from the empirical results that instability in government expenditure has detrimental effect on the growth of agricultural production. To attain sustainable growth in agriculture, the empirical findings suggest that provision of adequate public outlay on a predictable basis is an important stimulus to agricultural output growth. India has been switching over to new economic reforms reducing the public sector deficits and public sector intervention. Since public sector investment on agriculture induce the farmers to increase their farm investment, expenditure reducing policies should be guided by careful assessment of cost-effectiveness of on-going projects rather than by indiscriminately cutting across the board.

TABLE 17. IMPACT OF GOVERNMENT EXPENDITURE INSTABILITY ON AGRICULTURAL GROWTH

Particulars (1)	Coefficients (2)	t value (3)	P value (4)
Constant	7.127	63.008	0.000
Per capita cropped area	-0.128	-0.464	0.646
Instability index	-0.024	-0.531	0.599

R^2 : 0.46, F = 6.82.

There were obviously potential areas in agricultural sector, which could be adequately tapped through government intervention. Apart from the concerns related to food security and poverty alleviation, government involvement may be essential for creating exportable surplus through adequate investment on infrastructure, irrigation, agricultural research and extension as they are expected to have a high pay-off in India. Provision of these critically needed public goods would stimulate the private investment in the form of agricultural input markets, agro based industries, agricultural processing and product markets. Biases in the existing structure of government investment (e.g., irrigated vs rainfed, by crop, by farm size) need to be corrected. For achieving sustainable growth in the agricultural sector, a rational allocation of budgetary outlays and the development of better systems for establishing sectoral allocations remain to be the key issues.

(ii) *Capital Formation*

It is now recognised that without adequate investment, agriculture cannot make substantial contribution to the economic development of the country. The share of agricultural sector in the domestic product is declining over the years and one of the possible reasons could be relatively lower investment made both by the public and private sectors on agriculture. Slow growth of gross domestic capital formation, in particular declining public capital formation in agriculture, is a clear a warning signal and this trend thwarts the growth momentum (Table 18).

TABLE 18. GROSS CAPITAL FORMATION IN AGRICULTURE AND ALLIED SECTOR (AT 1993-94 PRICES)

(Rs. crores)

Year (1)	Public sector (2)	Private sector (3)	Total (4)
Gross capital (Rs. crores)			
1970s	4851.10	7297.40	12148.50
1980s	6443.30	7840.10	14283.40
1990s	4796.58	12547.75	17344.33
Share of agriculture to total (per cent)			
1970s	12.51	16.15	14.51
1980s	10.42	10.44	10.40
1990s	6.50	8.97	8.04

The capital formation in agriculture grew at the rate of 8.51 per cent during 1970s and declined at the rate of 0.33 per cent during 1980s and recovered during 1990s (1.99 per cent) (Table 19). And the growth in share of agriculture is however negative during the 1990s.

Private capital formation increased throughout the period though rate of growth was lower in the later years as compared to early years. Public capital formation in agriculture grew at higher rate of 9.5 per cent during 1970s but declined during 1980s and 1990s. The decline in 1980s was higher as compared to 1990s. This was mainly because a large proportion of the total resources ploughed into agricultural sector went to current expenditures on subsidies for fertilisers, irrigation, electricity, credit and other agricultural inputs, rather than investment during this period

(Mallick, 1993). The share of agricultural capital formation in the gross capital formation also declined during the 1980s and 1990s.

TABLE 19. GROWTH OF CAPITAL FORMATION IN AGRICULTURE AND GROWTH OF SHARE OF AGRICULTURAL CAPITAL FORMATION TO GROSS CAPITAL FORMATION

(per cent)

Sector (1)	1970s (2)	1980s (3)	1990s (4)	Overall
Gross capital formation				
Private	7.81	2.62	3.43	3.00
Public	9.50	-3.89	-0.50	0.20
Total	8.51	-0.33	1.99	1.98
Growth in share of agriculture				
Public	2.05	-6.49	-2.08	-3.06
Private	2.11	-1.89	-1.73	-2.57
Total	1.95	-3.89	-1.59	-2.65

The public and private investments were complementary rather than substitute for each other and thus falling public investment affects private capital formation. It is also evident from the estimated equations that the public and private investments were complementary (Table 20) and any such measure to reduce public investment will also hamper the private investment in agriculture. [4] The role of formal credit in private investment is also crucial as is evident from the estimated equations that credit influenced positively private capital formation in agriculture. [5]

TABLE 20. RESULTS OF PRIVATE AND PUBLIC INVESTMENT COMPLEMENTARITY

Period (1)	Intercept (2)	Public investment (3)	ATT – lag (4)	AGDP (5)	R^2 (6)
1970s	-20853.90	0.777	19794.76	3.093	
		(1.010)	(1.256)	(0.855)	0.51
1980s	-4107.78	1.203***	-1079.48	1.739*	
		(1.755)	(-0.367)	(3.674)	0.89
1990s	-50026.40	1.334	45617.2	0.430*	
		(1.156)	(1.610)	(4.612)	0.86
Overall	3134.48	0.362	1393.33	0.526	
		(1.578)	(0.440)	(7.466)*	0.81

Figures in parentheses are 't' values; *** and * Significant at 1 and 5 per cent level respectively.

Many empirical researches in India have tended to support the crowding in hypothesis in so far as public investment in the agricultural sector is concerned (Dhawan, 1996). Many economists have estimated the elasticity of private investments in the Indian agricultural sector with respect to public investments. Mishra and Chand (1995) however find no positive relationship between public and private capital formation in agriculture. Other studies find a relationship of almost one-to-one correspondence between the two categories of investments (www.tribuneindia.com). There is a room still for elementary enquiry into the magnitude and direction of the coefficient of private farm investments with regard to public investment in agriculture. In view of the existence of a relationship on a nearly one-to-one basis, the coefficient estimated by (www.tribuneindia.com) was 0.9805. Our estimates are 0.777 for the period 1970s and the magnitude of the coefficient increased to more than one during 1980s and 1990s lending support to the hypothesis of complementarity between private and public investments in Indian agriculture. Studies found that reduction in public farm investments depressed private investments by nearly 15 per cent (www.tribuneindia.com). No wonder, then, one notices a marked slowdown in the growth of private farm investments during the decade of the eighties as compared to the earlier two decades. The decline in public capital formation is also noticed in 1990s. However, private capital formation grew fast in the 1990s though the decline in trend of public investment continues. But one cannot complacent with this because the main factors influencing private investment include the level of public investment, profitability of production and availability of formal credit.

III

RURAL POVERTY

Trends

The years of rapid growth in the Indian economy coincided with the reduction in poverty. As average annual increases of more than 3 per cent in GDP in the first half of the 1970s accelerated to rates of 6 per cent in the last of the 1980s (World Bank, 1989) and 7 per cent in the early 1990s (Government of India, 1997), the incidence of poverty recorded notable decline and there is considerable potential towards reducing poverty in India to 25 per cent by 2000 A.D. (Venkataraman, 1998). According to Planning Commission (1998), the annual average rate of decline of the poverty ratio in India during the period 1973-74 to 1993-94 has been 2 per cent in rural areas and on the basis of the growth rate experienced between 1993-94 and 1996-97, the incidence of poverty has been worked out to 30.55 per cent in 1996-97 and 18.61 per cent in 2001-02. Rural poverty shows a slow decline in the 1970s and a faster decline in the 1980s till 1990–91. The post-reform period was marked by near stagnation in the growth of aggregate real output. However, there was reduction in poverty during the post- reform period. The percentage of rural persons below poverty line during 1993-94 was 37.27 and it declined to 27.09 per cent during 1999-2000 in spite of slow down in the growth rate of agricultural production during 1990s (Table 21).

TABLE 21. POPULATION BELOW POVERTY LINE, ALL INDIA

Particulars	Year		
	1983	1993-94	1999-2000
(1)	(2)	(3)	(4)
Rural			
No. of persons (lakh)	2519.56	2440.31	1932.43
Percentage of persons	45.65	37.27	27.09
Poverty line (Rs.)*	89.50	205.84	327.56
Urban			
No. of persons (lakh)	709.40	763.37	670.07
Percentage of persons	40.79	32.36	23.62
Poverty line (Rs.)	115.65	281.35	454.11
Combined			
No. of persons (lakh)	3228.97	3203.68	2602.50
Percentage of persons	44.48	35.97	26.10

Source: Government of India, 2002; * - Per capita per month.

To provide an evidence for asserting a trend in increase or decrease in rural poverty over the period, Planning Commission (1998) poverty levels were used and the results are reported in Table 22. One can see a discernible decline in the incidence of rural poverty in India. The analysis of Ahluwalia (1978) provided no evidence for asserting a trend increase or decrease in rural poverty in India for the period, 1957-58 to 1973-74. However, Bardhan (1973) reported an increase in the incidence of poverty over the sixties, which appears as an upswing in a pattern of cyclical variation. These differences are due to identifiable differences on some key issues in estimating rural poverty and could also be due to increase in the absolute number of people in poverty.

TABLE 22. TREND IN RURAL POVERTY - ESTIMATES OF LINEAR REGRESSION

Particulars (1)	β (2)	t ratio (3)	Probability level (4)
Constant	53.123	58.667	0.0000
Time	-0.8328	-12.610	0.0000

R^2 = 0.88; Dependent variable - Consumer expenditure (Government of India, 1998).

Trickle Down Mechanism Weakening ?

Empirical evidences indicate that the trickle down mechanisms have weakened considerably in the later time periods (Ghosh, 1996). Our results indicate that although rural poverty is found to be inversely associated with agricultural income per capita of rural population in all the time points, the strength of the relationship between poverty and agricultural growth are found to have declined considerably.[6] In the estimated equation, the value of the coefficient of PCGSDPA (per capita state gross domestic product) has declined consistently from -0.09 in 1972-73 to -0.003 in 1999-2000, and the estimated value of R^2 has declined from 0.696 to 0.422 (Table 23). These results are sufficient to indicate that trickle-down mechanisms have weakened considerably in the later time points.

TABLE 23. AGRICULTURAL GROWTH AND POVERTY – WEAKENING OF TRICKLE DOWN MECHANISM

Year (1)	Intercept (2)	PCSGDP agri (3)	t value (4)	R^2 (5)
1972-73	89.462	-0.090	-5.241	0.696
1977-78	83.113	-0.069	-4.121	0.586
1983-84	68.333	-0.055	-3.809	0.547
1986-87	52.330	-0.031	-3.281	0.473
1999-00	32.286	-0.003	-3.821	0.422

States constitute the sample.

Agriculture still needs to play a key role in supplying adequate food at affordable prices to ensure that poverty remain low. Since both agricultural production and productivity growth were largely stagnant during 1990s, the so called “trickle down” benefits of agriculture growth of the rural poor were much smaller. Since 1990s, the agricultural investment in India has stagnated. Without investments in agriculture, the poverty would be much higher today. One result of stagnation in investment was that poverty declined at a lower rate in the 1990s than in the 1970s and 1980s. Continued government support is needed to attain higher level of agricultural growth in the country for ensuring food and nutritional security.

In the context of weakening of trickle down effect, other factors like access to land, credit supply and employment programmes are found to be most important in alleviating the poverty. Land is an income generating asset of the primarily poor cultivator households (viz., the marginal and small farmers) and the incidence of rural poverty is expected to vary inversely with the average size of their operational holdings (Ghosh, 1996; Hossain, 2001). However, in a situation of decline in per capita land, the feasibility of increasing the average size of the marginal and small operational holdings through redistribution of land appears to be very limited. Under such conditions, provision of credit and other agricultural inputs at subsidised rates for the marginal and small farmers enabling them to use HYV technology and achieve higher productivity seems to be an alternative feasible policy measure for reducing the incidence of rural poverty (Ghosh, 1996). The adoption of modern varieties had a positive impact on poverty alleviation when they were grown under irrigated conditions. If modern varieties are adopted under rainfed conditions, then the poverty reduction effect is lesser (Hossain, 2001). The adoption of technology and the development of rural infrastructure were found to have a synergetic effect on the reduction of poverty (Hossain, 2001; Fan and Hazell, 2000; Kerr, 1996).

IV

TRADE AND POVERTY MISUNDERSTOOD ?

Trade, Agricultural Growth and Poverty

There are extensive and disquieting literatures (Desai, 1986; Ahluwalia, 1978, 1986; Rath, 1996) on quantifying the poverty line and absolute poverty in terms of the absolute number or the proportion of population below poverty line. A recurring theme in much of the literature (Ahluwalia, 1978, 1986; Lal, 1976; Bardhan, 1986; Ravallion and Datt, 1996; Gaiha, 1985) is to find the relationship between trends in rural poverty and agricultural growth. In recent studies, the growth effects of trade were more systematically analysed using a large sample of developed and developing countries. A large body of literature has examined the effects of trade on growth and many of these studies have found substantial growth effects of trade.

The important question is that how could increased participation in international trade affect the economic growth rate, and what implications will this have for the distribution of income and the incidence of poverty? The experiences suggest that rapid economic growth translates into sustainable reductions in poverty because there is a significant association between trade liberalisation and long run improvements in economic growth. Thus, there is likely to be a positive link between liberalisation and eradication of poverty in the long run. For example, the incidence of poverty fell by half from 26 per cent to 13 per cent of the population, just five years after trade was liberalised in the mid-1980s in Morocco (World Bank, 1997). Sachs and Warner (1995) estimated that countries with open economies (those integrated into the world economy) in developing regions grew, on an average by 2.5 per cent points more than those with closed economies. This, in turn, would have a positive impact on poverty reduction in the absence of an anti–poor bias in domestic policies and investment pattern.

International trade has grown twice as fast as income worldwide during 1990s. In India, per capita GDP growth in agriculture in the 1990s accelerated from 9 per cent a year in the early 1990s to 13 per cent at current prices. This acceleration in growth is even more remarkable given the inflation rate. At constant prices, per capita GDP grew at the rate 2.15 per cent in the post reform period, while in the earlier period the growth was less than 1 per cent (0.80). There was a sizable reduction in poverty in the post reform period and it was estimated that rural population below poverty line declined by 3 per cent in the 1990s, while it was less than one per cent in the early 1990s. Similarly, the percentage of population below poverty line also declined in the reform period, which is almost 2 per cent more than the earlier period (Table 24).

TABLE 24. GROWTH IN POVERTY, INCOME AND PRICES

(*per cent per annum*)

Year (1)	1970-71 to 1990-91 Mean (2)	CGR (3)	1991-92 to 1999-00 Mean (4)	CGR (5)
Per capita AgGDP (current Rs.)	1025.38	8.89	4648.66	12.59
Per capita AgGDP (constant Rs.)	906.64	0.80	1100.96	2.15
Rural population (000')	534868.38	1.77	682198.00	1.37
Rural population (BPL ′000)	256484.06	-0.63	227170.36	-3.01
Rural population (BPL per cent)	48.69	-2.35	33.43	-4.32
Agricultural production (Index)	106.41	2.84	163.88	2.37
Food articles (WPI)	104.01	7.97	345.22	8.39
Agricultural labour (CPI-General)	74.95	6.84	233.10	8.49
Agricultural labour (CPI-Food)	76.41	6.97	241.03	7.61

CGR - Compound Growth Rate; WPI - Whole Price Index; CPI - Consumer Price Index.

Exports of agricultural commodities in the post-reform period increased consistently and witnessed highest growth rates in India. The balance of trade in agriculture improved during the reform period and its contribution to GDP was also significant. Therefore, it is obviously relevant to consider the exports as an important factor influencing the agricultural growth and that leads to reduction in the incidence of rural poverty. By postulating that an important determinant of the extent of rural poverty is the growth in agricultural exports, recursive forms of equations were estimated to examine the effects of exports on agricultural growth.[7]

The results reveal that agricultural exports have positive significant influence on agricultural growth (Table 25). Further, it may be seen that the coefficient of the variable per capita agricultural GDP (PAGGDP) is not statistically significant and deviated from *a priori* expectation. However, introduction of lagged PAGGDP improved the explanatory power of the equation (R^2 = 0.92 increased to 0.93) but the coefficient of lagged PAGGDP was negative and significant indicating that the incidence of poverty depends also on the level of PAGGDP in the previous year (Table 26). Introduction of the time variable has improved the explanatory power of the equation (R^2 = 0.99) and both the current and lagged PAGGDP have *a priori* expected signs and PAGGDP was highly significant. The results confirm that there is an underlying time trend in the incidence of poverty after allowing for changes in poverty incidence associated with changes in PAGGDP. Thus there is clear evidence of an inverse relationship between rural poverty and agricultural performance.

TABLE 25. RELATIONSHIP BETWEEN AGRICULTURAL EXPORTS AND GROWTH - ESTIMATES OF THE RECURSIVE MODEL (1970-71 TO 1999-2000)

Variable (1)	Coefficient (2)	Standard error (3)	t ratio (4)	Probability level (5)
Constant	–3.960	0.9652	–4.106	0.0004
$CFAG_t$	–0.016	0.0602	–0.272	0.7878
$AGEXP_t$	0.070	0.0375	1.755	0.0921
INDAG	0.690	0.1044	6.500	0.0000
Time	–0.0107	0.0035	–3.013	0.0060

R^2 = 0.94, D-W statistic = 0.9806, F = 105.04 and Rho = 0.5096.

The upshot of Narain's (1977) results that it is not enough to take into account agricultural performance and time to explain temporal variations in rural poverty, it is equally necessary to consider changes in the nominal prices of goods consumed by the poor. He observed that inclusion of price as an independent variable increased the explanation of the variation in rural poverty substantially (R^2=0.93) and made regression coefficient of time highly significant (Table 26). After inclusion of price variables, the results show that the explanation power of the regressors moved up substantially (R^2=0.93 improved to 0.99). When CPIAl for food and CPIAL (general) were used, R^2 remained 0.99. But in both the cases the coefficient of current year per capita GDP turned negative and highly significant. When WPIF was used, current year GDP remained significant and negative. These results, after allowance is made for the changes in the incidence of rural poverty associated with other variables, proved that there is a definite negative relationship between the incidence of rural poverty and agricultural growth in India. The results also showed that there is a positive link between trade liberalisation and agriculture growth; and such linkage would help the country to eradicate poverty in the long run.

Export-led Growth

Agricultural trade openness, reflected in the ratio of agricultural exports to agricultural GDP, which was 4.27 per cent in 1990–91, increased to a maximum of 6.97 per cent in 1995–96 and thereafter there was a slow down to about 5.08 per cent in 1999–2000. Though growth of agricultural exports (16.83 per cent) was more than the growth of agricultural GDP at current prices (14.13 per cent), the ratio

TABLE 26. RELATIONSHIPS AMONG AGRICULTURAL EXPORTS AND GROWTH AND POVERTY - ESTIMATES OF THE RECURSIVE MODEL (1970-71 TO 1999-2000)

Equation (1)	Constant (2)	$PAGGDP_t$ (3)	$PAGGDP_{t-1}$ (4)	$CFAG_t$ (5)	$AGEXP_t$ (6)	INDAG (7)	Time (8)	CPIALF (9)	$CPIAL_{Gen}$ (10)	WPIF (11)	R^2 (12)	DW (13)
I	10.0028	0.1247 (0.325)	-	-0.1527 (-1.187)	-0.0069 (-0.080)	-0.7134* (-3.848)	-	-	-	-	0.92	0.8439
II	8.5600	0.2284 (0.633)	-0.4862 ** (-2.167)	-0.1169 (-0.967)	0.0275 (0.337)	-0.6709* (-3.863)	-	-	-	-	0.93	0.7719
III	-0.7307	-0.8874* (-4.5517)	-0.0840 (-0.7860)	0.0026 (0.0483)	0.0810** (2.2309)	0.7547* (4.608)	-0.0400* (-9.8416)	-	-	-	0.99	1.2939
IV	-0.8729	-0.8958* (-4.442)	-0.0789 (-0.713)	0.0119 (0.182)	0.0739 (1.626)	0.7628* (4.485)	-0.0414* (-6.202)	0.01697 (0.267)	-	-	0.99	1.3225
V	-0.6363	-0.8780* (-0.2279)	-0.0870 (-0.7849)	-0.0023 (-0.0363)	0.0852** (1.8908)	0.7466* (4.2723)	-0.0391* (-5.5006)	-	0.01697 (-0.1625)	-	0.99	1.2773
VI	-0.9914	-0.9048* (-4.4203)	-0.0769 (-0.6947)	0.0146 (0.2259)	0.0735** (1.73)	0.7673** (4.4952)	-0.0429** (-4.8401)	-	-	0.0318 (0.3615)	0.99	1.3461

almost remained constant. It is also evident that agricultural exports comprised about 48 per cent of total exports in 1960–61 and the share dropped sharply over the period and it was almost constant in the 1990s and at present agricultural exports comprises about one seventh (15 per cent) of the total exports and remaining 85 per cent consists of non-agricultural commodities. India's export of agricultural commodities has been on the increase and agricultural exports grew at the rate of 11.58 and 7.16 per cent in rupee and dollar terms respectively at current prices in the period between 1970–71 and 1990–91. The agricultural export growth was found higher in the 1990s and the export of agricultural commodities recorded 16.83 and 9.84 per cent respectively at current prices in rupee and dollar terms. Thus agricultural exports also grew significantly in the post-reform period and this could be attributed to the trade liberalisation policies followed in agriculture.

The import content of agricultural sector is insignificant as compared to that of the non-agricultural sector and as a result agriculture was found to be the net foreign exchange earner for the country. The ratio of agricultural imports to total GDP was less and it was around one per cent. Agricultural imports grew by about 11.03 per cent and 6.62 per cent in rupee and dollar terms respectively in the pre reform period, which is almost equal to the export growth. However, during the post reform period, agricultural imports grew more exponentially at the rate of 15.99 per cent in rupee terms and 9.06 per cent in dollar terms, which is not faster than exports. Reduction and rationalisation of tariffs and removal of non-tariff barriers have played a crucial role in increasing imports. The average unweighted tariff in agriculture declined from 113 per cent in 1990–91 to 26 per cent in 1997–98 (www.wto.org, 1998). The major import component is food and related items in which pulses and edible oils form major share. The share of food items in total imports increased significantly and persistently from 1.6 per cent in 1991–92 to 6.5 per cent in 1998–99. However, in 1999–2000 it declined to 5.1 per cent. The increase was essentially on account of the sharp increase in imports of edible oils. Balance of trade in agriculture at current prices was Rs.1,419 crores in 1991 and it increased to a maximum level Rs.9,827 in 1996–97 and at present it is Rs.8,509 crores. The ratio of balance of trade to GDP in agriculture has also improved in the post-liberalisation period due to higher export growth. The ratio of agricultural trade (exports and imports) to agricultural GDP was less than 10 per cent in 1970s and 1980s, but the ratio tended to increase in the 1990s and reached maximum of 12.06 per cent in 1995–96. There was a fluctuation in the ratio during 1990s and at present the ratio is 8.39 per cent indicating that the country switched to liberalised trade policies comprising import liberalisation and export promotion measures.

The elasticity of offer curve (ε)[8] at total trade (total exports and imports) is estimated at 0.82, while it was 0.79 in the case of agricultural trade (Table 27). Since $0 < \varepsilon < 1$, the elasticity of demand for imports necessarily becomes positive, which means that imports are necessarily a Giffen good. The elasticity of demand for imports worked out to 4.56 and 3.76 for total trade and agricultural trade respectively.[9] It is necessary that the imported commodity be a Giffen good for the imports demand elasticity to be positive but it is not a sufficient condition. Because even if the imports might still be negative since imports is equal to domestic consumption minus domestic production. Thus, even if domestic consumption falls, as imports become cheaper, it does not necessarily follow that imports also fall because domestic production falls too. Imports fall, if and only if, domestic consumption falls faster than domestic production. This is ruled out as unrealistic (Chacholiades, 1985). The elasticity of supply of exports[10] are -5.56 and -4.76 for total trade and agricultural trade It is important to note that the sum of elasticities of the demand for imports (e) and supply of exports (η) equal to -1.

TABLE 27. ELASTICITIES OF OFFER CURVE, DEMAND FOR IMPORTS AND SUPPLY OF EXPORTS

Particulars (1)	ε (2)	e (3)	η (4)	e+ η (5)
Total trade	0.82	4.56	-5.56	-1.00
Agricultural trade	0.79	3.76	-4.76	-1.00

Note : The offer curve elasticity (ε) was estimated using log-linear regression equation through OLS method. The elasticity of demand for imports (e) and the elasticity of supply of exports (η) were estimated using the relationship.

Do the results indicate that India shall continue to import goods at higher prices and export goods at lower prices in the global market? If it is for what commodity? This needs to be analysed further commodity-wise. How to make the Indian commodities particularly agricultural products globally competitive? India's exports tend to realise lower value for the same products than for some other countries. The average value of export per exporter is low. India perhaps has the largest number of registered exporters. Small size export trade gives exporter little clout with customers. In the case of manufactured products, though these products accounted for around 75 per cent of exports, they are fairly low value added products. High import duties also keep Indian products at lower values and Indian products less competitive in the world market.

For example, cotton is contaminated with impurities which add additional cost at every stage of processing and the cost works out to Rs. 100 per bale. Cotton Corporation of India (CCI) is trying to observe Bureau of Indian Standards (BIS) norms to strengthen quality upgradation measures by way of its incentive scheme to ginning and processing factories (Economic Times, 1998). In the case of rice, India continues to face stiff price competition from Vietnam and Pakistan in the low and medium quality markets, which makes it difficult for exporters to sell at a premium in the world market. Abysmal quality of non-basmati rice being exported is largely responsible for the drop in its international prices. Similarly, Vietnam's better quality robusta coffee could challenge Indian exportable grades in the more demanding European market. Colombia, which has made a dent in the highly lucrative US specialty market; Ethiopia's coffee is known to be naturally grown organic coffee with inherent good quality that is very much sought for its purity, aroma and flavour. Competitive measures like Net Protection Coefficient, Effective Protection Coefficient and Domestic Resources Cost were estimated by many studies and these measures indicated that India is in competitive position in many of the agricultural products like rice, cotton, fruits and vegetables, spices and condiments (Gulati *et al*., 1994; Gill and Brar, 1996; Sharma, 1998; Gulati and Sharma, 1994).

V

COMPLEMENTARITY OF BIOTECHNOLOGY

Modern agricultural biotechnology has evoked considerable debate mostly relating to the commercial cultivation of genetically modified crop varieties. There are wide ranging views expressed by different interest groups on the possible risks and benefits of biotechnology. Biotechnology could have far-reaching consequences for food safety, food security, employment, environmental sustainability, income distribution, and biodiversity especially in the developing countries. Private research on biotechnology is likely to concentrate on applied and adaptive research in seeds, pesticides, plantation crops and food processing, mostly for high-value commercial crops. In whatever crops it is applied the proponents argue that biotechnology will lead to more environment-friendly agricultural intensification like development of pest-resistant varieties such as Bt cotton and Bt corn. Opponents however argue that biotechnology will not lead to environment-friendly agricultural production citing the example of Roundup Ready soybeans which is tolerant to Monsanto's famous herbicide Roundup, thus increasing herbicide application. Further, insects' ability to develop resistance to genetically engineered crop varieties such as Bt cotton will ultimately lead to pest resurgence. Other concerns such as the impact of biotechnology on environment and biodiversity and the effect of genetically modified food on human health are also voiced. The recent retreat of Monsanto from European markets is argued as a sign of prevalence of social and political processes over the economists' emphasis on productivity and efficiency arguments.

It is pertinent to ask and search answers for the following questions: (a) Will biotechnology ensure sufficient benefits to the crops that make the poor countries, regions and people self-sufficient in food? (b) Will biotechnology enhance yield and drought tolerance of crops cultivated in many parts of our country? (c) Will major biotechnology companies invest their scarce financial and scientific human resources on crops and technologies that displace labour and increase unemployment in rural areas? (d) Will new seeds (crop varieties) be developed to suit the commercially important chemicals (herbicides, pesticides, etc.) produced by the biotech-cum-agrochemical multinationals or it will be the other way around?, (e) What will be the impact of likely increase in market power among biotech corporations (as exemplified by increasing concentration and integration in the industry as a result of IPR regime and the role of innovation capability in determining industry structure) on their control over agricultural systems especially the food security? As majority of investments in transgenic plants come from private sector with a clear goal of achieving a substantial return on investment, it is very likely that it may not be sufficiently suited to the demands of those who need it the most. Who controls the technology and for what purpose(s) matters the most while answering these questions.

VI

FUTURE AGRICULTURAL RESEARCH AGENDA

In the recent years public sector participation for agricultural development is declining and it affects the private investment due to complementarity. The service sector replaced agriculture with its fast rising share in GDP. Service sector share in GDP increased from about 48 per cent in 1993-94 to more than 56 per cent in 2002-03. Agriculture's share in GDP, in contrast, fell from 31 per cent to 22 per cent during the same period. To keep pace and pattern, the progress of agricultural growth should be further augmented through adequate investment. This calls for continuing attention and desired emphasis from the government in increasing outlays to agriculture. To attain sustainable growth in agriculture, empirical findings suggest that provision of adequate public funds on a predictable basis is an important stimulus to agricultural output growth. Hence, expenditure reducing policies should be guided by a careful assessment of cost-effectiveness of on-going projects rather than by indiscriminately cutting across the board.

In spite of the increasing role of private sector in agro-biological research, a vibrant public research system should continue. Public research should concentrate on developing the cost-effective technologies with quality trait in order to enhance the competitiveness of agricultural products both in the domestic and international markets. This will largely help in poverty eradication in the coming years. Both agricultural research and institutional reforms should be geared up to address the challenges posed by increasing environmental problem, changing rainfall pattern and more severe weather fluctuations causing higher risks and uncertainties in agriculture. To mitigate these problems, development of organic farming practices, integrated pest management strategies, and genetically modified pest and disease resistant crop varieties will have to be given more attention from agricultural researchers. Policy interventions are required to promote the adoption of these technologies.

The institutional and policy environment should be suitably tailored to increase the resource use efficiencies with minimum damage to the environment and human and animal health. It should, however, be noted that the agricultural policies, which bring about changes in farming practices, would have different implications for natural resource environment in different regions with different contexts, depending on the point of departure. The type of environmental costs typically experienced in the developed countries or regions will be quite dissimilar from those experienced in the developing countries or regions. It will also vary across different sections of the society within a region. Hence, continuous monitoring and impact assessment together with research focus on devising adaptive strategies for different classes of people should form part of the agricultural research system. Participatory research has not received the attention of the agricultural research managers and hence it should be pursued vigorously especially in the area of crop and resource management. This will ensure demand-driven research programmes.

Investments on water resource development especially the conservation and consolidation of traditional water resources should receive immediate attention. However, in view of the limited scope for further development of surface and groundwater resources in many parts of the country, investments on *in situ* water harvesting and conservation, watershed development, improvements in water use efficiency both at system level and at farm levels and drainage facilities needs urgent attention. Since the rate of growth of cultivated area has been declining and quality of land resources have also been deteriorated, the burden of accelerating agricultural production falls increasingly on the growth of productivity of land which requires appropriate technological change.

NOTES

1. $AGDP=b_o+b_1CA+b_2AL+b_3CREDIT$, where AGDP is Agricultural GDP at constant prices, CA denotes cropped area, AL indicates agricultural labour and CREDIT refers to credit supplied to agricultural sector at constant prices. Estimated as log-linear function.

2. The stability of the intercepts and coefficients of the production functions over time was statistically tested by applying Chow test (Gujarati, 1988). The calculated values were less than the 'F' table values at 1.00 per cent level of significance, indicating that the coefficients remain stable overtime and hence, the estimation was carried out for the pooled data (1970-71 to 2001-02). The contribution of government expenditure on agricultural output growth was empirically analysed by employing a neo-classical production function of the Cobb-Douglas type (Hayami and Ruttan, 1970; Antle, 1983; Elias, 1985). The model was estimated by Ordinary Least Squares (OLS) by incorporating expenditure variable along with other conventional inputs such as land and labour. The function is given by

$$\text{Log}\,(AGDP)_t = \beta_0 + \beta_1 \log (AGE)_t + \beta_2 \log (GCA)_t + \beta_3 \log (ALF)_t + U_t$$

where, the dependent variable AGDP is agricultural GDP at constant price expressed in crore rupees. Land and labour, representing the country's resource endowments, were measured by gross cropped area (GCA) expressed in thousand hectares and agricultural labour force (ALF) in million numbers. The agricultural government expenditure at constant price (AGE) is expressed in crores rupees. U_t is the stochastic disturbance term with $U_t \sim N(O, \sigma^2)$. β_1, β_2 and β_3 are the respective elasticities and β_0 is regression constant.

3. In order to test the effect of fluctuations in government expenditure on agricultural growth, the rate of change of agricultural production is assumed to be explained by the instability of expenditure, after accounting for other relevant explanatory factors such as land and labour. The intensive form of Cobb-Douglas production function was specified, i.e., output and lands were expressed in terms of labour. The function was estimated by Ordinary Least Squares (OLS) method. The intensive form of Cobb-Douglas production function assumes constant return to scale and reduces problems of multicollinearity and heteroscedasticity. The model is specified as follows:

$$\text{Log}\,(OPLRC)_t = b_0 + b_1 \log (LPLRC)_t + b_2 \log (IIAGE)_t + V_t$$

where, OPLRC refers to output per labour unit rate of change (output is agricultural GDP at constant price), LPLRC indicates land per labour unit rate of change, II AGE denotes instability index of agricultural government expenditure and V_t is stochastic disturbance term with $V_t \sim N(O, \sigma^2)$.

4. $PVCFA=b_0 + b_1 PCFA+b_2ATT_{t-1}+b_3AGDP$, where PVCFA is the private capital formation in agriculture at constant prices, PCFA refers to public capital formation in agriculture at constant prices, ATT denotes agricultural terms of trade (ratio of wholesale price index of agricultural commodities to wholesale price index of all commodities) and AGDP is the agricultural income (agricultural GDP at constant prices). The complementarity is also tested using the equation: $PVCFA=b_0+ b_1PCFA$, where PVCFA is the private capital formation in agriculture at constant prices and PCFA refers to public capital formation in agriculture at constant prices.(PVCFA=637.68 (3.29) + 1.42PCFA (8.99)*, $R^2 = 0.74$, * - Significant at one per cent level of probability).

5. $PVCFA = b_0 +b_1CREDIT$, where PVCFA is the Private Gross Capital Formation in Agriculture at constant prices and CREDIT refers institutional credit to agriculture measured at real terms. (PVCFA =2259.58 (15.06)+0.11(3.07)***, $R^2 = 0.33$).

6. $PR=b_0-b_1PCSGDP$, where PR is the poverty ratio and PCSGDP per capita state gross domestic product at constant prices.

7. The relationship between the incidence of poverty and agricultural growth over the period was examined through regression analysis. Planning Commission estimates (levels) of incidence of rural poverty (percentage of population below poverty line) were used for regression analysis. It was hypothesised that the incidence of rural poverty depends upon the level of per capita gross domestic product from agriculture. Further, an alternative hypothesis that the incidence of rural poverty depends not only on the current years level of per capita gross domestic but also on the level in the previous year, was also tested. There are other factors operating in the rural economy that influence the incidence of rural poverty. This hypothesis was tested including time as an additional variable. There are relations between changes in nominal prices of some commodities consumed by the poor and their real incomes. The changes in the nominal price of the consumption basket of the poor had a far greater and more immediate impact on their ability to cross the poverty line than on their incomes whether they are producers of these commodities or farm labourers. This is due to the rural poor's small share in the marketed agricultural surplus, rigidities in rural wages, which are increasingly monetised; and the widespread dependence of the poor on market purchases for consumption needs (Narain, 1961; Ahluwalia, 1978) It is indicated that the use of Consumer Price Index of Agricultural Labourers (CPIAL) to estimate poverty percentages would produce a spurious positive correlation between the price variable and the incidence of rural poverty. Narain (1977), however contended that although the measurement of poverty line was statistically influenced by CPIAL, its influence on the distribution of household expenditure was causal rather than statistical. If only the distribution of household expenditure remained unchanged over time, then the use of CPIAL in estimating poverty percentages would produce a spurious positive correlation. Therefore, in the present study two more equations were estimated by adding price as an explanatory variable to PAGDPAP and TIME. For price, the CPIAL was included as explanatory variable in one equation and another equation was estimated using Index Number of Wholesale Price of Food Articles (WPIF).

The recursive system of equation is given as

$$PAGGDP_t = \beta_0 + \beta_1 CFAG_t + \beta_2 AGEXP + \beta_3 INDAG + u_{1t} \quad ....(1)$$

$$PPBL_t = \beta_0 - \beta_1 PAGGDP_t - \beta_2 CFAG_t - \beta_3 AGEXP + \beta_4 INDAG\ u_{2t} \quad ....(2)$$

$$PPBL_t = \beta_0 - \beta_1 PAGGDP_t - \beta_2 PAGGDP_{t-1} - \beta_3 CFAG_t - \beta_4 AGEXP_t + \beta_5 INDAG + u_{3t} \quad ....(3)$$

where, PAGGDP is the per capita real gross domestic product in agriculture, $PAGGDT_{t-1}$ is lagged (one year) per capita gross domestic product, CFAG is the real capital formation in agriculture, AGEXP is the real agricultural exports, INDAG is the index of agricultural production and PPBL is the percentage of population below poverty line, u_t is error term. Improved agricultural performance, measured as an increase in the gross domestic product in agriculture per head of the rural population at constant prices (PAGGDP), is definitely associated with reduction in the incidence of rural poverty.

The rationale for having both $PAGGDP_t$ and $PAGGDP_{t-1}$ as explanatory variables is that poverty is defined in terms of consumption and consumption can be protected from a decline in income in any one year by borrowing or sale of assets. This cushion is exhausted, however, if there are two bad years in succession since the borrowing capacity is limited and assets sold have to be replaced. For this reason, a decline in income in one year does not lead to as large increase as poverty as when there are two bad years in succession. Equally, a rise in income levels immediately following a bad year does not reduce poverty as much as might be expected, since consumption loans undertaken in the previous years would have to be repaid, and assets sold replaced before consumption levels could recover fully. Lagged agricultural income was therefore an important variable on its own right.

To find out the underlying time trend in the incidence of rural poverty incidence associated with changes in PAGGDP, the equation (3) was modified as with inclusion of time variable.

$$PPBL_t = \beta_0 - \beta_1 PAGGDP_t - \beta_2 PAGGDP_{t-1} - \beta_3 CFAG_t - \beta_4 AGEXP_t - \beta_5 INDAG - \beta_6 TIME + u_{4t} \quad ....(4)$$

Time was included to identify the influence the host of factors like employment generation due to investment on socio-economic overheads in rural areas, development of cottage and village industries, growth of the tertiary sector in rural areas resulting from agricultural development, land reforms, development of co–operative institutions and growth in health education and other services. The temporal variation in the incidence of rural poverty was assessed after making allowances for the changes in the incidence of poverty associated with agricultural performance and the nominal price of the rural poor's consumption basket. Then equation (4) was modified as:

$$PPBL_t = \beta_0 - \beta_1 PAGGDP_t - \beta_2 PAGGDP_{t-1} - \beta_3 CFAG_t - \beta_4 AGEXP_t - \beta_5 INDAG - \beta_6 TIME - \beta_7 CPIAL + u_{5t} \quad ....(5)$$

$$PPBL_t = \beta_0 - \beta_1 PAGGDP_t - \beta_2 PAGGDP_{t-1} - \beta_3 CFAG_t - \beta_4 AGEXP_t - \beta_5 INDAG - \beta_6 TIME - \beta_7 WPIF + u_{6t} \quad ....(6)$$

Cov (u_{1t}, u_{2t}) = 0,Cov (u_{1t}, u_{3t}) = 0, Cov (u_{1t}, u_{4t}) = 0, Cov (u_{1t}, u_{5t}) = 0 and Cov (u_{1t}, u_{6t}) =0 where, CPIAL is the consumer price index of agricultural labourers. WPIF is the wholesale price index of food articles. The equations were estimated after logarithmic transformation for the time period, 1970-71 to 1999-2000.

8. The elasticity of offer curve is given as

έ = percentage change in imports / percentage change in exports

$$\frac{dy/y}{dx/x} \quad \frac{dy}{dx}\,\frac{x}{y}$$

i.e., έ = marginal terms of trade / average terms of trade.

The ratio y / x is the country's average terms of trade which show the number of units of y imported for each unit of x exported on the average. The dy / dx gives the ratio at which the country exchanged x for y on the margin.

9. The elasticity of demand for imports, e is given ase = percentage change in imports/ percentage change in the relative price of imports.

Since along the offer curve, the value of exports equals the value of imports, i.e., Px X = Py Y, the relative prices of imports (that is , Py / Px) is given by the ratio X/Y.

$$\frac{\left(dy/y\right)}{\left[d(X/Y)\right]/\frac{X}{Y}}$$

$$\frac{dy}{d\left(\frac{x}{y}\right)}\,\frac{x}{y^2} \quad \frac{dy}{(ydx - xdy)/y^2}\,\frac{x}{y^2}$$

$$\frac{(dy/dx)\,(x/y)}{1-\left[(dy/dx)\ (x/y)\right]} \quad \frac{\varepsilon'}{1-\varepsilon'}$$

$$\frac{\varepsilon'}{1-\varepsilon'} \text{ or}$$

$$\frac{1}{(1/\varepsilon') - 1}$$

in terms of έ

έ = e / 1+e

10. The elasticity of supply of exports, η is defined as η = percentage change in exports / percentage change in relative price of exports the relative price of exports is simply the ratio Px / Py, which along the offer curve is given by the ratio Y/X.

$$\frac{dx/x}{\dfrac{\left[d(y/x)\right]}{\frac{y}{x}}}$$

$$\frac{dx}{d(y/x)x^2}\,\frac{y}{x^2}$$

$$\frac{dx}{(xdy - ydx)x^2}\,\frac{y}{x^2}$$

$$\frac{1}{\left[(dy/dx)(x/y)\right]^{-1}}$$

$$\frac{1}{\varepsilon' - 1}$$

Adding the elasticity of demand for imports to the elasticity of exports, then

e + η = -1 or η = - (1+e)

That is the sum of the elasticities of the demand for imports e and supply of exports η is always equal to -1.

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ANNEXURE 1. GROWTH PERFORMANCE: PRODUCTIVITY OF SELECTED CROPS, SELECTED STATES

(Compound growth rate- per cent)

State	Rice			Wheat			Maize			Pulses			Groundnut			Banana		
	1970s	1980s	1990s	1970s	1980s	1990s	1970s	1980s	1990s	1970s	1980s	1990s	1970s	1980s	1990s	1970s	1980s	1990s
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Andhra Pradesh	2.38	1.98	1.43	0.24	1.49	-5.02	0.88	-1.60	4.50	1.02	4.49	0.57	0.85	0.63	-0.56	5.91	-2.82	12.08
Assam	-0.05	1.72	1.41	2.09	-1.60	0.57	1.07	0.58	1.48	-0.24	0.69	0.00	-	-	-	-0.23	-0.42	1.35
Bihar	-0.18	5.14	5.38	-0.29	2.28	2.16	8.17	5.71	2.52	-1.27	1.67	1.08	3.57	-46.28	0.00	1.42	0.40	31.45
Gujarat	6.80	0.77	2.30	1.64	-0.50	0.86	10.93	-3.17	2.18	0.61	-1.67	-2.19	5.18	-3.43	1.48	-2.43	12.70	10.51
Haryana	4.98	0.55	-1.45	2.00	3.93	1.58	-5.15	0.53	4.45	5.23	5.45	-1.23	4.84	-2.80	0.00	-	-	-
Himachal Pradesh	-	-	-	-0.21	1.75	0.73	0.09	0.51	1.35	0.74	-4.93	0.00	-	-	-	-	-	-
J&K	1.90	-0.58	-0.97	2.56	0.47	-4.85	0.72	-1.44	-0.65	-1.01	-1.62	0.00	-	-	-	-	-	-
Karnataka	1.48	0.38	1.32	6.32	-2.86	1.74	-3.18	0.62	0.14	3.30	-0.82	2.02	-0.97	1.95	0.95	0.80	11.27	8.03
Kerala	0.60	1.52	0.67	-	-	-	-	-	-	3.44	2.02	0.00	12.43	-3.30	0.24	-10.03	1.81	14.38
Madhya Pradesh	-1.73	3.51	-3.73	0.38	3.34	1.27	-1.41	3.77	1.54	-3.33	2.12	1.01	-2.02	4.73	2.54	3.65	-2.03	33.44
Maharashtra	7.00	0.13	0.46	8.39	2.20	1.42	11.29	-4.97	-0.24	3.10	4.51	2.33	3.46	3.28	0.87	1.09	0.67	17.48
Orissa	1.18	4.19	-2.95	1.19	-1.13	-2.95	-0.79	0.66	3.39	-2.48	0.01	-4.53	-4.19	-0.50	-5.90	-0.21	1.28	4.17
Punjab	4.21	0.71	0.12	2.30	3.00	2.06	0.21	-1.26	3.10	-0.45	3.63	-1.10	-1.10	1.85	0.47	-	-	-
Rajasthan	-	-	-	1.28	3.77	1.12	-2.53	0.94	0.56	0.79	-0.68	0.08	-4.29	4.58	1.65	-	-	-
Tamil Nadu	0.11	5.95	1.38	-	-	-	-	-	-	-	-	-	1.19	2.59	3.56	2.47	7.45	9.80
Uttar Pradesh	1.34	5.83	1.97	2.13	2.77	1.83	0.85	-2.80	0.55	2.82	4.52	0.44	-3.98	2.37	-0.76	-	-	-
West Bengal	1.69	6.39	1.39	-2.47	-0.66	1.32	-1.51	5.04	1.06	-1.77	0.03	-0.35	-	-	-	-	-	12.40
India	1.65	3.56	1.10	1.87	3.09	1.81	-0.51	2.06	2.25	-0.98	1.57	0.49	0.99	2.03	0.83	1.33	2.61	11.12

(Contd.)

ANNEXURE 1. (CONCLD.).

State (1)	Sugarcane			Sesamum			Sunflower		
	1970s (20)	1980s (21)	1990s (22)	1970s (23)	1980s (24)	1990s (25)	1970s (26)	1980s (27)	1990s (28)
Andhra Pradesh	-1.50	-1.54	1.06	-0.64	-23.95	-0.76	1.33	2.61	11.12
Assam	-1.31	1.16	-0.35	0.25	0.32	0.90	-4.76	1.68	0.94
Bihar	-1.51	4.66	-0.92	-0.34	-1.55	6.63	-	-	-
Gujarat	1.66	3.80	-2.52	-1.08	-4.55	6.91	-	-	-
Haryana	-2.57	2.96	0.47	1.54	-5.58	0.02	-	-	-
Himachal Pradesh	6.13	-7.83	-	4.30	-9.54	7.26	-	-	-0.92
J&K	12.94	-6.78	-	-0.10	-1.13	4.67	-	-	-
Karnataka	-2.22	0.34	2.39	1.98	3.03	2.79	24.45	-3.32	-0.97
Kerala	1.68	-2.30	2.64	-2.44	-1.23	5.08	-	-	-
Madhya Pradesh	-0.19	3.38	0.25	-5.66	6.36	2.10	-	-	-
Maharashtra	3.78	2.74	0.65	1.63	0.94	1.06	-6.80	-4.76	-0.80
Orissa	0.40	1.04	-0.74	-4.16	1.29	-4.54	-	-	-
Punjab	3.54	0.65	0.34	-1.21	1.15	-0.86	-	-	-3.51
Rajasthan	-0.31	1.23	-1.26	-4.76	0.87	-3.82			
Tamil Nadu	2.91	1.34	0.34	1.62	-1.25	4.09	-12.02	4.12	6.57
Tripura	2.98	1.66	0.00	-0.98	-1.39	-0.23			
Uttar Pradesh	-0.23	2.37	0.23	-8.74	-10.85	4.84	4.75	2.85	2.86
West Bengal	1.06	2.33	0.00	0.40	4.96	-1.17	-	-	-
India	0.57	1.28	0.84	-1.17	3.72	1.89	-3.14	-3.61	-0.11

ANNEXURE 2. SUSTAINABILITY OF AGRICULTURAL GROWTH IN INDIA DURING 1990S

Rice			Wheat			Maize			Pulses		
Declining productivity	Declining marginal productivity	Increasing marginal productivity	Declining productivity	Declining marginal productivity	Increasing marginal productivity	Declining productivity	Declining marginal productivity	Increasing marginal productivity	Declining productivity	Declining marginal productivity	Increasing marginal productivity
Haryana	Andhra Pradesh	Bihar	Andhra Pradesh	Andhra Pradesh	Assam	Jammu & Kashmir	Bihar	Assam	Gujarat	Andhra Pradesh	Himachal Pradesh
Jammu & Kashmir	Assam	Karnataka	Jammu & Kashmir	Bihar	Gujarat	Maharashtra	Karnataka	Andhra Pradesh	Haryana	Assam	Jammu & Kashmir
Madhya Pradesh	Haryana		Orissa	Haryana	Karnataka		Madhya Pradesh	Gujarat	Orissa	Bihar	Karnataka
Orissa	Gujarat		Delhi	Jammu & Kashmir	West Bengal		Rajasthan	Haryana	Punjab	Gujarat	Rajasthan
Punjab	Jammu & Kashmir			Madhya Pradesh			Uttar Pradesh	Himachal Pradesh	Uttar Pradesh	Haryana	
	Kerala			Maharashtra			West Bengal	Jammu & Kashmir		Kerala	
	Madhya Pradesh			Orissa			Manipur	Maharashtra		Madhya Pradesh	
	Maharashtra			Punjab				Orissa		Maharashtra	
	Orissa			Uttar Pradesh				Punjab		Orissa	
	Punjab			Delhi				Meghalaya		Punjab	
	Tamil Nadu			Himachal Pradesh				Nagaland		Tamil Nadu	
	Uttar Pradesh			Rajasthan						Uttar Pradesh	
	West Bengal									West Bengal	
	Punjab			Delhi				Meghalaya		Punjab	
	Tamil Nadu			Himachal Pradesh				Nagaland		Tamil Nadu	
	Uttar Pradesh			Rajasthan						Uttar Pradesh	
	West Bengal									West Bengal	

(Contd.)

ANNEXURE 2. (CONCLD.).

Groundnut			Sugarcane			Sesamum			Sunflower			Banana		
Declining productivity	Declining marginal productivity	Increasing marginal productivity	Declining productivity	Declining marginal productivity	Increasing marginal productivity	Declining productivity	Declining marginal productivity	Increasing marginal productivity	Declining productivity	Declining marginal productivity	Increasing marginal productivity	Declining productivity	Declining marginal productivity	Increasing marginal productivity
Andhra Pradesh	Andhra Pradesh	Bihar	Assam	Assam	Andhra Pradesh	Andhra Pradesh	Karnataka	Andhra Pradesh	Haryana	Andhra Pradesh	Karnataka	Gujarat	Gujarat	Andhra Pradesh
Orissa	Karnataka	Gujarat	Bihar	Bihar	Himachal Pradesh	Orissa	Madhya Pradesh	Assam	Karnataka		Maharashtra	Manipur	Karnataka	Assam
Uttar Pradesh	Madhya Pradesh	Haryana	Gujarat	Gujarat	Jammu & Kashmir	Punjab	Orissa	Bihar	Maharashtra		Tamil Nadu		Manipur	Bihar
	Maharashtra	Kerala	Orissa	Orissa	Karnataka	Rajasthan	Punjab	Gujarat	Punjab		Uttar Pradesh		Tripura	Kerala
	Orissa	Tamil Nadu	Rajasthan	Rajasthan	Kerala	Tripura	Rajasthan	Haryana					Andaman & Nicobar	Madhya Pradesh
	Punjab	Poondicherry		Haryana		West Bengal	West Bengal	Himachal Pradesh						Maharashtra
	Rajasthan			Madhya Pradesh				Jammu & Kashmir						Meghalaya
	Uttar Pradesh			Maharashtra				Kerala						Orissa
				Punjab				Maharashtra						Tamil Nadu
				Tamil Nadu				Tamil Nadu						West Bengal
				Uttar Pradesh				Tripura						
				Rajasthan				Uttar Pradesh						
				Tripura										
				West Bengal										
				Poondicherry										

ANNEXURE 3. STATE-WISE FERTILISER CONSUMPTION AND IMBALANCE IN USE OF FERTILISERS - SELECTED STATES

(Nutrients - kg/ha)

States	1970s				1980s				1990s				Growth rate of fertiliser consumption, 1990-91 to 2000-01 (per cent)			
	N	P	K	Total NPK	N	P	K	Total NPK	N	P	K	Total NPK	Nitrogen	Phosphorus	Potash	Total
Andhra Pradesh	27.9 (10.19)	8.9 (3.24)	2.7 (1.00)	39.4	31.9 (8.86)	10.4 (2.89)	3.6 (1.00)	45.9	90.99 (8.00)	37.69 (3.31)	11.37 (1.00)	140.02	4.38	6.23	9.15	5.24
Karnataka	15.6 (3.01)	5.9 (1.15)	5.2 (1.00)	26.7	17.5 (2.78)	7.4 (1.17)	6.3 (1.00)	31.2	45.94 (3.22)	24.41 (1.71)	14.27 (1.00)	84.62	8.13	6.30	6.00	7.17
Kerala	13.3 (1.99)	6.7 (1.00)	9.0 (1.34)	29.0	14.3 (1.79)	8 (1.00)	11.1 (1.39)	33.4	28.15 (1.87)	15.04 (1.00)	25.69 (1.71)	68.88	-1.13	-3.57	-4.43	-2.89
Tamil Nadu	34.9 (3.65)	9.6 (1.00)	11.3 (1.18)	55.8	37.6 (3.45)	10.9 (1.00)	14.7 (1.35)	63.2	72.82 (2.59)	28.07 (1.00)	35.05 (1.25)	135.94	3.71	3.44	-0.21	2.61
Gujarat	16.9 (6.41)	8.1 (3.07)	2.6 (1.00)	27.6	19.7 (5.63)	11.3 (3.23)	3.5 (1.00)	34.5	53.03 (10.14)	20.86 (3.99)	5.23 (1.00)	79.12	3.65	1.36	1.70	2.82
Madhya Pradesh	4.7 (9.47)	2.2 (4.40)	0.5 (1.00)	7.4	5.7 (8.14)	2.8 (4.00)	0.7 (1.00)	9.2	24.26 (13.20)	13.90 (7.56)	1.84 (1.00)	40.07	1.90	3.90	2.60	2.65
Maharashtra	11.3 (3.66)	3.7 (1.18)	3.1 (1.00)	18.1	13.3 (4.03)	4.6 (1.39)	3.3 (1.00)	21.2	42.43 (4.76)	18.42 (2.07)	8.91 (1.00)	69.76	4.15	5.59	2.42	4.27
Rajasthan	5.4 (21.67)	1.2 (4.60)	0.3 (1.00)	6.8	6.3 (21.00)	1.4 (4.67)	0.3 (1.00)	8	22.06 (67.76)	8.21 (25.23)	0.33 (1.00)	30.60	7.48	3.60	-5.87	6.16
Haryana	27.2 (17.35)	4.5 (2.88)	1.6 (1.00)	33.3	34.5 (15.68)	5.8 (2.64)	2.2 (1.00)	42.5	96.72 (123.47)	27.84 (35.54)	0.78 (1.00)	125.31	6.24	5.32	5.87	6.04
Punjab	59.2 (15.11)	19.1 (4.86)	3.9 (1.00)	84.2	81.1 (18.02)	32.3 (7.18)	4.5 (1.00)	117.9	128.13 (54.27)	36.97 (15.66)	2.36 (1.00)	167.46	1.63	-1.90	7.22	0.84

(Contd.)

ANNEXURE 3. (CONCLD.).

States	1970s				1980s				1990s				Growth rate of fertilizer consumption, 1990-91 to 2000-01(per cent)			
	N	P	K	Total NPK	N	P	K	Total NPK	N	P	K	Total NPK	Nitrogen	Phos-phorus	Potash	Total
Uttar Pradesh	28.7	6.0	2.9	38.0	36.9	9	3.4	49.3	80.94	20.15	3.45	104.55	4.26	6.91	1.70	4.67
	(10.01)	(2.08)	(1.00)		(10.85)	(2.65)	(1.00)		(23.45)	(5.84)	(1.00)					
Himachal Pradesh	9.0	2.0	1.6	12.6	13.2	2.5	1.6	17.3	26.37	4.90	3.60	34.87	1.67	2.68	3.25	1.89
	(5.59)	(1.25)	(1.00)		(8.25)	(1.56)	(1.00)		(7.33)	(1.36)	(1.00)					
Jammu and Kashmir	13.2	2.8	0.8	17.0	16.3	4.1	1	21.4	38.60	11.39	1.60	51.59	5.30	7.55	-8.91	5.16
	(17.15)	(3.63)	(1.00)		(16.30)	(4.10)	(1.00)		(24.11)	(7.11)	(1.00)					
Bihar	12.5	2.0	1.1	15.5	13.9	2.5	1.3	17.7	57.53	14.33	4.77	76.64	8.53	8.63	8.31	8.46
	(11.67)	(1.89)	(1.00)		(10.69)	(1.92)	(1.00)		(12.05)	(3.00)	(1.00)					
Orissa	5.9	1.6	0.9	8.5	6.5	2	1.1	9.6	19.39	5.70	3.72	28.88	8.85	9.50	9.54	9.17
	(6.47)	(1.75)	(1.00)		(5.91)	(1.82)	(1.00)		(5.21)	(1.53)	(1.00)					
West Bengal	16.2	5.7	4.2	26.1	21.2	9	5.7	35.9	58.05	28.34	18.74	105.21	3.65	5.04	6.90	4.59
	(3.90)	(1.36)	(1.00)		(3.72)	(1.58)	(1.00)		(3.10)	(1.51)	(1.00)					
Assam	1.6	0.2	0.3	2.0	2.1	0.3	0.4	2.8	9.21	3.72	3.82	16.75	18.48	24.29	15.56	19.13
	(6.33)	(6.33)	(1.00)		(7.00)	(1.00)	(1.33)		(2.48)	(1.00)	(1.03)					
India	17.60	5.18	2.85	25.75	21.4	7	3.6	32	52.68	18.79	6.96	78.43	4.22	3.71	2.62	3.94
	(6.18)	(1.82)	(1.00)		(5.94)	(1.94)	(1.00)		(7.56)	(2.70)	(1.00)					

Figures in parentheses denote the ratio of NPK.

ANNEXURE 4. MARGINALISATION OF AGRICULTURAL HOLDINGS, MAJOR STATES

(Average size in ha; Operational holdings in '000 Nos.)

State	1970-71		1976-77		1980-81		1985-86		1990-91	
	Average size	Operational holdings	Average size	Operational holdings	Average size	Operational holdings	Average size	Operational holdings	Average size	Operational holdings
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Andhra Pradesh	2.51	5420	2.34	6154	1.91	7370	1.72	8231	1.56	9290
Assam	1.47	1964	1.37	2254	1.49	2298	1.31	2419	1.27	2523
Bihar	1.52	7577	1.10	9936	2.16	11030	0.93	11711	0.83	12966
Gujarat	4.11	2433	3.71	2737	2.54	2930	3.17	3145	2.93	3517
Haryana	3.7	913	3.58	999		1012	2.76	1347	2.43	1530
Himachal Pradesh	1.53	609	1.63	621	1.18	638	1.30	753	1.21	834
Jammu & Kashmir	0.94	979	0.94	979		1035	0.86	1185	0.83	1217
Karnataka	3.20	3551	2.98	3811	2.54	4309	0.4	4408	2.13	5776
Kerala	0.70	2305	0.49	3501	0.66	4181	2.41	4919	0.33	5418
Madhya Pradesh	4.0	5299	3.58	6061	3.38	6411	2.91	7603	2.63	8401
Maharashtra	4.28	4951	3.66	5764	3.14	6862	2.64	8101	2.21	9470
Orissa	1.89	3407	1.60	3576	1.73	3328	1.47	3586	1.34	3948
Punjab	2.89	1375	2.74	1504		1020	3.77	1088	4.74	1117
Rajasthan	5.46	3727	4.65	4365	2.42	4487	4.34	4743	4.11	5107
Tamil Nadu	1.45	5314	1.25	6112	1.62	7191	1.01	7707	0.93	7999
Uttar Pradesh	1.16	15639	1.05	16971	1.75	17817	0.93	18985	0.90	20074
West Bengal	1.20	4216	0.99	5267	0.88	5878	0.92	6130	0.90	6284
All-India	2.30	70493	2	81548	2.43	88883	1.69	97155	1.55	106637
Gini Coefficient	0.3348	0.4200	0.3121	0.5280	0.3177	0.5377	0.3229	0.5881	0.3240	0.5871