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Sustainability of Agriculture*

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I

THE CONCEPT AND ITS POLICY SIGNIFICANCE

Sustainability of agriculture has been interpreted in a number of ways in the recent literature. It is however, not a new concept. Organic methods of farming or 'permanent agriculture' which respected the integrity of the soil and related ecological systems have been referred to as 'sustainable'.[1] Among recent writers on the subject, Conway (1985) maintains that an agricultural system that can overcome a stress, defined as a discontinuity in the situation to which it is subject, can be referred to as sustainable. The FAO (1989), on the other hand, defines sustainable agriculture as the successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of environment and conserving natural resources. Parikh and Ghosh (1991) consider soil in particular to be an important resource base and think it should be treated as the reference point for defining sustainability. Jodha (1991) treats sustainability as a characteristic of the agricultural system: "It is the ability of the system to maintain a certain well defined level of performance over time, and if required to enhance the same through linkages with other systems without damaging the ecological integrity of the system."

The notion that seems to underlie most of the above ways of viewing the concept is that growth must be achieved without impairing the resource base. In other words, the land/soil and its intrinsic qualities should be maintained unimpaired in the process of growth. And this should hold true over a relatively long run. A period of high growth rates should not be followed by a period in which a so-called plateau in productivity is reached. Sustainability is, in other words, the desired ideal of achieving growth while maintaining natural capital intact.

This concept of sustainable growth has existed in economic thought in one form or the other. Classical political economy was concerned with the notion of sustainable growth, in particular in relation to land. Malthus considered resources to impose a limit to growth and the focal point of Ricardo's analysis was relative growth on non-homogeneous plot of land. Mill's notion of a stationary state in which outputs and inputs grew at the same rate provides the closest approximation to the present approach to the notion of sustainability. Marx too stressed that "work is not the source of all wealth, nature is just as much the source of use value as work, which is itself only an expression of a natural force, human labour power."

Later day extensions of these ideas have resulted in alternative approaches to the problems. In neo-classical economics the attempt to take account of this area has seen the emergence of resource management models. These models view the maintenance of environmental standards as another constraint to maximising/minimising discounted streams of utility/disutility either over finite or infinite time horizons. Alternatively, the new

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institutional economics stresses property rights. It states that a well spelt out system of property rights, be it private, public or common, would solve many of the problems encountered due to ecological constraints. The new science of bio-economics traces the origin of scarcity and consequently the limits to growth to the operation of the laws of thermodynamics. Simultaneously, a dis-satisfaction with the monolithic concept of land and an appreciation of the interdependence between different natural processes have become a part of mainstream economics. As Daly (1990) puts it: "The production process functions within the ecosystem and its links with the ecosystem should determine the optimal level at which it should function."

At the present juncture in Indian agriculture, the concept of sustainability in agriculture has attained a certain policy significance. The reasons for this have to be viewed in the context of the evolution of agricultural policy in India which has been preoccupied primarily with the issue of increasing productivity. This was natural and correct in a country where foodgrain shortage was endemic. The sixties saw the emergence of the high-yielding variety (HYV) technology and the thrust of policy was towards increased production in selected areas - the so-called intensive development areas. In a sense, the last thirty years have seen the culmination of the success of this policy approach manifested in the spread to other areas of the country. Even in the late seventies, however, the need for a new policy thrust in agriculture was already beginning to emerge.[2] It had become obvious that an extension of the same irrigation-fertiliser based technology to a lage number of new regions was not possible and/or viable. An examination of productivities across regions indicated that the ecological parameters were significant in determining both correct policy options and levels of productivity to be aimed at. By the late eighties, the two important policy questions had become: (1) a high level of productivity with a plateau was being reached in some high productivity regions; (2) large parts of the country seemed to continue to have low levels of productivity: an appropriate strategy for them was required. In both cases, it seemed as if the ecological factors and the limits to productivity imposed by them were emerging as significant. It is this emergence of ecological constraints within the context of an economic view of productivity potential that brought sustainability issues to the fore. The empirical question that arose was: Would Indian agriculture be sustainable over the next decade or more?

Before examining sustainability issues in the Indian context, some significant inter-relationships between the process of technological change and the presence or otherwise of sustainability in the ensuing agricultural growth are examined.[3] Technological change increases productivity as a consequence of introduction of new inputs or through new methods of combining old inputs. When this technological change operates as an exogenous factor, the high levels of productivity that follow do not necessarily address the issue of the maintenance of natural capital over time. Further, required change in institutions is assumed to take place. The outcome is that if these institutional factors happen to be favourable and if the correct configuration of ecological factor is available, the change becomes a success in terms of both productivity and sustainability. Preservation of the natural resource base is not central to such a process of technological change. It may be an outcome given a favourable combination of the new technology and emerging institutional and location-specific ecological factors.

Alternatively, if requisite technological change begins with location-specific natural resources and asks the question: what kind of increases in productivity can be obtained by improving on the management and use of these factors within the institutional constraints of the region, the emerging technology considers both productivity and sustainability as equally significant characteristics. Such a view of technology as specific to regional ecological and institutional factors implies that productivity of the ensuing agricultural process is left unspecified in the first instance. It is an output variable in the simultaneous system.

Such an analysis of the links between productivity and sustainability, on the one hand, and technological change, institutions and ecology, on the other, emphasises that sustainability is a characteristic of the process of economic growth. It is a characteristic that shall have to be contended with either ex post as in the situation of exogenous technological change or at the outset as when planning for growth with appropriate natural resource management. Growth is in the final analysis "the consequence of positive feedbacks between the socio-system and the eco-system whereby these systems can evolve in a manner favourable to man".[4] It also implies value judgements with respect to the model of development being looked for. Such a model should include planning and adaptation of the farming system to the environment of the region and focus on a harmonious use of the various biological resources within the agro-system.

II

SUSTAINABILITY OF EXOGENOUS, PRODUCTIVITY ORIENTED TECHNOLOGICAL CHANGE

The bio-chemical technology introduced in the mid-sixties has been the major exogenous technological change witnessed by Indian agriculture. This irrigation-fertiliser based HYV technology has spread to roughly one-third of the 140 million hectares of net sown area in this country. What is the track record of this technology with respect to the issue of leaving natural capital intact? In this case, the erosion of natural capital could have taken two major forms: land degradation and/or over-use of water. One of the key issues then is: has irrigation based agriculture resulted into waterlogging, salinity or other forms of land abuse either in the catchment or the command area that will undermine its future productivity.

Estimates of waterlogging and salinity in the country are subject to wide variation. Definitions of the phenomenon, time of measurement and method of measurement have all affected the magnitudes arrived at.[5] An estimate based on Central Water Commission (CWC) data places waterlogging as a percentage of irrigation potential created at between 0.22 per cent and 14 per cent for different states in India. Further, it is not related solely to the level of development in the state.

In Punjab, which epitomises the success story of Indian agriculture, waterlogging is limited to about 5 per cent of irrigation potential created. It must be noted also that this is a state where groundwater potential has been almost fully utilised, and there exists a network of canals. It is the conjunctive use of surface and ground water, the appropriate soil and drainage conditions and the suitable institutional support which have made the new technology sustainable at the level of productivity that it reached in the late eighties.

TABLE I. WATERLOGGING AND SALINITY

State (1)	Waterlogged area as a percentage of irrigation potential created (upto 1990) (2)
1. Andhra Pradesh	8.65
2. Bihar	13.19
3. Gujarat	7.07
4. Haryana	11.11
5. Karnataka	1.83
6. Kerala	2.40
7. Madhya Pradesh	0.22
8. Maharashtra	0.31
9. Orissa	13.80
10. Punjab	5.17
11. Rajasthan	9.25
12. Uttar Pradesh	0.94
13. Tamil Nadu	1.14
14. Jammu and Kashmir	0.97
Total	5.90

Source: CWC unpublished data from Office of Member, Water Planning, Government of India, New Delhi, 1989.

It does not follow from this that an expansion of the same technology to other areas will have similar impact. Reports from the command area of the Indira Gandhi Canal in nearby Rajasthan confirm this (for detailed information, see Urmul Trust, 1992). The hard pan layer underlying the desert soils creates a hydrological barrier which, by preventing seepage, results in rise in water tables at a rate of 1 to 8 metres per year. Whereas large areas are already facing the problem of waterlogging, the threat of probable degradation of 38.09 per cent of the Stage 1 command area remains. Further, studies carried out in Stage 2 reveal that in 33. 8 per cent of the area a hard pan existed within five metres of the surface. This seems typical as similar situations have arisen with regard to irrigation projects elsewhere.[6] Such situations are clear instances of an ecological barrier to the unquestioning replication of a top-down irrigation-fertiliser based technology. Under some sets of circumstances, the process of agricultural development that it results in is bound to be unsustainable.

Expansion of irrigation-fertiliser based technology often implies the construction of large reservoir based projects at appropriate sites. These mega projects alter natural systems by affecting patterns of land use in their catchment areas as well. The total impact on the system must induce this change, which at times takes the form of forest degradation as well. Two questions can be asked in this context. Firstly, what is the incremental cost of the alteration in natural systems in the catchment in addition to that in the command? Alternatively, in view of the irreversible nature of some kinds of changes in natural eco-systems, is it permissible at all? Some estimates which have a bearing on both these questions[7] are now presented.

It is postulated that the increased cost of creating a hectare of irrigation potential depends on the relative location of the catchment and the command areas of the project being considered. This seemingly apparent statement is the consequence of the variety in the forest types found in India and the variation in the magnitudes of waterlogging and salinity in different canal commands. Data from about 105 projects are put together to determine the catchment/command area ratio and further, the ratio of forest area in the command. Further, on the basis of alternative estimates of the value of a hectare of forest land lost,[8] the incremental cost of creating irrigation potential (equal to one hectare in the command) is obtained. The results, presented in Table II, give an estimate of this increase for projects affecting different kinds of forests and having command area lying in different states. If only use value of forests is taken into account, this increase lies in the range of 21 to 26 per cent. Such an increase is likely to affect economic viability, and more important, sustainability even if it is assumed that the loss can be made up for.

TABLE II. ENVIRONMENTAL COST OF CREATING AN ADDITIONAL HECTARE OF IRRIGATIONAL POTENTIAL

(as percentage of capital cost)

Location of command area	Forest type in catchment area		
	Tropical dry deciduous	Tropical moist deciduous	Tropical thorn
(1)	(2)	(3)	(4)
Andhra Pradesh	24.37	23.11	22.07
Gujarat	23.66	22.40	21.36
Orissa	26.71	25.46	24.42

Note: Only 'use value' of forests has been considered.

Availability of groundwater has been the basis for the expansion and entrenchment of the irrigation-fertiliser based bio-chemical technology in some regions. Notable cases are Gujarat and Western Uttar Pradesh. The use of this common property resource has had diverse impacts. While at the macro level, only some 18 million hectare-metres of the 47.5 million hectare-metres of available groundwater is currently used, the picture with respect to level of exploitation varies from region to region. From the viewpoint of sustainability of the process of agricultural development, it is important to see that tendencies towards over-exploitation are kept in check.[9] In view of the fact that over 95 per cent of the area served by groundwater in India is commanded by privately owned wells, the possibility of over-exploitation is a very real one unless it is limited either by legal restrictions or by organisational structures. Further, in a regime of private ownership, water markets have emerged in many parts of the country. Though these markets are claimed to have ensured equitable distribution, studies have pointed out towards the danger of over-exploitation being encouraged by them. One method of avoiding this could be increasing the private cost of water exploitation in these areas by imposing a pro-rata tariff on electricity.

Another of these problems is concerned with long-run productivity deficiency, which reduces the marginal productivity of highly productive crop lands. Larger application of fertilisers is no substitute for poor agronomic management. The Indian Council of Agricultural Research (ICAR) has reported that micronutrient deficiencies have become a major constraint on crop production in India's present agricultural programmes. Two surveys done by ICAR in 1982-83 and 1988-89 indicate some broad trends. There has been increased incidence of zinc, copper and manganese deficiency in soils, as well as boron and molybdenum in some case, with samples showing growing deficiencies in micronutrients concentrations as reported in Table III.

TABLE III. MICRONUTRIENT DEFICIENCY IN SELECTED STATES

State	Percentage of samples with zinc deficiency		Percentage of samples with copper deficiency		Percentage of samples with iron deficiency		Percentage of samples with manganese deficiency	
	1982-83	1988-89	1982-83	1988-89	1982-83	1988-89	1982-83	1988-89
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Andhra Pradesh	37	72.6	0	0	0	10	0	6.2
Bihar	58	48.2	29	2	3	4	2	0.6
Gujarat	26	N.A.	0	N.A.	17	N.A.	0	N.A.
Haryana	80	18.3	0	0	72	62	1	0
Madhya Pradesh	86	67.1	0	0	3	7	3	0
Pondicherry	10		0	N.A.	0	N.A.	2	N.A.
Punjab	25	12.5	0	2.5	1	1	0	4
Tamil Nadu	31	81.2	5	23	44	31	3	9
Uttar Pradesh	94	69.0	3	48	30	29	1	40
All states	47	67.0	2	15	24	23	1	7.2

Source: All India Coordinated Scneme of Micro and Secondary-Nutrients and Pollutant Elements in Soils and Plants, 22nd Annual Report, 1988-89, Indian Institute of Soil Science, Bhopal, 1991; All India Coordinated Scheme of Micronutrients in Soils and Plants, 1(th Annual Report, 1982-83, Indian Council of Agricultural Research, New Delhi.

On balance, most productivity oriented environments seem to come up against constraints, when viewed from the sustainability angle. A close watch needs to be kept on their ecological costs. Simultaneously, a good mix of market and non-market instruments to keep these costs within acceptable ranges has to be evolved. Even so, it is clear that new technologies with a focus on sustainability also need to be developed.

III

SUSTAINABILITY INVESTMENTS AS AN ALTERNATIVE STRATEGY

Another equally significant issue concerns the form that agricultural development in rainfed areas of the country takes. A large part of non-forest wasteland, estimated to be about 95 million hectares, lies in this zone. And for wasteland where the potential productivity is higher than actual productivity, the challenge of formulating sustainable (or for that matter any) agricultural development strategies remains, by and large, untackled. More than 60 per cent of this land lies in the Central Plateau region where terrain is undulating and exploitable water is lower than the national average. This resource endowment coexists with a variety of property rights in land. The two together make the area unsuited for the adoption of a state-run canal system or a privately operated tubewell system. Simultaneously, however, the percentage of the population below the poverty line is in the range of 40 to 49 per cent as compared to 38 per cent for the country as a whole so that income and productivity are crucial.[10]

The strategy that is beginning to emerge in this context is the outcome of a variety of experiments conducted at local level.[11] The common element underlying these experiments, diverse though they are, is "the preservation of land and water resources, *in situ* for intensive use and management through a holistic perspective of agricultural systems". Simultaneously, an in-depth understanding of local resources and institutions is the other starting point of most of such initiatives, be it the Pani Panchayat of Salunkhe, Annasaheb's experiment in Ralegaon Sidhi or the Sukhomajri experiment. The technology adopted varies from region to region. In regions with annual rainfall above 700 to 800 mm, and with appropriate sites, rain water harvesting has been tried successfully. In regions with lesser rainfall, other measures for soil and water conservation have been attempted. In some situations, the focus has been on agro-forestry; in others on groundwater recharge for rangeland protection and in still others on rain water harvesting for irrigation.

From the viewpoint of agricultural development, gains from such experiments may be limited. Cropping intensity increases by 5 to 15 per cent and incremental yields by 0.5 to 1.0 per tonne hectare. However, the consequent increases of 60 to 100 per cent in the productivity of large tracts of arid and semi-arid land will make a significant difference to the nation's foodgrain budget. More importantly, this increase shall be compatible with the protection of soil and forest resources. In other words, natural capital is kept intact in this approach which aims to increase productivity by starting from the local level.

The increasing number of such local level experiments emerging in different parts of India validate the viewpoint that this approach constitutes an alternative. Note, however, that its success is ensured only under a specific set of circumstances. In regions where degradation has crossed a certain critical level, it may need to be supplemented by direct government intervention to constitute an effective poverty alleviation strategy.[12] Further, the socio-legal system must evolve in a complementary fashion. The major requirements of such evolution are a decentralised system of decision-making and a degree of participatory resource management with a set of communal norms that govern such management. In other words, the process of technological change rooted in the preservation of local level resources reveals the complementarities as well as the incompatibilities between ensuring sustainability and achieving productivity increases in the context of existing institutional structures.[13] Similar problems are steam-rollered by top-down technologies in initial stages. Later, they result in inconsistencies between productivity, sustainability and equity goals. Grass-root based technological change, on the other hand, tackles these issues head on. It requires, however, a large input of local level leadership, a resource which may be in short supply in most developing country situations.

IV

DIRECTIONS FOR FUTURE POLICY

Two types of agricultural investments have been focused in this paper: those that increase productivity but may not necessarily sustain agricultural productivity in the long run and those that ensure conservation and to a limited extent raise productivity.[14] In the next phase of its development, Indian agriculture shall have to consider both types for adoption. It shall, however, have to be kept in mind that when the primary goal is one or the other, negative repercussions for the other are kept within limits.

Another significant policy conclusion is that the two types of investments seem to indicate different kinds of approaches to government intervention in the agricultural sector. A top-down approach to such intervention shall have to rely on easily replicable, capital intensive solutions. Approaches that start from the grass-roots are not, in general, as capital intensive. The major input they require is human resources to act as catalysts in the process. The corresponding benefit in the latter kind of approaches is that social acceptability of the technological change has to be reckoned within the initial stages. Large scale centrally engineered technological change seems to assume that both ecology and social institutions shall mould themselves in its wake. At times such assumptions are realised. When they are not, both the ecological and social sustainability of the change may be threatened. In the climate of decentralised decision-making, it shall become important to examine seriously the potential of technological change which begins at the other end of the spectrum.

NOTES

1. An early writing in this area is the article by King (1911) (as quoted by Tibaldi, 1991) who referred to the centuries old agriculture of East Asia as sustainable. See also Tibaldi (1992).
2. See Swaminathan (1977) for an expression of such a view.
3. For further analysis of these interlinkages, see Chopra and Rao (1992).
4. See Norgaard (1981) for an exposition of this view.
5. See Sinha (1986) for a discussion of these issues.
6. See Holling (1992) for details of a case study for a semi-arid part of Spain. Large areas in the U.S. are known to face similar problem.
7. See Chopra *et al.* (1993), in particular Section 9 for the detailed estimates.
8. In one approximation, only the use value is taken whereas in another use, option and existence value is taken. The latter accounts in some way for the irreversible nature of the loss of forest land.
9. For an analysis of groundwater and related problems, see Shah (1991).
10. One could argue alternatively that these regions be supplied by the state subsidised networks of food distribution. However, the track record of public distribution systems in India is one of increasing cost and poor targeting efficiency with respect to the poor. See, among others, Tyagi (1990) and Dev and Suryanarayana (1991).
11. For a description of such experiments, see Alagh (1990), Rajagopalan (1991) and Chopra and Kadekodi (1993).
12. See Chopra and Kadekodi (1993). Note, however, that under some circumstances, a natural-capital based strategy shall be the only one that results in self-sustaining growth.
13. A study of attempts at such change, for instance, the Chakriya Vikas Pranali in Bihar brings out these issues succinctly.
14. To recapitulate, examples of the first are intensive use of irrigation and the second category includes tie-ridging that prevents run-off and conserves the soil, integrated pest management or biotechnology.

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