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Agricultural Development and Sustainability: *An Inevitable Nexus*

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Abstract Intimate relationships between agricultural development and other areas of human activity determine countless linkages with global issues of environmental protection, population increase, food supply, and world trade. This broad background leads to different perceptions of sustainable agriculture by different interest groups. The profitable diversification away from overproduction of basic commodities and satisfaction of environmental pressure groups are major concentrations in developed countries. Elsewhere, the main concern is to maintain a trend of increasing production: food security with a future dimension. Achieving this depends crucially on protecting the agricultural resource base. Input and input substitution are important correlated issues, but the core of sustainability is avoidance of any attrition of the potential for future production. It demands safeguarding soil and water qualities, gene pools and the natural resource base against loss and degradation. Most of the resource degradation and eroding potential are rooted in economic, social and political issues; few such problems will be solved unless the primacy of these issues is addressed and recognized. We should consider trade-offs between agricultural development and its probable impact on nature or society. In order to stabilize our food production system, alternative paths of development in the agricultural sector are to be sought concomitantly. There will be development but it should be sustained for the future. The research and extension agenda, thus, are required to be considered in a timely and need-base fashion. Sustainable agriculture will probably remain illusive until government and concerned agencies recognize it as arising only as the aftermath of a synthesis of strategies on population, employment, economic planning, technical research, strategies of extension and national investment.

Key words: Agricultural development, sustainability, agricultural resource base, environmental protection.

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1. INTRODUCTION

Today environmental concerns and social and economic justice are at the top of global issues for survival. The Earth Summit 1992 and Global Forum in Brazil brought together more heads of state and NGOs from the North and South than any other meeting in history. They raised global environmental and economic issues that have never before been deemed so urgent. The sustainability of food and agriculture was regarded as an issue of unparalleled importance. This is because agriculture is central to human well being, because it is fundamental to environmental issues, and because it is in crisis (ALLEN, 1993). Agriculture is by far the most important of the world's economic activities; it uses one-third of the total land surface and employs 45% of the working population (GRIGG, 1995). Food production and distribution are the cornerstones of human subsistence. Unless we develop a sustainable agricultural system, life itself is at risk.

Agriculture is, without doubt, unsurpassed as a cultural agent of environmental change. By its very nature, agriculture requires modification of the environment in which it is practiced. The degree of modification also varies temporally and spatially. Further, all agricultural systems, no matter how simple or sophisticated, have many features in common. These are the manipulation, through human controls, of trophic energy transfer and nutrient exchanges that are components of bioecological cycles (MANNION, 1995). Agriculture itself has its own far-reaching environmental effects. Food production, distribution, and consumption form the most basic intersection between society and nature, a fact that has generated intensive discussions and dynamic developments relevant to all 'green' issues. Yet despite global awareness of the issues, profound systemic and social crises continue to confront the world in food and agriculture. Resources are depleted, toxins enter the food chain, people go hungry and starve. Such enormous ecological and social problems require immediate, concentrated efforts towards transformation to a new form of agriculture, one that ensures our ability to provide ourselves with food now and into the future (ALLEN, 1993).

This transformation means working towards sustainable agriculture. Sustainable agriculture examines the transformation of the environment in the course of its development. It argues that the development in agriculture and its sustainability is necessary to feed the future generation but without severely hampering the environment and depleting the natural resource bases. There should be trade-offs between developmental processes in agriculture and their matter to sustain into future. In this modern age of environmental consciousness agriculture should be benign to the environment, society and public health. Thus, we find that the agricultural development process is necessary to boost up food production for our survival while keeping the global environment less disturbed. This article focuses on analyzing the urgent bridge between the steady development in agriculture and its sustainability in the future.

2. SUSTAINABLE DEVELOPMENT: *THE CONCEPTUAL REVIEW*

Development is usually defined principally in terms of 'economic growth' as countries experience increased growth their productive capacity expands and they 'develop'. The crudest, and most familiar, indicator of development is gross national product (REDCLIFT, 1987). In this study we have considered 'development' as the development of agriculture and its processes.

A great deal of effort has gone into trying to define sustainability in absolute terms. Since the Brundtland Commission's definition of sustainable development in 1987, there have been at least 80 more definitions constructed, each emphasizing different values, priorities and goals. Precise and absolute definitions of sustainability, and therefore of sustainable agriculture, are impossible (PRETTY, 1998). Most view the key criterion of sustainable development as that provided by the so-called Brundtland Report. That is, sustainable development meets the need of the current generation without compromising the ability of future generations to meet their future needs. Sustainable development includes the sustainability of agricultural systems and agro-ecological integrity. Sustainability itself is a complex and contested concept. To some, for example, it implies persistence and the capacity of something to continue for a long time. To others, it is not to damage or degrade natural resources.

In a world where growth and development often come at the expense of resource degradation, it is imperative to understand the nature of this degradation and explore possible solutions. The preferred approach to development is one that is sustainable (D'SOUZA and GEBREMEDHIN, 1998). However, the way to sustainable development is neither obvious nor simple; for one thing, sustainability has many, interrelated, components. These may be economic, social or demographic, community, environmental, and human health.

The concept of sustainability received its greatest boost from the publication of the World Conservation Strategy. The World Conservation Strategy (WCS) and other related documents brought this concept of sustainability to the attention of a much wider audience. In addition, the Strategy explicitly linked the maintenance of ecological processes and life-support systems. It concerns the sustainable utilization of resources and the maintenance of genetic diversity. In almost all developmental activities this sustainability has now become a central point of discussion. Action towards sustainability is highly dependent on the material and cultural context in which actors are situated (FLORA and KROMA, 1998). Sustainability has been framed in terms of a broad range of objectives: meeting basic human needs while maintaining ecological process and life-support systems, preserving genetic diversity, and ensuring sustainable utilization of species and eco-systems (IUCN/ WWF, 1980).

Different scientists define sustainability in different ways. Again it varies from issue to issue or depends on the condition of the surrounding environment. An economist may define sustainable development as living on interest and not on capital, but this fails to emphasize adequately the importance of the preservation of natural resources and the environmental aspects of sustainability. Sometimes, a more comprehensive definition is needed (GREENLAND, 1997), such as that offered by DUMANSKI (1993). He refers specifically to land management as: Sustainable land management combines technologies, policies and activities aimed at integrating socioeconomic principles with environmental concerns so as to...

i) maintain or enhance production
ii) reduce the level of production risk
iii) protect the potential of natural resources and prevent degradation of soil and water quality
iv) be economically viable
v) be socially acceptable.

Of the two major trends in a sustainable development perspective, one, exemplified by the economic approach taken by PEARCE *et al.* (1989), fails to take into account the contradictions of sustainability. 'Sustainable development', in this view, is treated as a modification of a traditional strategy, rather than a alternative to it, and this approach is therefore limited in scope and application. The second major trend, exemplified by the Brundtland Report, treats sustainable development as an alternative concept of development, and, therefore, in the end, shows more promise, as discussed earlier.

Finally, we conceive the idea of sustainable development as a relative issue both spatially and temporally. Its scope and magnitude varies from place to place, issue to issue. Whatever the issue chosen, the matter of sustainability should be focused on that issue. Surrounding factors, such as, economy, society, culture or environment should be considered at an early stage though the sustainable perspective would vary from person to person. Here the thinking of sustainable development will refer to sustainable development in agriculture. However, a detailed discussion on the sustainability of agriculture and its necessary linkages will come forward.

3. SUSTAINABLE AGRICULTURE: *THE SEMANTICS*

While the concept of sustainable development was gaining a base for supporters, a parallel but apparently independent evolution was occurring with respect to the concept of sustainable agriculture. In the developed nations, starting around 1970s, there began a reaction to chemically dependent, large-scale, commercial agriculture. The reaction was propelled further by cost-price squeezes in North American and European agriculture that periodically created 'farm crisis' situations and threatened the incomes and futures of smaller scale family farms.

The search for alternatives to modern agriculture harbored many names; including low-input agriculture, alternative agriculture, biological agriculture, and organic agriculture, as well as, sustainable agriculture. While some adherents considered sustainable agriculture to only be a set of substitute technologies to commercial agriculture practices, others offered sustainable agriculture. As an alternative belief system, "sustainable" tended to emphasize reduced chemical use, family and group self-reliance, a global village view of the world, a respect for nature and ecosystems, a high value on the family farm, and voluntary simplicity. Similar to sustainable development concepts, sustainable agriculture concepts provided a more holistic philosophy that emphasized systems and connections, and tended to eschew reductionist thinking (BATIE and SMITH, 1998). With this holistic philosophy, multi-disciplinary systems-based science was considered essential to creating a new understanding and a new set of appropriate technologies for agriculture.

Literally, sustainability is the ability to 'keep in existence; keep up; maintain or prolong' (NEUFELDT, 1988). Thus, sustainability refers to 'keeping an effort going continuously, the ability to last out and keep from falling'. In the context of agriculture, it basically refers to the capacity to remain productive while maintaining the resource base (REIJNTJES, *et al.*, 1992). For example, the Technical Advisory Committee of CGIAR (1988) states: "Sustainable agriculture is the successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources."

As per the collection of HANSEN (1996), the variety of meanings acquired by sustainability to agriculture (Box 1) have been classified according to the issues motivating concern (WEIL, 1990), their historical and ideological basis (KIDD, 1992; BRKLACICH *et al.*, 1991), and the hierarchial levels of the systems considered (LOWRANCE *et al.*, 1986).

The difference between sustainability as a system-describing and as a goal-prescribing concept (THOMPSON, 1992) identifies two on-going views that differ in their underlying goals. The goal-prescribing concept interprets sustainability as an ideological or management approach in agriculture. This concept developed in response to concerns about the negative impacts of agriculture, with the underlying goal of motivating adoption of alternative approaches. The system-describing concept interprets sustainability either as an ability to fulfil a diverse set of goals or as an ability to continue (HANSEN, 1996). This concept can be related to concerns about the impacts of global change on the viability of agriculture, and to the goal of using sustainability as a criterion for guiding agriculture as it responds to rapid changes in its physical, social and economic environment.

Box 1: Sustainable agriculture : *some interpretations.*

Sustainability as an ideology:

"... an approach or a philosophy ... that integrates land stewardship with agriculture. Land stewrdship is the philosophy that land is managed with respect of use by future generations." (NEHER, 1992)

"... a philosophy and system of farming. It has its roots in a set of values that reflect a state of empowerment, of awareness of ecological and social realities, and of one's ability to take effective action." (MACRAE *et al.*, 1990)

"... a philosophy based on human goals and on understanding the long-term impact of our activities on the environment and on other species. Use of this philosophy guides our application of prior experience and the latest scientific advances to create integrated, resource conserving, equitable farming systems." (FRANCIS and YOUNGBERG, 1990)

Sustainability as a set of strategies:

"Farming systems are sustainable if they minimize the use of external inputs and maximize the use of internal inputs already existing on the farm." (CARTER, 1989)

"... a loosely defined term of the range of strategies to cope with several agriculturally related problems causing increased concern in the USA and around the world." (LOCKERETZ, 1988)

"... a management strategy which helps the producers to choose hybrids and varieties, a soil fertility package, a pest management approach, a tillage system, and a crop rotation to reduce costs of purchased inputs, minimize the impact of the system on the immediate and the off-farm environment, and provide a sustained level of production and profit from farming." (FRANCIS *et al.*, 1987)

Sustainability as the ability to fulfil a set of goals:

"A sustainable agriculture is one that, over the long term, enhances environmental quality and the resource base on which agriculture depends, provides for basic human food and fiber needs, is economically viable, and enhances the quality of life for farmers and society as a whole." (ASA, 1989)

"... agricultural systems that are environmentally sound, profitable, and productive and that maintain the social fabric of the rural community." (KEENY, 1989)

"... an agriculture that can evolve indefinitely toward greater human utility, greater efficiency of resource use, and a balance with the environment that is favorable both to humans and to most other species." (HARWOOD, 1990)

Sustainability as the ability to continue:

"A system is sustainable over a defined period if outputs do not decrease when inputs are not increased." (MONTEITH, 1990)

"... the ability of a system to maintain productivity in spite of a major disturbance, such as caused by intensive stress or large perturbation." (CONWAY, 1985)

"... the maintenance of the net benefits agriculture provides to society for present and future generation." (GRAY, 1991)

"Agriculture is sustainable when it remains the dominant land use over time and the resource base can continually support production at levels needed for profitability (cash economy) or survival (subsistence economy)." (HAMBLIN, 1992)

Any definition of sustainability as a guide to agricultural practice must recognize the need for enhancement of productivity to meet the increased demands created by growing populations and rising incomes. With this view RUTTAN (1987) emphasizes the implications for research on sustainability:

"...any attempt to specify the technology and practices that meet the criteria of sustaining and enhancing productivity would be premature. At present it is useful to define sustainability in a manner that will be useful as a guide to research rather than as an immediate guide to practice. As a guide to research, it seems useful to adhere to a definition that would include (a) the development of technology and practices that maintain and/or enhance the quality of land and water resources, and (b) the improvements in plants and animals and the advances in production practices that will facilitate the substitution of biological technology for chemical technology"

However, sustainable agriculture means different things to different people. The goal and the working direction may be same, but pinpointing different issues of emphasis. The economists see economic uplifting from the sustainability in agriculture. While the producers target production, the consumers emphasize food safety and proper distribution, environmentalists believe in ecological preservation, and the sociologists foresee social acceptance or integrity. So, in simple words we can say that the agriculture is sustainable which degrades neither land nor people. It should evolve indefinitely towards greater human utility, greater efficiency of resource management, and a balance with the environment. The new-found importance attached to sustainability represents the convergence of different factors reflecting, on the one hand, societies' recognition of rapid changes to the quality and quantity of natural and environmental resources and, on the other, the political necessity to act with respect to those changes. The consensus has emerged that no single objective function exists for the achievement of sustainable agricultural systems. It is to be a multidimensional concept containing many diverse elements and goals. Hence, composite definitions of the concept are to be preferred.

It is thought that no single definition of sustainability in agriculture would suffice to meet the goal. Rather it should be multidimensional and a systems approach. Thus, the definition suggests that sustainable agriculture should be one that:

i) has a long-term perspective for food-fiber production
ii) preserves the natural resource bases-renewable or non-renewable
iii) has less external input dependent on and profitable to producers
iv) enhances the quality of human life
v) maintains or enhances the quality of environment, and
vi) is economically viable and socially just.

4. IMPACTS OF AGRICULTURAL DEVELOPMENT

Agriculture has had a profound influence on the earth's surface and the process that operate thereon. There are few parts of the globe that remain unaffected by agriculture. Even where there has been no direct modification of landscapes the indirect consequences of agriculture, are often manifest. The case is true of low and high latitudes alike. The environmental impact of agriculture began with the initial domestication of plants and animals and the inception of the first agricultural systems. Thereafter, as agriculture spread from its centers of origin throughout prehistory and history, its impact intensified (MANNION, 1995). Currently, there are quite different trends occurring in the developed and developing worlds. In the former, excess food production in many nations has led to the formulation of policies to encourage set-aside. In the developing world the trend is in the opposite direction; as a consequence of high population growth and the existence of a large population of landless poor, agriculture is expanding into lands hitherto undisturbed. Then, social and economic pressures are the major stimuli for the spread of agriculture.

Government policy has its impact on the development of agriculture. Throughout the developed worlds, agricultural policies have encouraged increased specialization and intensification on the part of farmers, which in turn has led to numerous unintended consequences (Figure 1). For example, the land resource base has been valued almost exclusively for its commodity function as a producer of food, with little recognition given to the provision of other important goods and services. Despite these issues, much of the concern today is still focused on the problems of the economies of overproduction and not the ecology of overproduction (NIJKAMP and SOETEMAN, 1988).

The economic effects and environmental implications of the developmental and supportive policies are clear. Higher marginal costs of production associated with present levels of output can only be sustained by artificially high prices or subsidies on inputs. As GIRT (1990) has suggested, the consumer is supporting, through taxes in many cases, land management practices that accelerate soil erosion and other forms of environmental degradation. The behavior of the farmers with respect to the policies is of course completely rational in terms of the short-term interests of the farming community. By ensuring higher returns to producers, either through lower costs or

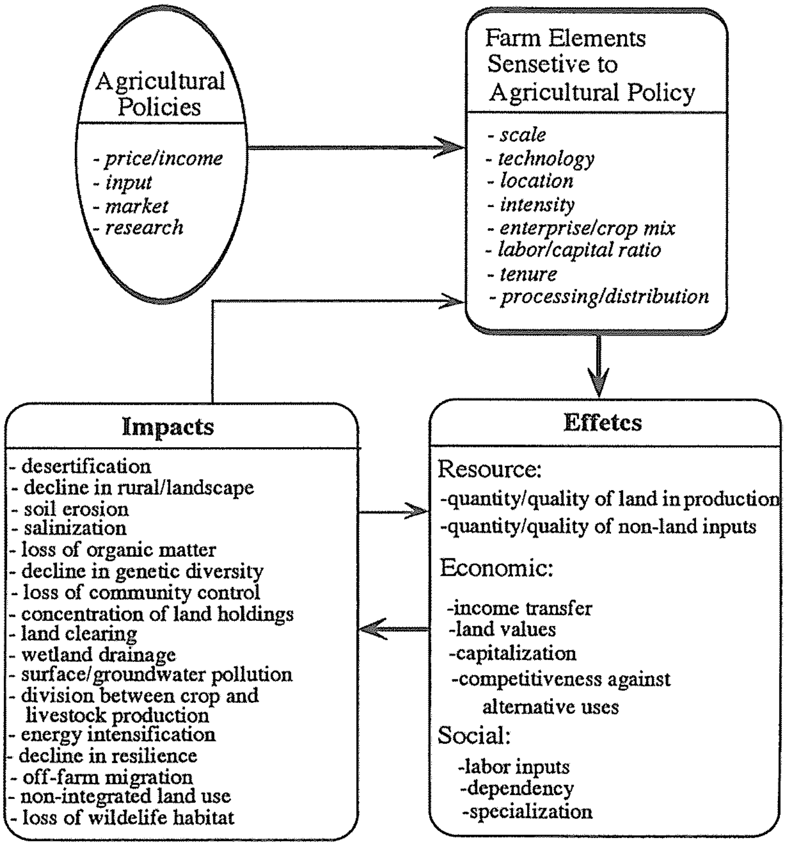

Fig. 1. Conceptualization of agricultural policy induced change to social, economic and natural systems (from PIERCE, 1992)

higher prices, the value of agricultural goods and land is overstated. As a result, these conditions increase the opportunity cost of land remaining as wetlands or in alternative uses (PHIPPS and CROSSON, 1986). The cost of removing land from production for conservation purposes is thereby increased by these measures. The social cost of policies to restrict pesticide and fertilizer use are also exaggerated (LICHTENBERG and ZILBERMAN, 1986).

4.1. *Loss of Biodiversity and Natural Habitats Through Landscape Change*

Change in landscape is a vast topic but the impact of agricultural development on it is evident. It is reported that some 75% of earth's habitable land has been disturbed in some way. Only 15.6% of Europe's land area remains undisturbed whilst 31.8% is partially disturbed and 56.6% is heavily disturbed (HANNAH *et al.*, 1994). Transformation of natural ecosystems has been so overwhelming that it is impossible to locate existing woodland habitats that can be considered an analog to the primeval forests characteristic of the climatic climax vegetation of 7000 to 5000 years ago. It is estimated that the world's forests have decreased by 15.15% and the world's woodlands by a further 13.8% (WILLIAMS, 1990). RICHARDS (1990) observes that 18.7% of this 28.95% overall decrease has occurred since 1700. These forests or woodlands are not the only ecosystems and habitats that have diminished in the wake of agriculture. Even wetlands have been gradually reduced in extent to accommodate the expansion of agriculture. It is estimated that the USA, excluding Hawaii and Alaska, only 47% of the wetlands are in existence (DAHL, 1990). Greek Macedonia has lost 94% of its marshlands since 1930 (MANNION, 1995).

The fragmentation of natural habitats has been most widespread in Europe due to its long history of agriculture on the continent and the other pressures of population growth, and urban and industrial spread. The issue of habitat fragmentation also has its impact on bird populations (JARVIS, 1993). The habitat has diminished in extent due to soil improvement for agriculture and a host of other factors. The changes in invertebrate populations due to habitat destruction and fragmentation of landscape have drawn the attention of environmentalists (THOMAS and MORIS, 1994). Today it is clear that the spread and intensification of agriculture has unquestionably caused the extinction of species and the alteration of habitats exerts an impact on environment (WILSON, 1988; MAY, 1994). For example, the impact of European settlers was considerable and enduring; much of it was due to the introduction and expansion of agricultural systems suited, by dint of many centuries of practice and innovation, to Europe. In some areas there was complete removal of the native vegetation cover; in others, modification occurred. Overall, since the initial colonization of Australia in 1788, 70% of the flora and faunal communities have been altered (Box 2). Similar impacts can also be seen in different parts of the world, both developed and developing.

4.2. *Land Degradation: The Soil Erosion*

Accelerated soil erosion is one of the most significant ways in which agriculture brings about environmental change, though not all of the world's soil erosion is caused by agricultural practices. Deforestation, logging, mining and construction activities all contribute to the 75×10^9 tons of soil which are lost from the earth's surface annually (MYERS, 1993). Agriculture is, however, the major cause of this substantial alteration to an important earth surface process. Precise data on the amount and rate of soil erosion are relatively sparse. Global erosion in 1970 has been put by BROWN (1984) at 14×10^9 t yr^{-1} compared with 11×10^9 in prehuman times. MANNION (1995) said that

Box 2: Impact of European Settlement on Australia's Fauna and Flora.

1. The impact on Flora:

- 70% of the flora communities have been altered
- 65% of the original tree cover
- 75% of the rain forest has been cleared for grazing and agriculture
- 165 species of plants (out of 20,000) are now extinct
- 209 species of plants are considered endangered
- 784 species of plants are considered vulnerable
- this means that 5% of the flora is extinct or under pressure

2. The impact on fauna:

- 20 species of mammal (out of 263) are now extinct
- examples of these include the thylacine, the Alice Springs mouse, four species of wallaby, four species of hopping mice and two species of bandicoot
- at least 5 species of birds have become extinct (out of 522)
- the flightless birds have been most acutely affected, e.g. the Tasmanian emu

Source: HOBBS and HOPKINS, 1990; HUMPHRIES and FISHER, 1994)

11×10^6 ha of the world's land is lost annually as a result of soil erosion. From different estimates it is perceived that soil erosion is the first and still the most deleterious impact of agriculture on the environment. Prior to World War II, soil erosion was as emotive an issue as pollution or acid rain is at present (JACKS and WHYTE, 1939). Soil erosion is mostly found in the areas of modernized, exhaustive agriculture zones. High population density aggravates the situation as well.

Due to rapid soil erosion, the arable soil loses its nutritious upper crust. Thus, the soil becomes less fit to crop cultivation. Sometimes, the opening of soil by uncovering the vegetative layer, causes a tremendous impact on soil fertility and future crop productivity as well. Frequent tillage disturbs the soil and opens it up. As a result increased temperature and aeration speed the decomposition of organic matter; this is accompanied by a decline in the structural stability of soil. Consequently it becomes more susceptible to wind and water transport (TIVY, 1990). Erosion imposes on-farm costs of lost nutrients and of diminished moisture holding and root-zone capacity (TWEENTEN and AMPONSAH, 1998). Due to the adoption of the careful management of soil and crop production strategies, the erosion of soil has reduced to a great extent, even under conventional agricultural practices. The average sheet and rill water erosion rate has fallen from nine tons per acre in 1938 (MAGLEBY *et al.*, 1995; USDA, 1938) to nearly 3 tons per acre in 1992. Table 1 shows that at least 50% of all soil erosion is due to agriculture, with over grazing and cultivation being the major causes. Additionally, soil erosion is one of the processes involved in desertification.

Material lost by wind erosion from farmland can be transported considerable distances, as is evidenced by dust records from the African Sahel. In some cases eroded material may be deposited on other farm land, where its impact will depend on its nutrient status and stability. Short-distance transport of sand particles can bury relatively fertile land under shifting sand dunes. Of the soil lost by water erosion, some will be deposited on the gentler valley and floodplain slopes. A very high proportion, however, finds its way into freshwater bodies and eventually into the oceans. The resulting sedimentation is one of the most prevalent and widespread types of water pollution. It impairs water quality and reduces the efficiency of reservoirs, irrigation

Table 1. Extent of erosion of soil in the world, from 1945 to mid-1980s (based on World Resource Institute, 1992).

	Water erosion		Wind erosion		Main cause(s)	% due to main cause
	Total (10^6 ha)	% of all degraded land	Total (10^6 ha)	% of all degraded land		
Africa	227.4	46	186.5	38	Overgrazing and cultivation	73
North & Central America	106.1	67	39.2	25	Overgrazing and cultivation	60~96
South America	123.2	51	41.9	17	Overgrazing and cultivation	54
Asia	440.6	59	222.2	30	Overgrazing and cultivation	53
Europe	114.5	52	42.2	19	Overgrazing, cultivation & industry	52
Ocenia	82.2	81	16.4	16	Overgrazing	88
World	1093.7	56	548.3	28		63

channels and navigable waterways as well as increasing liability to river flooding. In addition, soil erosion can result in nutrient losses from farmland (PIMENTEL *et al.*, 1976; KOWAL and KASSAM, 1978). The run-off from arable land contributes to the nutrient enrichment or eutrophication of the waters into which it drains. This results in an increased rate of algae growth, increase in water turbidity and depletion of oxygen. Aerobic plants and animals die and the rate of decomposition and recycling of nutrients can decline to a level at which freshwater bodies may be regarded as virtually dead or unusable. However, the most serious impact of enhanced soil erosion on agricultural land is loss of productivity, though in regions where artificial fertilizers are used increasingly intensively, the detrimental consequence of soil erosion on productivity may be masked.

4.3. *Impact of Fertilizer Use*

Before World War II most of the nitrogen, potassium and phosphorus added to the soil came from farmyard manure. Since then, there had been a rapid increase in the use of chemical fertilizers, mainly in the form of straight nitrogen. This has led to a great increase in crop yields but also to an increase in the nitrates in surface and ground water. In surface waters the increased nitrogen has caused eutrophication, a rapid growth of plants such as weeds that clog rivers, and encourage algae on the surface that cut out light, so indirectly reducing the oxygen supply of fish. Nitrates have also reached very high concentrations in groundwater which provide human water supplies, which is where most of the fertilizer is used. Sometimes stomach cancer and blue baby syndrome are thought to be related to high concentration of nitrites in drinking water (GRIGG, 1995). Water draining from cropland can contain on average 10~15mgl^{-1} nitrate in a year's discharge (DIX, 1981). The amount of nitrate lost from the land varies, however, dependent on the amount applied; the volume of water involved; the soil texture; and the organic matter content of the soil.

There are also basic reasons why environmental concerns should not indiscriminately obstruct further growth of fertilizer use in the developing country, where environmental degradation is largely due to the widespread incidence of poverty and excessive land utilization interactions. The rapid growth of fertilizer use in many developing countries (Table 2) has played a key role in their escape from the Malthusian trap characterized by growing human misery and

Table 2. Fertilizer consumption in the developing countries (excluding China).

Regions	Consumption (million tonnes)				Annual growth (%)		
	1969/71	1979/81	1988/90	2010	1970-80	1980-90	1988/99-2010
Africa (sub-Sahara)	0.4	0.9	1.2	3.3	6.2	2.8	4.8
Near East/North America	1.3	3.5	5.6	13.1	10.6	4.8	4.1
East Asia	1.9	4.1	7.0	13.8	7.7	6.2	3.3
South Asia	2.9	7.3	14.7	32.8	10.3	7.9	3.9
Latin American/Carribean	2.8	6.8	8.2	16.9	10.1	3.0	3.5
Developing countries	9.3	22.6	36.8	79.8	9.6	5.6	3.8

Source: Alexandratos, 1995.

environmental degradation. Also, it has initiated technological transformation of traditional agriculture, which is not altogether environmentally benign (DESAI, 1990). Unbalanced dose, improper and untimely application, adulteration, etc. are the main reasons for unwanted environmental impacts of chemical fertilizers in developing countries. Whereas the overuse of fertilizers is the main concern for the developed world.

4.4. *Use of Crop-Protection Chemicals*

The majority of crop-protection chemicals are pesticides. About 4.4×10^6 tones of pesticides are used every year (EDWARDS, 1993). In 1993 the global agrochemical market was worth US$$25.28 \times 10^9$ (W. M. Consultants Ltd, 1994). All these crop-protection chemicals are used to increase the efficiency of crop production. But they have their serious environmental impacts if proper care is not taken. The production projection of FAO implies three changes that, in the light of the past approaches to pest control, could pose serious threats to the environment. First, further reduction in the length of fallow periods may not only endanger soil fertility, but in the absence of suitable corrective actions, could lead to more serious and more frequent weed, insect and disease attacks because the causal agents are able to survive in greater numbers from one cropping season to the next. Second, the increase in the area of land carrying two or more crops a year could have similar effects as the reduction in fallow periods. Finally, the rise in the demand for vegetables, and to a lesser extent fruit, could lead to greater pollution and health risks from excessive use of insecticides. These crops tend to receive excessive applications of pesticides and are often applied too close to harvest, either as an insurance against the risk of loosing a high-value crop or in order to improve their cosmetic appearance and hence their price (ALEXANDRATOS, 1995). Such excessive application rates can pose numerous risks to the people applying them, to consumers, to natural predators of pests and to drinking water supplies.

In developing countries the extent of indiscriminate use is going on at large rate. People bother less about the dose, application time or safety of use (RAHMAN, 1997). The traditional use is prevailing. The most devastating matter is the use of banned pesticides in farming and storing of farm produces. Thus, the health hazards due to a lack of careful use is quite prevalent in developing countries. The unbalanced use of pesticides leads the pests resistant to pesticides, resulting in increased but less effective usage of pesticides. New pesticides, therefore, need to be developed continuously. Inappropriate choices of insecticides may disrupt the balance between pests and natural enemies by being more deadly for the natural enemy than for the pests themselves, thus upsetting natural control mechanisms (ALEXANDRATOS, 1995). The perception by farmers of yield losses due to pest attacks are often higher than actual losses. This, together with the desire to reduce risks, induces the farmers to use large quantities of pesticides that have only marginal or no benefit in terms of yield gains or even induce pest outbreaks. Moreover, in many countries, the overuse of pesticides was and still is encouraged by pesticide subsidies.

Water contamination is common in the case of pesticide application in fresh water to control weeds, pests, larvae or algae. The atmosphere receives an input of pesticides as a result of spraying. Dust and particular matter can carry pesticides over great distances: detectable levels of persistent compounds such as DDT have been recorded from the Antarctic area and remote oceanic islands. The effects of pesticides have their effects on non-target species. They can kill birds substantially. The predators of such poisoned birds may also be killed due to the pesticidal poison. There is less doubt about the pesticidal effects on wildlife extinction (MANNION, 1995; TIVY, 1990). Many small mammals are now extinct due to pesticidal effects. The decline of reproductive capacity is evidenced by thin shelled and improperly formed birds' eggs. Pesticide has also been believed to be a major threat to the butterfly population which is declining in nature (POTTS, 1986; RANDS and SOTHERTON, 1986). Bees and insect pollinators are reducing in the environment due to the multifarious use of pesticide in farming practices. Herbicides are also causing threat to the environment as in the case of toxicity to aquatic animals like fish (IVENS, 1993; EDWARDS, 1993) and, in some cases, are toxic to mammals including humans.

4.5. *Soil Degradation: Salinity and Alkalinity*

Change in farming method or in environment can lead to more alkaline or acid soils. Loss of forest cover, acid rain, and industrial pollution lead to acid rain, causing acidic soil. It is claimed that soil acidity has reduced crop yields in parts of eastern Canada by 10%. Of far greater importance, however, is the occurrence of saline and alkaline soils in the arid and semiarid regions of the world. Saline soils occur under two conditions. First, many semi-arid areas are naturally saline; ground water, with a large salt content reaches the surface and the high rates of evaporation lead to the crystallization of soils (GRIGG, 1995; ALEXANDRATOS, 1995). It can limit the type of crop that can be grown, reduce crop yields or cause the abandonment of land. There are over 5 million ha of saline soils in Western Australia and salinity has led to the abandonment of some 260,000 ha.

A second concern is the salinity that occurs in irrigated and semi-arid regions. Irrigation causes the water table to rise to within a short distance of the surface. The processes of salinization and alkalization of soil and water due to irrigation are shown in Figure 2. In Punjab, for example, irrigation has raised the water table 7~9 feet since 1895. These has been the result of over application of water by farmers, leaks from canals and a lack of underdrainage to remove surplus water. It was estimated in the 1980s that between a third and a half of all irrigated land was affected by salinity to some extent. Although only 14% of the world's arable land is irrigated, it produces one-third of the value of world agriculture output and so salinization may have a serious impact on world food output. In South-West Asia and North Africa, half the irrigated land in Iraq is salinized, a third in Egypt, a quarter in Pakistan and 15% in Iran. Nor is salinization confined to developing countries or ancient civilizations; it is a major problem in the areas of recent irrigation in the south-west of the USA (GRIGG, 1995). Without proper management of irrigation water or

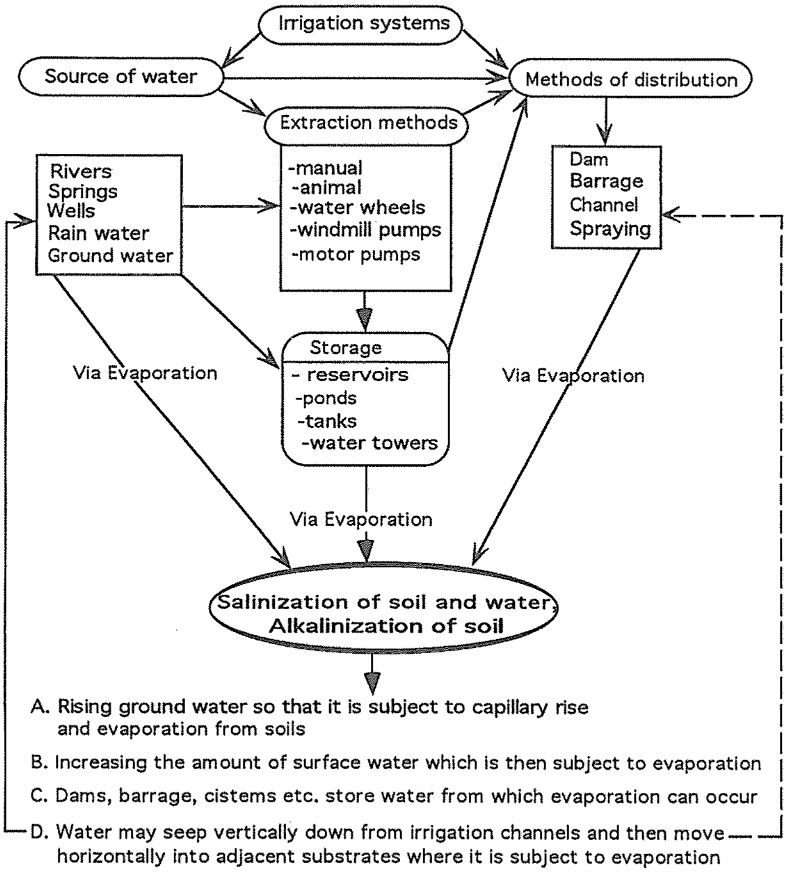

Fig. 2. Relationship between irrigation, salinization and alkalinization. (Source: MANNION, 1995)

reclamation of degraded soils, salinity or alkalinity may cause serious further threat to the further food production in the world.

5. SOIL QUALITY AND PRODUCTION FACTORS TOWARDS SUSTAINABILITY

Different physical, chemical and biological properties of soil interact in complex ways that determine its potential fitness or capacity to produce healthy crops. The integration of these properties and the resulting level of productivity is often referred to as 'soil quality'. Soil quality can be defined as the inherent attribute of a soil that is inferred from its specific characteristics and observations (PARR *et al.*, 1992). Soil quality is often related to soil degradation, which can be defined as the time rate of change in soil quality.

Food productivity of agricultural soils worldwide is decreasing. Foodgrain production per capita decreased significantly in some parts of sub-saharan Africa, the Near East, and Asia during the 1980s. This might be due to over population, periodic drought, flood, or poor management and exploitive farming practices. These are associated with the degradation of agricultural lands by wind and water erosion, nutrient depletion, and the loss of soil productivity (FAO, 1986; PARR *et al.*, 1990). However, there is a strong consensus that extensive soil degradation and loss of

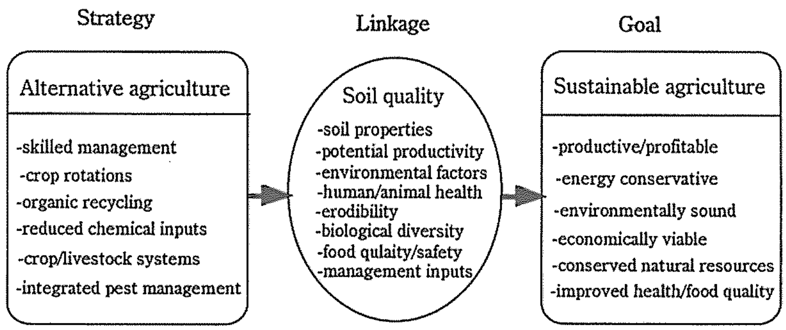

Fig. 3. A conceptual diagram chowing how soil qulaity provide a link between alternative and sustainable agriculture (slighty modified from Parr *et al.*, 1992)

productivity can no longer be tolerated (Brown and Wolf, 1984). Because of poor management and exploitive agricultural practices, many US farmers treat the soil like dirt. Soil is like the oil reserves in the world. It's quality needs to be maintained to have sustainable systems for agricultural development.

Improved soil quality can be indicated by the following attributes needed to maintain a sustainable production system (Parr *et al.*, 1992). It can take the following form:

Soil Quality Index $= f(SP, P, E, H, ER, BD, FQ, MI)$

where, SP=soil properties ER=erodibility
P=potential productivity BD=biological diversity
E=environmental factors FQ=food quality
H=health (human/animal) MI=management inputs

Knowing these attributes of soil quality, we should monitor or assess the world soil quality or status (Sanders, 1992). Because, soil quality and land use should be given high priority in observational and monitoring programs on global change issues. However, a diagram of how the attributes of soil quality link the strategy of alternative agriculture to sustainable agriculture is shown in figure 3. Soil quality is at a pivotal position in this concept, and many would agree that soil quality is the 'key' to agricultural sustainability.

6. ALTERNATIVE AGRICULTURE: *A PATH TOWARDS SUSTAINABILITY?*

Alternative agriculture is a goal and movement. Like every goal, alternative agriculture is rooted in value judgements. By their very nature, value judgements vary from person to person; they change slowly in good times, but they shift more abruptly in response to crises. The values that give rise to alternative agriculture movements include alarm over human health risks from exposure to agricultural chemicals in air, water, and foods, abhorrence of environmental degradation, severe soil erosion, depletion of natural resources, and a desire to protect the rights of future generations to an abundance of food, clean water and a decent environment (Madden, 1989).

The National Research Council (1989) of the USA states alternative agriculture as a system of food and fiber production that applies management skills and information to reduce costs, improve efficiency and maintain production levels through such principles and practices as :

- crop rotations instead of monoculture

- integrated crop/livestock systems
- nitrogen fixing legumes
- integrated pest management
- conservation tillage
- integrated nutrient management
- recycling of on-farm wastes as soil conditioners and biofertilizers.

Low-input or alternative agricultural practices are the promising strategies for preventing ground water pollution and lowering farmer's production costs (ANONYMOUS, 1988). These goals could be achieved by reducing, or largely excluding, the use of chemical fertilizers and pesticides. Actually, these are the strategies needed to achieve sustainability in agricultural flourishment in the future. Thus, it is advocated that we should choose low external input and energy management systems, i.e., alternative strategies, to establish the sustainable agriculture. Profitable and efficient production is needed with an emphasis on improved farm management and the conservation of soil, water, energy, and biological resources.

7. THE TRADE-OFF BETWEEN AGRICULTURAL DEVELOPMENT AND ENVIRONMENT: *AN OPTION FOR SUSTAINABILITY*

World population is increasing day by day, requiring more food in the future. In this trend of more food and fibre needs, high input technologies and management systems have been adopted in agricultural development. Consequently the environmental impacts of agricultural development have come into focus in recent years. Under these crucial circumstances, the concept of 'sustainable development' has emerged as an alternative way to development. It looks into the present need and future demand of the generations.

The way of agricultural development and environmental management systems are different from those developed in developing countries. This is because the need for present day and future perspectives are different and diversified. So, the trade-off varies from country to country and region to region. Developed ones emphasize the environmental dimensions and the measures needed to limit natural resource degradation, in spite of the economic and social costs that may be associated with such measures. Developing countries, by necessity, tend to argue for different issues. They recognize the importance of shifting to a more sustainable growth path and the conventions of biodiversity and climate change. But they also emphasize the need to ensure that environmental measures do not have adverse effects on their development, arguing, for example, that unless rural poverty is eliminated, many of their people have no alternative to overexploition of natural resources for day-to-day survival (ALEXANDRATOS, 1995).

Though the development scenario and the consequences of further evolution in agriculture are different between developed and developing countries, we suggest some balance measures conforming to the ideas of ALEXANDRATOS (1995):

a. use of external inputs in farming systems in a way to minimize the cost-profit ratio
b. farming practices should be energy conservative
c. lesser reliance on chemical inputs and an emphasis on integrated plant nutrient management (IPNM) and integrated pest management (IPM)
d. biological nitrogen fixation (BNF), green manuring, use of composts, etc., need to be practiced along with a minimum use of chemical fertilizers

e. sound crop-livestock systems to achieve the nutrient balance
f. population control to exert less pressure on the arable land and forest reserves
g. conserving natural resources
h. practicing crop rotation with suitable crops for soil nutrient conservation
i. the rise in public willingness to pay for a better environment
j. environmentally oriented shifts in technology development
k. limiting water degradation while promoting water development and water saving
l. developing the potential for biotechnology to release environmentally friendly technology (EFT)

8. RESEARCH AND EXTENSION ISSUES FOR SUSTAINABLE AGRICULTURE

Research and development programs in both developed and developing countries are dealing with the challenges of producing adequate food for a growing population while conserving natural resources for the future. Research focuses on ecological approaches to crop production, breeding crops for stress tolerance, efficient nutrient and water cycling, crop/animal integration, biological pest management, and the impact of technology on environment and society. Extension will pursue a broad, participatory agenda with a focus towards on-farm research and demonstration (FRANCIS, *et al.*, 1995).

Over the last century, large strides have been made in increasing food production to meet human needs. Rapidly expanding population and increasing demand for a higher standard of living have combined to tax our research capabilities and natural resource base to sustain growth of food production potential (BROWN, 1993). Now there is emerging awareness of the impact of these food production activities on the environment.

According to DURNING (1989), "poverty can drive ecological deterioration when desperate people overexploit their resource base, sacrificing the future to salvage the present. The cruel logic of crucial short term needs forces landless families to put rain forest plots to the torch and mountain slopes to the plow. Environmental decline, in turn, perpetuates poverty, as regarded ecosystems offer diminishing yields to their poor inhabitants. A self-feeding downward spiral of economic deprivation and ecological degradation takes hold". So, these are the challenges to be met by present and future research and extension priorities.

8.1. *The Research Agenda*

The unique challenges for a universal research agenda towards sustainable agriculture are zonal or regional climatic, edaphic or the socio-economic variations. The climate and ecosystem differences are tremendous among contrasting locations (CHAMBERS, 1990). However, we may focus our research agenda towards the following aspects to achieve sustainability in agricultural development.

a. Development of biotic and abiotic stress tolerances in new cultivars which may endure the stress of environmental problems like droughts, salinity/alkalinity, diseases or other insect pests.
b. Development of agronomic research for environmentally friendly agriculture (EFA). For example, reduced tillage to cut machinery and fossil fuel costs and preserve moisture; legumes and grass cover crops, and alternative methods of weed management to reduce

application rates of herbicides (Francis *et al.*, 1995).

c. Care should be taken at the time of the development and introduction of new technologies so that they do not bring severe impact on the farming community and society as whole. Modern technology needs to boost agricultural production and, also, it should be society friendly.

d. Improved management strategy to use biological fertilizers and green manuring needs to be adjusted along with the proper application of chemical fertilizers.

e. Farming systems research is needed to develop a farm as a complete unit of farming. It may provide a nice scope towards better nutrient recycling within the farm. This approach is more helpful for a developing country where subsistence farming is dominant.

f. Emphasis is needed on increased efficiency in the use of internal resources and their substitution for external inputs wherever possible (Rodale, 1983).

8.2. *Extension Strategies*

The traditional extension strategy of the 'Training and Visit' (T & V) system was implemented in many countries but it was often referred to by farmers as 'Talk and Vanish' (T & V) system (Francis, *et al.*, 1995). But with the recent ideas of 'rapid rural appraisal' (RRA) and ecosystem analysis, various methods were explored to help farmers observe and evaluate farms as whole systems (Conway and Barbeir, 1990).

In the present day, we need the international farming systems research and extension network. This involves the farmer at all stages of the process, from problem identification through considering alternatives to testing in the field to interpretation and communication of results. Continuous involvement of farmers will assure a better understanding of the alternative technologies and increased potential for adoption. Making farmers full members of the research and extension team is a goal that will help overcome the lack of acceptance of new technology by them.

We need a 'holistic' researching system that integrates research and extension functions in order to discover, organize, communicate, and utilize to serve the public good. In an attempt to define public good Burkhardt (1986) explains that there are 'basic human needs' common to all:

1. Adequate, affordable, nutritionally sound food
2. Adequate, affordable, clothing and shelter
3. Water, air and a clean, livable environment
4. Means to provide for a livelihood
5. Accessible educational opportunities

What is needed in the present-day extension is balance, diversity, and an ability to adapt to changes which we perceive as useful in helping agriculture be sustainable into the future-as well as profitable and ecologically viable in the short run (Francis *et al.*, 1988). Following are perspectives for extension which may foster a sustainable agricultural system.

- *Focusing on internal resource utilization*: for probable greater efficiency and profitability in the system, the in-farm or in-community resources should be utilized if they can substitute for purchased or nonrenewable inputs.
- *Emphasizing information as a key production input*: wherever information can be substituted for a purchased input, greater resource use efficiency may result and the

production system can become more sustainable for future.

- *Focusing systems rather than components*: future advances need an appreciation of the entire system and the interactions among component crops and crops with the environment.
- *Stressing participatory systems for developing information*: on-farm trial and validation options need to be explored, when producer and local extension personnel become full participants in the research process and feel ownership of the research process.
- *Focusing community as well as on farming*: viable communities are critical to the achievements of a viable agriculture, value-added industries based on locally produced agricultural products can bring jobs and vitality to communities.
- *Highlighting value-based decisions*: as opposed to letting new technology set the agenda for the future, we need to empower people to make their own rational decisions about the use of this technology; there are some components which may logically sit on the shelf, while others are quickly adjusted to a farming system (FRANCIS, *et al.*, 1988).

9. THE ENDPIECE

Undoubtedly, the concept of sustainable agriculture is complex, at least in the variety of its applications to so many widely different environments and, in each of them, to a continuum of interlocking technical, economic and political factors. Still we need a sustainable agriculture and we have to define it generally. One can go on searching for new definitions, but what is important is to develop methods of measurement, which relate to their particular social, ecological and economic conditions prevailing in a given area. So, we should try to integrate considerations of ecological sustainability with those of economic viability and social equity. Now the world, both developed and developing, should search for their own ways and strategies to work out the concepts of sustainable agriculture in order to find linkages with its development.

Global agricultural systems face a number of challenges as the millennium approaches if the world's population of c. 8×10^9 by the year 2020 is to be fed adequately (MANNION, 1995). These challenges involve adjustments at global, regional and local levels and within varied political and economic frameworks.

Agricultural development and sustainability are very much linked to maintaining a healthy soil that is resilient to the stresses imposed on it either by natural forces or farming practices. Soil should be healthy and of quality for the development in agriculture to meet future needs. Proper biological amendments need to be incorporated in restoring soil quality. In particular, the balance of organic/biological fertilizing should be stressed in developing countries where the soil is not replenished with nutrients properly after each harvest. Rather, the gap between each harvest is diminishing day by day owing to the demand of more foods in feeding an increasing population. Additionally, in order to restore soil productivity and forests, we need to control the population boom in developing countries.

At present it is useful to characterize sustainability in a manner that will be useful as a guide to research rather than as an immediate guide to practice. As a guide to research, emphasis should be focused on the development of technology and practices that maintain and/or enhance the quality of land and water resources, and the improvement in plant and animal and the advances in production practices that will facilitate the substitution of biological technology for chemical technology. Such an agenda should also need to define what is biologically feasible without being excessively limited by present economic constraints.

What is needed in extension is balance, diversity, and an ability to adapt to changes which we perceive as useful in helping agriculture be sustainable into the future-as well as profitable and ecologically viable in the short run. Extension needs to deliver programs relevant to where the needs are the greatest. It needs to empower its clientele to solve community problems by putting what has been learned into action. Extension must become involved in community action, allying with local citizens in influencing lawmakers and developing policies towards sustainable development in agricultural systems. On-farm research and the validation of technology need to be explored, where farmers and local extension personnel become full participants in the research process and feel ownership in the research agenda for community development. Individual farmers need to be motivated and inspired in ways so that they feel the ethics of sustainability through the trade-offs between unanticipated consequences and developments in modern agriculture. Local or international campaigning should be continued to make people understand the inevitability of sustainability in agricultural development for future just.

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農業の発展とその持続性－必然的な関連性－

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農業の発展と人間活動の他の分野との間の密接な関係は，環境保全，人口増加，食糧供給と世界貿易など地球規模の諸問題と数えきれない関連性を規定している。この広大な背景は，利害関係の異なるグループによって，持続的農業に関して異なった理解をもたらしている。主要食糧の過剰生産からの有利な他の手段への転換や環境圧力集団の活動は，主に先進国に集中している。他方途上国では，主要な関心事は将来の食糧の安全保障など，生産の拡大を維持することである。これを達成するためには，農業資源基盤の維持に決定的に依存している。投入と投入代替は重要な相互関係問題であるが，持続性の焦点は，将来の生産のための潜在力のどんな縮小も避けることにある。それはロスや破壊に対して，土壌と水の質，種のプール，自然資源基盤の保全を求めるものである。大部分の資源の衰退と潜在力の破壊は，経済的，社会的，政治的問題に起因している。主要なこれらの諸問題は呼びかけられ，認識されることなしには，解決されることは少ない。我々は農業発展とそれが自然と社会へ与えるその影響との矛盾を考慮すべきである。食糧生産システムを安定化させるために，農業における発展の代替可能な道を同時に見出していく必要がある。発展は必要であるが，それは将来のために持続的でなければならない。そのため，研究と普及の計画は，タイムリーで必要性に基づいた方法を考慮することが求められる。政府や関係機関が，持続的農業は人口対策，雇用・経済計画，技術研究，普及計画，国家投資などの総合的結果として起こることを認識すべきである。

キーワード：農業発展，持続性，農業資源基盤，環境保全