SUSTAINABLE AGRICULTURAL DEVELOPMENT: THE ROLE OF INTERNATIONAL COOPERATION

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The Green Revolution, Dryland Agriculture and Sustainability : Insights from India

INTRODUCTION

The green revolution of the 1960s, which enabled LDCs like India to overcome chronic food deficits and large food imports through a significant rise in domestic foodgrain output, continues to evoke considerable interest among researchers and policy makers regarding the nature of its impact, particularly its implications for growth, equity and sustainability. These concerns have brought to the fore a number of issues.

Firstly, why is it that, despite the impressive growth achieved by Indian agriculture following the green revolution, instability too has shown a tendency to rise, as indicated by a number of studies (Mehra, 1981; Hazell, 1982; Nadkarni and Deshpande, 1982, 1983; Rao *et al.*, 1988)? Though a similar phenomenon had been observed in the context of traditional agriculture in India (Sen, 1967), instability has worsened in the latter period. These findings raised doubts as to whether greater instability was an inevitable price to be paid for attaining higher rates of agricultural growth. Though interventionist policies, such as buffer stock operations and foreign trade, can help to cushion the effects of fluctuations in domestic output, they may be costly relative to measures to achieve agricultural growth with stability. The importance of achieving sustained agricultural growth cannot be disputed since it affects the interests of producers, consumers and the economy as a whole, and more so since the poverty ratio has been observed to move in line with the vagaries of agriculture (Ahluwalia, 1978). There has, therefore, been considerable interest in understanding the nature of the association between growth and instability and causes underlying them.

Secondly, though there is widespread acknowledgement regarding the green revolution's role in boosting foodgrain output in many LDCs, including India (at least in its initial phase), doubts have been growing regarding its cost-effectiveness and sustainability, as suggested by some studies from India (Rao, 1983; Nadkarni, 1988), which note a steady and more than proportionate rise in the cost of cultivation, following the green revolution. If this is so, it suggets that the strategy of growth based on the green revolution technology is not sustainable.

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Thirdly, the intensification and chemicalization of agriculture associated with the green revolution has also brought in its train serious ecological problems such as waterlogging, salinity and alkalinity in the irrigated regions and soil erosion, declining water-table and desertification in the dry or semi-arid regions. These focus attention on the environmental costs of various growth strategies.

Lastly, despite the scale neutrality of the new agricultural technology, institutional and economic constraints coupled with the policy bias favouring well-endowed regions, crops and farms have not only resulted in a widening of interpersonal and regional inequities but also led to sectoral imbalances within the agricultural sector, a notable example being the failure of the green revolution to benefit pulses and oilseeds in India, unlike its positive impact on wheat and rice. That growth without equity is not sustainable needs no elaboration.

Keeping these concerns in view and given the constraints of a conference, this paper addresses itself to the following issues. Apart from a fresh look at the growth/instability question with particular reference to dryland agriculture in India, it also attempts to verify the general validity of the 'increasing costs of cultivation' argument using disaggregated data. It then assesses the impact of watershed development programmes on the agriculture and economy of dry regions in India.

Equity and food security considerations apart, the prohibitive costs of future irrigation investments and remote possibilities of irrigation benefiting around 40 per cent of India's arable lands, even if potentials are fully realized, explain this focus on dryland agriculture, in addition to the green revolution. The analysis is both at national (All-India) level and for Karnataka state in South India, which reports about two-thirds of its area as drought-prone with low and uncertain rainfall. The data are from the official reports of the goverments of India and Karnataka and cover the period 1955–6 to 1988–9, unless otherwise indicated.

GROWTH AND INSTABILITY

For analysing the growth and instability question only major crops and crop-groups have been considered. For measuring growth, linear trends with slopes expressed as percentages at respective means have been computed; for instability the coefficient of variation around the trend (CVT) or mean (CV – in cases where the trends are not statistically significant or negative) have been used. These figures are presented for the pre- and post-green revolution phases of Indian agriculture. Though production variability is the outcome of area and yield variability, and their interaction effects, our interest is primarily in yield instability. This is because, while adjustments in area reflect conscious decision making by farmers (hence area is subject to endogenous factors within a farmer's control), yield variations also arise on account of exogenous factors like weather which are beyond a farmer's control. Yield rather than area variability has also been the major source of production variability in India. Moreover, land being a limiting factor in India, as in most Asian countries, efforts for sustained agricultural growth have to concentrate on accelerating and stabilizing yield rates.

In line with most Asian country experiences, foodgrain production in India – dominated by rice and wheat – has kept pace with population increases; but marginally below domestic demand. Annual growth rates in foodgrain output have been 2.6 per cent between 1955–6 to 1988–9, as against 2.2 and about 3 per cent for population and domestic demand respectively. While area and yield were the major sources of output growth in the years prior to the green revolution, it has been largely dominated by yield thereafter. A review of crop performance during the pre- and post-green revolution periods (periods I and II) reveals that at the All-India level all crops except coarse cereals and pulses, registered a significant growth in output in period II (Table 1). Wheat, rice and sugar-cane, which had the benefit of irrigation and modern inputs, fared better than other crops. For most crops, yield rather than area has been the major source of output growth in this period. However, despite a significant improvement in yields, coarse cereals lost area to wheat and rice, resulting in their slow growth. Near stagnation in area and yields contributed to slow growth of pulses too. Other crops, groundnut and cotton, registered lower growth rates in period II compared to period I.

Unlike the situation at the All-India level, where the dry crops had to bear the brunt of the backlash effects of the green revolution, Karnataka's experience stands in sharp contrast where they have shared in the gains of agricultural growth. Here coarse cereals and pulses registered significant increases in output in period II. In fact, among coarse cereals, maize and finger millet fared exceedingly well with annual growth rates in output ranging between 5 and 6 per cent (Ninan, 1991). Other dry crops, groundnut, and cotton have fared better in this period. What is significant is that in most of these cases output growth was realized through significant improvements in yield rates rather than through extension of cultivated area. Obviously, the efforts of the local agricultural scientists and extension workers to evolve and popularize location-specific dry farm technologies has had a better pay-off in Karnataka.

A perpelexing feature, however, is that, along with growth, instability in yields has increased for most crops except wheat and sugar-cane, where it has reduced. The irrigated crops, wheat, rice and sugar-cane, have shown lower levels of instability compared to other crops. Rice, despite being a largely irrigated crop, reported an increase in yield instability, indicating the diverse environments and constraints under which it is grown in India, as in the rest of Asia. Access to yield-enhancing technologies has encouraged rice to move to marginal areas also. For most crops except sugar-cane (at the All-India level) fluctuations in yields have been of a higher amplitude than in area (Ninan, 1991). Despite the impressive performance of dry crops in Karnataka, instability in output and yields too have risen sharply in period II. For instance, the CV of finger millet output rose from 6 to 53 per cent over the two periods, minor millets from 7 to 37 per cent, and pearl millet from 22 to 27 per cent (Ninan, 1991).

This phenomenon of instability moving in sympathy with agricultural growth is reported from other regions as well, including South and South-east Asia (Barker *et al.*, 1981), though there are exceptions also (for example, for Bang-

TABLE 1 *Growth and instability in Indian agriculture (for All India and Karnataka State, 1955–6 to 1988–9)*

Crops/crop groups	Percentage of crop's area: to gross sown area (1986–7)	Percentage of crop's area: under irrigation	Growth rates (per cent per annum): Pre-GR P	Pre-GR Y	Post-GR P	Post-GR Y	Instability (CVT/CV, per cent): Pre-GR P	Pre-GR Y	Post-GR P	Post-GR Y
ALL INDIA										
Rice	23	43	4.0*	2.4*	2.6*	2.0*	5.0	5.1	8.5	7.0
Wheat	13	77	3.3*	2.3**	4.9*	3.1*	8.2	7.2	7.1	5.8
Coarse cereals	23	9	2.6*	1.6*	0.5	1.4*	3.1	3.5	9.8†	7.3
Pulses	13	10	0.4	–0.01	0.6	0.3	9.1†	8.3†	10.5†	8.5†
Foodgrains	72	33	3.0*	2.2*	2.5*	2.3*	4.4	3.8	6.7	5.4
Groundnut	4	15	3.4*	neg.	1.3**	1.2**	5.6	5.5†	8.6	12.1
Cotton	4	31	3.2*	3.00**	1.8*	2.1*	9.9	8.8	11.3	8.9
Sugar-cane	2	82	7.0*	4.1*	2.6*	1.4*	9.4	5.2	8.3	4.4
KARNATAKA STATE										
Rice	10	61	4.4*	1.4**	0.8**	0.9*	5.4	4.7	11.2	9.3
Wheat	2	28	7.0*	5.2*	0.1	1.2***	17.4	9.3	27.3†	19.2
Coarse cereals	40	8	3.1*	2.4	2.4*	2.5*	5.1	17.2†	18.7	18.7
Pulses	14	4	–0.05	0.9	1.0***	0.2	4.9†	4.9†	15.4	13.1†
Foodgrains	66	18	3.3*	2.4*	1.3	1.4*	4.2	4.2	11.6	10.9
Groundnut	9	20	–2.4	–1.7	1.4***	1.0***	16.2	13.2	20.8	14.6
Cotton	4	18	–0.04	4.8*	1.9**	4.9*	12.3†	11.5	23.1	22.7
Sugar-cane	2	99	9.3*	3.9*	3.5*	-0.4	5.5	6.1	11.0	8.7†

Notes: P-Production; Y-Yield per ha.
Pre-GR: Pre-green revolution period, 1955–6 to 1964–5.
Post-GR: Post-green revolution period, 1967–8 to 1988–9.
Growth rates are linear trends with slope expressed as per cent at respective means.
*, **, ***=significant at 1, 5 and 10 per cent levels of significance; remaining growth rates are not significant at the above levels of significance.
CVT/CV are coefficient of variation around trend and mean, respectively, expressed in percentage terms; † = CVS, the rest are CVTs.

Sources: *Agricultural Statistics at a glance*, Directorate of Economics and Statistics, Ministry of Agriculture, Govt. of India, February, 1989; and publications of the Directorate of Economics and Statistics, Government of Karnataka.

ladesh's case, see Alauddin and Tisdell, 1988). Further, though the level of relative instability in India is low by international standards, absolute variability for large low-income countries like India is high (Valdés and Konandreas, 1981); moreover with large on-farm retentions of crop produce and highly skewed income distribution patterns in LDCs, as in India, even small variations in relative instability have important economic and welfare implications (Hazell, 1982). The factors contributing to yield instability are briefly as follows:

(1) Climatic factors like rainfall are an important factor behind yield variability. A recent study suggests that agricultural output has become more sensitive to rainfall in the post-green revolution period, with the elasticity of output with respect to rainfall increasing for most crops except wheat and some rabi (winter) crops in this period (Rao *et al.*, 1988). This is because of the strong complementary relationship between use of modern inputs and availability of moisture either through rainfall or irrigation, and also the fact that growth has taken place under diverse environments and constraints. Other empirical evidence (cf. Nadkarni and Deshpande, 1982), however, revealed that rainfall could not wholly

account for the increased variability, which arises on account of other factors too.

(2) The extension of cultivation to marginal lands or riskier regions has contributed to higher yield instability (Sen, 1967). While this seems appropriate and valid for that particular phase of agricultural growth dominated by extensive methods, the same cannot be said about the subsequent phase (in the post-green revolution period) when intensive methods have become prominent. Particularly in the ecologically fragile areas such as semi-arid/dry regions the use of yield-enhancing technologies may have accentuated instability because of the strong complementary relationship between these modern inputs and availability of moisture, a critical factor in these areas. Despite coarse cereal area falling and yields rising, instability has increased sharply, which supports the above observations.

(3) Factors associated with the new agricultural technology, particularly widespread use of HYVs, chemical fertilizers and greater susceptibility of new crop varieties to pests and diseases, have accentuated instability (Mehra, 1981; Hazell, 1982). For instance, the shift from the traditional crop varieties with a diversified genetic base to HYVs which have a narrow, common genetic base has contributed to greater instability. So, also, the substitution of chemical fertilizers for organic manures has had an adverse effect on soil health, aggravating instability. The yield instability-accentuating properties of HYVs and chemical fertilizers are, however, neutralized in the presence of (assured) irrigation which has a stabilizing effect on yields (Mehra, 1981; Rao *et al.*, 1988).

(4) The new agricultural technology, along with a changed price and policy environment, has altered the production opportunities facing farmers, which has effected changes in the traditional crop patterns and systems. The shift from risk-spreading and risk-adjusting crop systems and practices like multicropping and crop diversificaion to monocropping and crop specialization has tended to increase risks in farming. New profit-making opportunities have encouraged farmers to neglect some ecologically (apart from nutritionally) beneficial crops. For instance, pulses which had to bear the brunt of the backlash effects of the green revolution are good nitrogen fixers and help in enhancing soil fertility. Further, the mutual compensating mechanism of crops/regions (which helped in reducing overall instability) whereby a bad crop in one region can be offset by a good crop in another, has been affected owing to shifts in the cropping pattern and systems; yield correlations across crops and regions have increased following the green revolution (Hazel, 1982; Nadkarni and Deshpande, 1982, 1983; Anderson *et al.*, 1987).

(5) The transition from subsistence to commercialized agriculture involving greater dependence of farmers on off-farm or market inputs, market-oriented production and so on, while bringing about closer integration of farmers with the larger economy, has also made them more vulnerable to market uncertainty and market distortions (Nadkarni and Deshpande, 1983; Rao *et al.*, 1988).

(6) Differences in infrastructure such as irrigation, institutions to provide inputs, credit, extension and other support services, have also influenced yield variability (Nadkarni and Deshpande, 1983; Rao *et al.*, 1988).
(7) Environmental degradation (shrinking common property resources, deforestation) induced by demographic and economic pressures have affected women's time allocation patterns, with more time being required for fuel and forage gathering. This has affected household and farm productivity, more so since they provide specialized skills and labour for agriculture.
(8) Access to free or subsidized inputs may also have played a role in accentuating instability. Since farmers get these inputs at prices or terms which do not reflect their real costs, they are tempted to use them intensively beyond economic or efficient levels, with adverse user costs and negative externalities. Also the advent of modern inputs has lulled farmers into complacency and a neglect of traditional environmentally sound crop practices and resource maintenance techniques evolved over centuries; modern inputs are looked upon as mere substitutes for traditional inputs and practices rather than as complementary.

COST ECONOMICS

The transition from a low- to high-cost economy in the post-green revolution period is another conspicuous attribute of Indian agriculture (Rao, 1983; Nadkarni, 1988). These observations were, however, based on highly aggregative data at country or sectoral (agricultural) level. Using disaggregated data, an attempt is made to see how far this is valid as to crop and region. Input–output ratios (that is, value of inputs as a ratio of the value of output) and the share of paid out costs in the total unit cost of production have been computed for two points of time. Two series of input–output ratios have been computed for each crop, one using paid out costs only and the other considering total costs inclusive of the imputed value of all owned inputs, including imputed wages for family labour. These data are available for the period 1970–1/1971–2 to 1982–3, covering the post-green revolution period, and hence give an opportunity to see how far the green revolution is to be blamed for the rise in the cost of cultivation. Triennial averages have been used to arrive at these ratios.

Evidence in Table 2 suggests that for both irrigated and dry crops the green revolution belt, as well as other areas, is afflicted by the malady of increasing costs of cultivation. The input–output (IO) ratios show positive signs in most cases. These increases are modest for some crops or regions, conspicuous for others. Wheat, and rice in particular – which benefited the most from the green revolution – have reported substantial increases in these ratios in a number of states. However, within the green revolution belt, while these ratios for wheat registered a conspicuous increase in Haryana, in Punjab the rise was only marginal. For rice, not only the traditional rice-growing areas (such as West Bengal) but also new areas (such as Haryana) have witnessed sizable increases. The dry crops, sorghum and maize, also reported a sharp upward swing in these ratios.

The burden of rising production costs in Indian agriculture is borne out by the fact that the share of paid out costs in the total unit cost of production has risen for most crops, in all regions, for the period under review. The increases are particularly sharp for some of the coarse cereals, sorghum, pearl millet and maize. Rice and wheat, too, reported large increases in some regions. This rise is largely on account of the growing importance of market or factory-produced inputs such as HYVs, fertilizers, pesticides and modern farm machinery in the input profile of Indian farming after the green revolution.

This emerging feature of Indian agriculture, whereby more inputs are required to produce a given level of output, indicates that it is becoming less efficient and more expensive. In fact, in some instances, inputs inclusive of all paid out costs and the imputed value of owned inputs exceed the returns (for example, with rice in Haryana, sorghum in Andhra Pradesh). Studies by the IFPRI, at Washington, confirm that aggregate input productivities of Indian agriculture are falling. The narrowing gap between (the value of) inputs and outputs also implies that smaller surpluses are available for future investment in agriculture. In fact, studies suggest that real public and private investment in agriculture for India has declined in recent years (Shetty, 1990); and so also have agricultural growth rates (Nadkarni, 1988). These are disturbing trends indeed, which could impede sustained agricultural growth in India.

The results presented above suggest that (a) Indian agriculture has reached that phase where diminishing returns are in operation; (b) it is increasingly relying on scarce, costly, external rather than local resources; (c) input prices are rising faster than farm product prices, which supports the views of the farmers' lobby that domestic policies are framed to deliberately depress farm product prices; and (d) terms of trade have turned adverse for agriculture. These tendencies are also visible in varying measure in other regions of Asia and the less developed world.

IMPACT OF WATERSHED DEVELOPMENT PROGRAMMES

The biases and weaknesses associated with the green revolution prompted efforts for suitable alternatives that combine environmental concerns with development needs. To illustrate this, the case of watershed development programmes, which are being implemented on an experimental basis in the dry belt of India, is cited here. As against the green revolution strategy which focused exclusively on croplands and ignored environmental costs, these programmes are holistic in nature, covering both arable and non-arable land development. These programmes seek to promote soil and moisture conservation as well as to enhance the productive capacity of drylands.

Karnataka has been in the forefront in experimenting with such programmes since 1984. Though a long-term impact assessment of these programmes may have to wait, available evidence (Table 3) suggests that they have had a favourable impact in terms of growing additional crops, enhancing crop yields and net returns, and generating employment. These programmes thus offer a

TABLE 2 *Cost economics of Indian agriculture (for the period between 1970–1/1971–2 to 1972–3 and 1979–80/1980–1 to 1982–3)*

Crops and states		Input–output ratios			Share of paid-out costs in total unit cost of production (%)		
		Base period	Terminal period	Per cent increase/ decrease	Base period	Terminal period	Per cent increase/ decrease
WHEAT							
Haryana	(a)	0.37	0.52	41	46	60	30
	(b)	0.67	0.88	31			
Punjab	(a)	0.47	0.52	11	51	62	22
	(b)	0.84	0.82	–2			
Uttar Pradesh	(a)	0.42	0.46	10	34	50	47
	(b)	0.75	0.74	–1			
Rajasthan	(a)	0.40	0.55	38	41	61	49
	(b)	0.71	0.88	24			
RICE							
Andhra Pradesh	(a)	0.47	0.57	21	52	60	15
	(b)	0.80	0.91	14			
West Bengal	(a)	0.32	0.53	66	30	53	77
	(b)	0.70	0.94	34			
Orissa	(a)	0.38	0.47	24	41	54	32
	(b)	0.74	0.83	12			
Haryana	(a)	0.67	0.85	27	68	63	–7
	(b)	0.74	1.01	37			
Karnataka	(a)	0.25	0.38	52	38	51	34
	(b)	0.49	0.65	33			
SORGHUM							
Maharashtra	(a)	0.35	0.55	57	20	56	180
	(b)	0.74	0.97	31			
Karnataka	(a)	0.28	0.34	21	20	39	95
	(b)	0.60	0.67	12			
Andhra Pradesh	(a)	0.44	0.71	61	36	46	28
	(b)	0.85	1.20	41			
PEARL MILLET							
Gujarat	(a)	0.42	0.47	12	25	60	140
	(b)	0.77	0.79	3			
Rajasthan	(a)	0.33	0.28	–15	20	38	90
	(b)	0.85	0.73	–14			
Haryana	(a)	0.47	0.40	–15	19	17	–11
	(b)	1.15	0.93	–19			
MAIZE							
Rajasthan	(a)	0.27	0.36	33	13	42	223
	(b)	0.67	0.86	28			
Himachal Pradesh	(a)	0.35	0.56	60	35	43	23
	(b)	0.78	1.24	59			

Note: 1. Input–Output ratios are the value of inputs expressed as a ratio of the value of output.
2. Two types of input–output ratio have been computed for each crop, denoted as (a) and (b) respectively: (a) only paid-out costs including value of farm-produced inputs and own bullock labour are used to arrive at the value of inputs here; (b) inputs here include total costs consisting of all paid-out costs plus rental value of own land, interest on own fixed capital and imputed wages for family labour.
3. The ratios/percentages are arrived at using triennium averages of the available data. Base period is based on data for 1970/1–72 to 1973–4 and terminal period on 1979–80/1980–1 to 1982–3.

Source: Computed from data published in *Indian Agriculture in Brief* (21st edn), Directorate of Economics and Statistics, Ministry of Agriculture, Govt. of India, 1987.

ray of hope for the disadvantaged dryland farmers to participate in the development process.

CONCLUSIONS

While irrigated crops and those with access to modern farm technology have dominated the growth process in India, dry crops and drought-prone regions have also shared the gains of agricultural growth in certain pockets. But this growth has been accompanied by increasing yield instability and production costs. These are obstacles to realizing sustained agricultural growth. Whether attaining higher yields involves a trade-off with greater stability or not is difficult to surmise. While evidence presented here points to instability rising with growth, experience of some developed countries and LDCs shows higher yields being combined with greater stability (Barker *et al.*, 1981; Alauddin and Tisdell, 1988). But assuming that such trade-offs do exist, how do countries respond? Generalizations are difficult since risk preferences among countries, and between farmers, could vary; and so also perceptions and policy responses. LDCs like India when faced with a severe food crisis in the 1960s gave emphasis to raising yields. This strategy complemented by stabilization policies, has enabled India to expand food supplies as well as to cope with fluctuations in domestic output; but these have not necessarily been costless.

Reducing risks and costs in farming without inhibiting growth constitute an important agenda for agricultural planners and scientists. Risk reduction or management has to centre around (a) crop, varietal and economic diversification (especially in dry regions where agriculture has to survive on a poor resource base); (b) development of crop varieties and technologies that can withstand environmental stresses and shocks; (c) development of infrastructure such as irrigation, input delivery systems and market institutions, and (d) stabilization policies (crop insurance, buffer stocks, target-oriented public distribution systems, price support) to insulate producers and consumers from weather and market-related risks. Cost-reduction strategies should focus on (a) economizing and, wherever possible, substituting external with local resources: for instance, legumes in traditional crop rotations were an inexpensive source of nitrogen (local resource) as against expensive synthetic nitrogen (external resource); so also organic manures which are less hazardous and expensive, and labour-intensive, have been increasingly discarded after the advent of chemical fertilizers; (b) research and development of cost-effective technologies; (c) resource conservation (soil and water conservation); and (d) shifting to sustainable alternatives (natural farming, watershed management, biological methods of pest control and nutrient use). The accent on 'resource exploitation' which characterized the green revolution-based growth strategy has to give place to one based on 'resource conservation' using modern science and traditional wisdom.

The strategies for promoting sustained agricultural growth will have to keep in view the diverse environments and constraints under which agricultural growth is taking place. While in the irrigated regions, or those with plentiful water, emphasis has to be on improving water-use efficiency through proper

TABLE 3 *Impact of watershed development programmes on dryland development in Karnataka State, India.*

Item	Variables			
	CROP YIELDS (Quintals per ha)			
	With watershed		*Without watershed*	
Crops	*Mittemari*	*Gonur*	*Mittemari*	*Gonur*
Finger millet	12.3	—	9.6	—
Groundnut	13.2	—	9.6	—
Sorghum	—	8.5	—	6.0
Groundnut+redgram	—	5.5+2.1	—	2.8+0.5
Pearl millet+horsegram	—	2.9+1.3	—	1.8+0.4
Minor millet+horsegram	—	2.6+0.8	—	0.2+0.2
Finger millet+horsegram	—	5.3+1.1	—	2.5+0.5
Sunflower+redgram	—	2.5+1.0	—	(not grown)
Sorghum+redgram	—	3.7+3.2	—	(not grown)
Maize+redgram	—	6.4+1.4	—	(not grown)
	RELATIVE ECONOMICS OF HORTICULTURAL CROPS			
	Annual		*Horticultural*	
	Sorghum	*Groundnut*	*Mango*	*Acid lime*
Benefit–cost ratio	1.2	1.5	6.9	4.9
			Sweet lime	*Cashew*
			2.9	1.3
	NET RETURNS (Achalu micro-watershed)			
	Year: *1986–7 (Bench-mark)*		*1989–90*	
Net returns in rupees per ha of net cropped area	–46		2575	
	(Joladarashi watershed)			
	With watershed		*Without watershed*	
	(rupees per ha)			
Crops				
Sorghum	1003		642	
Coriander+safflower	1042		902	
Safflower (local)	403		309	
	EMPLOYMENT (Achalu micro-watershed)			
	Year: *1986–87 (Benchmark)*		*1989–90*	
Man-days per ha of net cropped area	67		106	

Source: State Watershed Development Cell, Government of Karnataka, Bangalore.

regulation and management (relevant for South and South-east Asia), in the dry and semi-arid regions where water, apart from land are overriding constraints, the policy goals should aim at moisture and soil conservation and encouraging income-enhancing crops (such as fruit trees) and economic activities (pastoral, agro-forestry) that are less water- and land-intensive. Ultimately, an economic environment that is growth- and equity-promoting and which interacts in harmony with nature is the desired goal.

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DISCUSSION OPENING – MAURIZIO MERLO*

The theme explored by Ninan and Chandrashekar is a vast and difficult one. In fact, the authors make clear that their objective is limited to providing some insights relating to Indian agriculture generally, but probing more deeply into the specific experience of Karnataka State.

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The insights relate first to production performance which is associated with growing instability in agricultural output. It is also stressed that the green revolution has increased cultivation costs and seems to have created external costs because of environmental degradation. The widening of income disparity amongst farmers, and regional inequities and other sectoral imbalances are also said to have stemmed from the green revolution.

Coming to the key issue of the paper, namely agricultural growth and its associated instability, one can note that a very technological view is adopted, since growth is defined in terms of physical production and yield per hectare of the main crops in India. The paper attempts to compare growth before and after the green revolution, which occurred in the 1960s. The analysis therefore distinguishes the two key periods as 1955–6 and 1966–89. The dividing line, probably chosen because of data availability, seems to be hardly justifiable, given the production performances reported in Table 1. Especially when expressed in terms of yield per hectare, the growth rate does not vary significantly between the two periods. Indeed it seems to be higher, particularly in Karnataka State, before the green revolution. Certainly, some explanation should be provided to avoid this apparent anomaly. It would also be interesting to distinguish between growth specifically due to the green revolution from more general effects of irrigation expansion or watershed management.

The instability associated with growth is, however, quite clearly demonstrated in Table 1. The reasons for yield instability rising after the green revolution include rainfall failure, cultivation of ecologically fragile marginal land, sensitivity of HYVs and chemical fertilizers to moisture, specialization of agricultural systems, transition from subsistence to commercialized agriculture, environmental degradation and neglect of traditional practices and resource maintenance. The paper seems to blame the green revolution for causing instability, but it can equally well be argued that instability is intrinsic to any form of development. Social and economic turbulence has been part of the development process, and agriculture in this context, as the weakest (and residual) sector of the economy, has always been liable to experience difficulties and disarray. In other words, instability has always marked the transition from subsistence to commercialized farming. Agricultural policies have to some extent been originally conceived and implemented specifically to alleviate the socio-economic conditions of rural areas during the process of economic development.

From this point of view the paper appears to be too limited to technological aspects, overlooking any socio-economic and historical perspective, and failing to refer to basic economic theories which would have helped to explain its main thesis. The authors are right to pose the question concerning the extent to which attaining higher yields involves a trade-off with greater stability, but their answers appear to be limited.

Coming to the cost economics, Table 2 quite clearly shows a noticeable increase in input–output ratios and of the share of paid out costs in total unit costs of production. Above all it is paid out costs for fertilizers, pesticides, seeds and equipment, which have increased in weight. The trend in itself is not surprising: it can be found in many other developed and less developed countries and inevitably it assumes dramatic connotations when agriculture progresses from an essentially subsistence orientation to a commercialized structure. The main surprise, given the rather poor average production performances of India (1.6 ton/ha of wheat, 1.3 of rice and 1.1 of maize), is that a share of 50–60 per cent of paid out costs seems quite high. Perhaps it would be wise to ascertain how much the supposed scale neutrality of the new technologies is actually verifiable, or whether monopoly marketing of such inputs as seed and fertilizer is contributing to the size of costs.

The assertion that the terms of trade have become adverse for agriculture, and consequently that the farmers' lobby is displeased, seems quite reasonable, and would certainly satisfy any farmers' audience around the world.

The key question of the paper is whether modern agricultural technology is not, or at least is no longer, viable for India and other LDCs. The issue is no longer left only to agricultural economists and scientists; it has importance and momentum in the political arena, being linked to various theses advanced by radical and fundamentalist movements which question the very concept of development. These views have certainly surfaced in India. Objectively speaking, there are arguments which cannot be easily dismissed as suggested by Ninan and Chandrashekar. On balance, however, it would perhaps be better to argue that it is the old-fashioned and highly costly technology, which has characterized the green revolution, that is no longer acceptable. Technology in itself is the inescapable key to meeting production objectives, but it needs to be a new 'clean' higher-level technology originating from greater genetic improvements, but with more attention being paid to traditional practices and avoiding excessive reliance on pesticides and fertilizers. The huge investments made, in recent years, by the very same big companies responsible in the past for the old technology, are promising signals that things are moving quickly in the right direction. The real danger for India, and many other poor countries, is that the older, environmentally unfriendly, technologies will remain in use.

The general conclusions are very important; namely that stability of agricultural growth needs to be based on diversification, technologies effectively suited to Indian agriculture, substitution of external with local resources, less accent on resource exploitation which characterized the green revolution, and more emphasis on resource conservation using modern science and traditional wisdom. Technology in itself cannot be the only solution. Ninan and Chandrashekar are right to underline the fact that the development of infrastructure, such as watershed management, irrigation and services, can go a long way in aiding the expansion of agricultural production with greater stability. Nevertheless technology, of a suitable form, still has a vital role to play.