SUSTAINABLE AGRICULTURE- IRRIGATION, CROPPING PATTERN AND CROP PRODUCTION

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ABSTRACT

The expression "safeguard," from the Latin sustinere (sus, from underneath and tinere, to keep up), to hold in life or keep, infers long-term period help or lastingness. Since it relates to horticulture, reasonable portrays cultivating frameworks which may be "equipped for holding their profitability and quality to society inconclusively. Practical horticulture is both reasoning and an arrangement of cultivating. It has its roots in an immovable of qualities that shows a perception of both natural and social substances. It includes plan and control methods that work with natural procedures to save all assets, diminish waste and ecological harm, even as keeping or enhancing ranch gainfulness. Working with characteristic soil systems is of exact noteworthiness. Economical farming structures are intended to take amplify advantage of ebb and flow soil supplement and water cycles, vitality streams, and soil life forms for nourishment producing. As pleasantly, such structures expect to give sustenance this is nutritious, without being polluted with stock that would harm human wellness.

INTROCUCTION

Agriculture is a widely and majorly practiced activity in India. The country is mainly known for it’s agrarian economy. A majority of the rural population is closely related to agriculture in one or the other way.

In simplest phrases, sustainable agriculture is the manufacturing of meals, fiber, or exceptional plant or animal merchandise using farming techniques that protect the environment, public health, human groups, and animal welfare. The phrase sustainable has grown to be very popular in recent years and it's far now used to explain loads of things. Sustainable agriculture is a kind of agriculture that specializes in generating long-term plants and cattle at the same time as having minimum outcomes on the surroundings. This kind of agriculture tries to discover a top balance among the want for food production and the preservation of the ecological gadget inside the environment. In addition to generating meals, there are several general goals associated with sustainable agriculture, consisting of holding water, reducing the use of fertilizers and pesticides, and selling biodiversity in plants grown and the ecosystem. Sustainable agriculture additionally specializes in retaining monetary balance of farms and assisting farmers improve their techniques and satisfactory of existence.

The term Agroecology which can also be regarded as the science of sustainable agriculture. As researchers explore indigenous agricultures, which are modified relics of earlier agronomic forms, it is increasingly apparent that many locally developed agricultural systems routinely incorporate mechanisms to accommodate crops to the variability of the natural environment and to protect them from predation and competition. These mechanisms make use of regionally available renewable inputs and ecological and structural features of the agricultural field, fallows, and surrounding vegetation. Agriculture in these situations involves managing resources other than the "target" crop. These production systems were developed to balance out environmental and economic risk and maintain the productive base of agriculture over time. While such agroecosystems can include infrastructure like terraces, trenches, and irrigation works, the decentralized, locally developed agronomic knowledge is central to the continuing performance of these production systems.

THE DYNAMICS OF SUSTAINABLE AGRICULTURE

Sustainable agriculture embraces several variants of nonconventional agriculture that are often called organic, alternative, regenerative, ecological or low-input. Just because a farm is organic or alternative does not mean that it is sustainable, however. For a farm to be sustainable, it must produce adequate amounts of high-quality food, protect its resources and be both environmentally safe and profitable. Instead of depending on purchased materials such as fertilizers, a sustainable farm relies as much as possible on beneficial natural processes and renewable resources drawn from the farm itself. To understand the rationale for sustainable agriculture, one must grasp the critical importance of soil. Soil is not just another instrument of crop production, like pesticides, fertilizers or tractors. Rather it is a complex, living, fragile medium that must be protected and nurtured to ensure its long-term productivity and stability. Healthy soil is a hospitable world for growth_ Air circulates through it freely, and it retains moisture long after a rain. A tablespoon of soil contains millions of grains of sand, silt and clay and has a vast expanse of internal surface area to which plant nutrients may cling. That same tablespoon of soil also contains billions of microorganisms, including bacteria, actinomycetes, fungi and algae, most of which are principal decomposers of organic matter. Decomposition results in the formation of humus and the release of many plant nutrients. The microbes also produce sticky substances called polysaccharides that glue soil particles together and help the soil to resist erosion.

Sustainable agriculture does not represent a return to pre-industrial revolution methods; rather it combines traditional conservation minded farming techniques with modern technologies. Sustainable systems use modern equipment, certified seed, soil and water conservation practices and the latest innovations in feeding and handling livestock. Emphasis is placed on rotating crops, building up soil, diversifying crops and livestock and controlling pests naturally. Whenever possible, external resources-such as commercially purchased chemicals and fuels-are replaced by resources found on or near the farm. These internal resources include solar or wind energy, biological pest controls and biologically fixed nitrogen and other nutrients released from organic matter or from soil reserves. In some cases external resources may be essential for reaching sustainability. As a result, such farming systems can differ considerably from one another because each tailors its practices to meet specific environmental and economic needs. A central component of almost all sustainable farming systems is the rotation of crops-a planned succession of various crops growing on one field. When crops are rotated, the yields are usually from 10 to 15 percent higher than when they grow in mono culture. In most cases monocultures can be perpetuated only by adding large amounts of fertilizer and pesticide. Rotating crops provides better weed and insect control, less disease build up, more efficient nutrient cycling and other benefits. A typical seven-season rotation might involve three seasons of planting alfalfa and ploughing it back into the soil, followed by four seasons of harvested crops: one of wheat, then one of soybeans, then another of wheat and finally one of oats. The cycle would then start over. The first season of wheat growth would remove some of the nitrogen produced by the alfalfa; the soil's nitrogen reserves would be depleted much less by the soybeans, which are legumes. Oats are grown at the end of the cycle because they have smaller nutrient requirements than wheat. Regularly adding crop residues, manures and other organic materials to the soil is another central feature of sustainable farming. Organic matter improves soil structure, increases its water-storage capacity, enhances fertility and promotes the tilth, or physical condition, of the soil. The better the tilth, the more easily the soil can be tilled and the easier it is for seedlings to emerge and for roots to extend downward. Water readily infiltrates soils with good tilth, thereby minimizing surface runoff and soil erosion. Organic materials also feed earthworms and soil microbes. The main sources of plant nutrients in sustainable farming systems are animal and green manures. A green manure crop is a grass or legume that is ploughed into the soil or surface mulched at the end of a growing season to enhance soil productivity and tilth. Green manures help to control weeds, insect pests and soil erosion, while also providing forage for livestock and cover for wildlife. By raising a diverse assortment of crops and livestock, a farm can buffer itself against economic and biological risks.

Diversity results from mixing species and varieties of crops and from systematically integrating crops, trees and livestock.

What Is Agroecology?

The term agroecology has come to mean many things. Loosely defined, agroecology often incorporates ideas about a more environmentally and socially sensitive approach to agriculture, one that focuses not only on production, but also on the ecological sustainability of the production system. This might be called the "normative" or "prescriptive" use of the term agroecology, because it implies a number of features about society and production that go well beyond the limits of the agricultural field. At its most narrow, agroecology refers to the study of purely ecological phenomena within the crop field, such as predator/prey relations, or crop /weed competition.

The Ecological View

At the heart of agroecology is the idea that a crop field is an ecosystem in which ecological processes found in other vegetation formations such as nutrient cycling, predator/prey interactions, competition, commensalism, and successional changes also occur. Agroecology focuses on ecological relations in the field, and its purpose is to illuminate the form, dynamics, and function of these relations. Implicit in some agroecological work is the idea that by understanding these processes and relations, agroecosystems can be manipulated to produce better, with fewer negative environmental or social impacts, more sustainably, and with fewer external inputs. As a result, a number of researchers in the agricultural sciences and related fields have begun to view the agricultural field as a particular kind of ecosystem—an agroecosystem—and to formalize the analysis of the ensemble of processes and interactions in cropping systems. The underlying analytic framework owes much to systems theory and the theoretical and practical attempts at integrating the numerous factors that affect agriculture (Spedding 1975, Conway 1981a and1981b, Gliessman 1982a, Conway 1985, Chambers 1983, Ellen 1982, Altieri 1983, Lowrance et al. 1984).

The Social Perspective

Agroecosystems have various degrees of resiliency and stability, but these are not strictly determined by biotic or environmental factors. Social factors such as a collapse in market prices or changes in land tenure can disrupt agricultural systems as decisively as drought, pest outbreak, or soil nutrient decline. On the other hand, decisions that allocate energy and material inputs can enhance the resiliency and recuperation of damaged ecosystems. Although human manipulations of ecosystems for agricultural production have often dramatically altered the structure, diversity, patterns of energy, and nutrient flux and mechanisms of population regulation within agricultural fields, these processes still operate and can be explored experimentally. The magnitude of the differences in ecological function between a natural and an agricultural ecosystem depends tremendously on the intensity and frequency of the natural and human perturbations that impinge on an ecosystem. The results of the interplay between endogenous biological and environmental features of the agricultural field and exogenous social and economic factors generate the particular agroecosystem structure. For this reason, a broader perspective is often needed to explain an observed production system. An agricultural system differs in several fundamental ways from a "natural" ecological system in its structure and function. Agroecosystems are semi-domesticated ecosystems that fall on a gradient between ecosystems that have experienced minimal human impact, and those under maximum human control, like cities. Odum (1984) describes four major characteristics of agroecosystems:

1. Agroecosystems include auxiliary sources of energy like human, animal and fuel energy to enhance productivity of particular organisms.
2. Diversity is greatly reduced compared with many natural ecosystems.
3. The dominant animals and plants are under artificial rather than natural selection.
4. The system controls are external rather than internal via subsystem feedback.

The Agroecology Challenge

Conventional agricultural scientists have been concerned primarily with the effect of soil, animal, or vegetation management practices upon the productivity of a given crop, using a perspective that emphasized a target problem such as soil nutrients or pest outbreaks. This means of addressing agricultural systems has been determined in part by the limited dialogue across disciplinary lines, by the structure of scientific investigation, which tends to atomize research questions, and by an agricultural commodity focus. There is no question that agricultural research based on this approach has been successful in increasing yields in favored situations. Increasingly, however, scientists are recognizing that such a narrow approach could limit agricultural options for rural peoples, and that the "target approach" often carries with it unintended secondary consequences that have often been ecologically damaging and had high social costs. Agroecology research does concentrate on target issues in the agricultural field, but within a wider context that includes ecological and social variables. In many cases, premises about the purposes of an agricultural system may be at variance with the purely productionist or yield focus of some agricultural scientists. Agroecology can best be described as art approach that integrates the ideas and methods of several subfields, rather than as a specific discipline. Agroecology can be a normative challenge to existing ways of approaching agricultural issues in several disciplines. It has roots in the agricultural sciences, in the environmental movement, in ecology (particularly in the explosion of research on tropical ecosystems), in the analysis of indigenous agroecosystems, and in rural development studies. Each of these areas of inquiry has quite different aims and methodologies, yet taken together, they have all been legitimate and important influences on agroecological thought.

IRRIGATION MANAGEMENT STRATERGIES FOR SUSTAINABLE AGRICULTURE

Irrigation has long played a key role in feeding the expanding world population and is expected to play a still greater role in the future. As supplies of good-quality irrigation water are expected to decrease in several regions due to increased municipal–industrial–agricultural competition, available freshwater supplies need to be used more efficiently. In addition, reliance on the use and reuse of saline and/or sodic drainage waters, generated by irrigated agriculture, seems inevitable for irrigation. The same applies to salt-affected soils, which occupy more than 20% of the irrigated lands, and warrant attention for efficient, inexpensive and environmentally acceptable management. Technologically and from a management perspective, a couple of strategies have shown the potential to improve crop production under irrigated agriculture while minimizing the adverse environmental impacts. The first strategy, vegetative bioremediation—a plant-assisted reclamation approach—relies on growing appropriate plant species that can tolerate ambient soil salinity and sodicity levels during reclamation of salt-affected soils. A variety of plant species of agricultural significance have been found to be effective in sustainable reclamation of calcareous and moderately sodic and saline-sodic soils. The second strategy fosters dedicating soils to crop production systems where saline and/or sodic waters predominate and their disposal options are limited. Production systems based on salt-tolerant plant species using drainage waters may be sustainable with the potential of transforming such waters from an environmental burden into an economic asset. Such a strategy would encourage the disposal of drainage waters within the irrigated regions where they are generated rather than exporting these waters to other regions via discharge into main irrigation canals, local streams, or rivers. Being economically and environmentally sustainable, these strategies could be the key to future agricultural and economic growth and social wealth in regions where salt-affected soils exist and/or where saline-sodic drainage waters are generated.

Just 20% of the world's croplands are irrigated but they produce 40% of the global harvest which means that irrigation more than doubles land productivity (FAO, 2003). In developing countries, irrigation improves economic returns and can boost production by up to 400%. On the other hand, irrigation can have unwanted environmental consequences. About one-third of the world's irrigated lands have reduced productivity as a consequence of poorly managed irrigation that has caused water logging and salinity.

A sustainable strategy of agricultural water resources – An example from China

Deficit irrigation requires more accurate and real-time allocation of agricultural water resources, especially in arid areas. Sustainable water management for food security needs to include: (i) the optimal allocation of water resources; (ii) high efficiency of agricultural water use; (iii) prevention and control of water pollution; and (iv) countermeasures to combat extreme climate disasters and other considerations. In recent years, the Ministry of Water Resources of China put forward an agricultural water management strategy for 'increasing grain yield and water-saving' in north-east China, limiting groundwater abstraction for saving' in North China Plain, 'water-saving with high efficiency' in north-west China, and 'water-saving with drainage reduction' in south China. Research and the extension of efficient irrigation technology have developed rapidly in China. On the North China Plain, winter wheat yield increased significantly when crops received 3600m3 hm–2 from microspray irrigation technology, with a WUE of 1.7kg m–3, while WUE under traditional border irrigation is 1.5kg m–3 (Zhang et al., 2013). Maize production in north-east China has reached 15000kg hm–2 under drip irrigation; the average yield increment is 6000–7500kg hm–2 compared with yields under conventional cultivation and surface irrigation. Fifty percent of the irrigation water is saved by using drip rather than sprinkler irrigation, and 86% is saved if drip irrigation is used rather than surface irrigation. There is a clear economic benefit of using drip irrigation in addition to the water-saving benefit. According to the survey data in north China, 8550 Renminbi (RMB) hm–2 of irrigation is required for the total cost of water supplies, irrigation equipment, plastic film, and conventional cultivation management for drip irrigation. If calculated on the basis of maize yield of 15 000kg hm–2 and a local price of 1.2 RMB kg–1, the income will be 18 000 RMB hm–2, and the net income will be 9450 RMB hm–2; compared with the average net income of conventional maize, the efficient water-saving technology provides 6000 RMB hm–2 in benefit to the local farmers. Optimizing water transport and distribution in the irrigation canal system is also necessary for achieving water-saving irrigation at the scale of an irrigation district or catchment. With the extension of high and new technology in agricultural water management, digital canal system management greatly promotes the practice of precision scheduling of water resources and precision irrigation. In order to meet the requirement of optimizing water distribution in canal systems, there is a need to apply computer and information technology to control water volume flow in real time. In order to optimize management of a canal system, automation of engineering control equipment, advanced systems software, and decision-making support are all needed in the large irrigation districts in north China. A sustainable strategy for management of agricultural water resources involving deficit irrigation based on physiological responses of crops needs to: (i) either reduce ET without yield reduction or improve yield with a similar ET; (ii) construct a compensatory mechanism for agricultural water-saving for farmers; (iii) improve water-saving efficiency by rural land circulation and scale operation;(iv) develop advanced practical water-saving technologies and economical, reliable, and durable equipment and facilities in the field; (v) construct and improve the system for water-saving technology extension and service; (vi) strengthen basic research on water-saving irrigation under changing environmental conditions; and (vii) establish national ET monitoring and an agricultural water-saving experimental research network.

Methods that may cut down irrigation are of considerable interest and should be explored further. Deficit irrigation methods have been assessed systematically by the irrigation community in different parts of the world and are now used widely in crop and fruit production in many countries, Much of this work is still relatively empirical, but through these efforts we have gained a good appreciation of what are the most drought-sensitive developmental stages of many important food crops. Cowan (1988) and others have argued that plants have evolved mechanisms to maximize carbon gain and growth in environments where rainfall is unpredictable. This suggests that crop plants should be able to regulate their water use according to the water availability in the soil. Our understanding of the theoretical basis of active regulation of WUE has now increased to the point where physiological control mechanisms might be exploited to tune deficit irrigation methods for different crops and different environments. Such tuning might deliver increased WUE, yield, and crop quality. Further gains can be achieved if we also include in our manipulations accurate and real-time assessments of water availability that allow effective allocation of water resources.

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CROPPING PATTERN INTEGRATED FARMING SYSTEMS

The components of a farm must be integrated for it to persist. A dynamic model for a farm is a simple mass flow model, which consists of two parallel paths of flow through the farm. One pathway is a socio-economic flow which has inputs of land, labor, capital, culture, and knowledge or information. Land, labor, and capital are the traditional inputs of economic models, and labor and capital-based inputs are often considered interchangeable, e.g. herbicides are substitutes for hand-weeding or cultivation (National Research Council (NRC), 1989). Tradition, information, and knowledge can also be substituted for labor and capital, e.g. appropriate intercropping can minimize weed problems. Outputs of the socio-economic pathway are fulfillment of livelihood needs and include income, health, knowledge, social stability, and a sense of community. Income is the most commonly recognized output of a farm, but livelihood goes well beyond income because farming is also a lifestyle. The formulation and perpetuation of values and the persistence of a community sense are probably equally important outputs. The importance of internal socio-economic processes on a farm are often overshadowed by the inputs from which they develop and the outputs they produce. The farm provides collateral for loans to cover capital expenditures and operating costs. Land appreciation is a hedge against inflation, provides money in the bank, and represents a retirement account. Farming provides a lifestyle that binds a household together and is a heritage that can be passed to future generations through inheritance of the farm. Indigenous knowledge is typically a product of generations of adaptation of farming practices to local environments. Family, tradition, and formulation of values are all processes that are facilitated on the farm. The biophysical flows run in parallel with the socio-economic flows. Physico-chemical inputs include energy for operations such as tillage, harvesting and storage, and agrochemicals for fertilization and pest control. Biological inputs include organic matter such as crop residues, animal manure, legume nitrogen, cover crops, rotations, and cropping patterns. Physico-chemical and biological inputs are familiar components of conventional agriculture, but their values have not usually been optimized or integrated. Less obvious, but CA. Edwards et al. / Agriculture, Ecosystems and Environment 46 (1993) 99-121 103 of great importance is knowledge or information. Use of genetically improved varieties of crops and animals, management of farming practices, and biological pest control are examples of information. These inputs often provide substitutes, that are both cost effective and environmentally benign, for inputs of labor, energy, or chemicals. For example, seeds for a pest-resistant line of a crop costs a farmer little more than for one without resistance but eliminates the need for pesticides and the labor to apply them and stabilize production. The internal processes occurring within the farm are important in maintaining its natural resource base and its ability to support continued production. Nutrients are recycled and made available for plant growth through the soil decomposer community (Wild, 1973). The combined activities of the soil fauna and flora stabilize soil structure and increase the permeability, long term fertility, and resilience of the soil (Coleman et al., 1984). Nitrogen-fixing bacteria increase the soil stock of nitrogen (Miller, 1990). Soil organisms assist in control of pests through various mechanisms including competition, antagonism, predation, and allelopathy (Baker and Cook, 1974). Soil microorganisms can metabolize toxic organic compounds (Edwards, 1966). The maintenance of a healthy soil ecosystem provides for evolution and adaptation of the soil biota and community to changing conditions. Sustainable systems add greater biological diversity to nutrient cycles, thereby increasing their longevity and promoting interactions between the decomposer and consumer communities. The socio-economic and biophysical flows run in parallel and are interdependent. The ability of a farmer to produce food and income is tied directly to internal biological processes. Adoption of the best farm management practices and indigenous knowledge depend upon natural resources and are the results of interactions between farmers and their biophysical and socio-economic environments. Socio-economic and biophysical inputs can often substitute for one another. For example, weeds can be controlled by herbicides or by cover crops, rotations, hand-weeding or cultivations (NRC, 1989). It is the understanding of the pattern of parallel flows and the interdependence between the flows that defines an integrated farm or farming system. For a farm to be sustainable, the flows must be coupled. When either flow or the interaction between them is sufficiently disrupted, the system becomes unsustainable. Consequently, intervention by science and technology in an integrated farm requires consideration of the whole system and the socio-economic and biophysical flows within and through the system. Such an integrated farm model represents an agroecosystem. Both agricultural sciences and ecology have contributed to our knowledge of agro-eco systems. The traditional agricultural sciences have developed a large body of information on the components of agroecosystems, and many of the current ecological theories were developed in agroecosystems. For example, much of the literature on insect ecology (e.g. Andrewartha, 1954) resulted from work 104 C.A. Edwards et aL / Agriculture, Ecosystems and Environment 46 (1993) 99-121 done in agricultural systems with a goal of pest control. Agroecology is a relatively new discipline that integrates the techniques and paradigms of ecology with the practices of agricultural sciences for the study of agroecosystems. We realize that a farm is only one level of an agroecosystem. The farm sits within a hierarchy of levels that includes, for example, fields; farms, households, watersheds and regions (Conway, 1985; Lowrance et al., 1986) In the interest of simplicity, we have restricted our discussion to the farm level, but many of the concepts apply equally to other subsystems and levels of the hierarchy.

CROP PRODUCTION FOR SUSTAINABLE AGRICULTURE

A framework for the farmer that will ensure the sustainability of crop production--according to the definition outlined above---can be derived by following procedure;

1. Identification of actual emissions and releases resulting from crop production.
2. Determination of ambient concentrations, depositions and loads by assessing the corresponding impact pathways to ecosystem(s) and their components.
3. Selection of ecosystem indicators to describe the condition of the ecosystem and its components affected directly or indirectly by crop production practices.
4. Determination of threshold values for these indicators.
5. Determination of maximum tolerable emission and releases based on the threshold values identified above by tracing the impact pathways back to the farm level.
6. Derivation of farm-level indicators to describe those agricultural management practices relevant in the context of sustainable crop production.
7.Determination of critical uses of farm inputs as the threshold values for these indicators.
8. Identification of production schemes that adhere to the framework established by the threshold values for farm inputs, thus satisfying the criteria for sustainable crop production.

CONCLUSION

The lack of price supports for other crops effectively discourages farmers from diversifying and rotating their crops and from planting green manures. Instead it gives them powerful incentive to practice monoculture to achieve maximum yields and profits. The long-term economic benefits of sustainable agriculture may not be evident to a farmer faced with having to meet payments on annual production loans. Many conventional farmers are greatly in debt, partly because of heavy investments in specialized machinery and other equipment, and their debt constrains the shift to more sustainable methods. To date, society has neither rewarded farmers financially nor given them other incentives for choosing sustainable methods that would benefit the public. Then, too, there is little information available to farmers on sustainable practices. Government-sponsored research has inadequately explored alternative farming and focused instead on agri-chemically based production methods. Agribusinesses also greatly influence research by providing grants to universities to develop chemical intensive technologies for perpetuating grain monocultures. Shifting mainstream agriculture toward more sustainable methods will require more than new laws and regulations; it will also require more research and public education. A high research priority is the development of specific cropping systems that produce and consume nitrogen more efficiently. Itis essential to learn how much nitrogen is fixed by legumes under various conditions, as well as the optimum means for integrating legumes into More must be learned about alternatives to fertilizers and the cycling of nutrients through the agricultural ecosystem. Effective strategies must be developed for controlling pests, weeds and diseases biologically. The strategies may rely on beneficial insects and microorganisms, allelopathic crop combinations (which discourage weed growth), diverse crop mixtures and rotations and genetically resistant crops. More research should also be done on the relative benefits of various cover crops and tillage practices and on integrating livestock into the cropping system. collected and preserved continually. Well-managed collections of germ plasm will give plant breeders a broader genetic base for producing new crops with greater resistance to pests, diseases and drought. New breeds of crops being developed by biotechnology, such as grains that fix their own nitrogen, may eventually be included in sustainable cropping systems. But neither biotechnology nor any other single technology can fix all the problems addressed by a balanced ecological approach. The success of sustainable agriculture does not hinge on creating super crops: the system works with crops that are available now. Better education is as important as further research. Farmers need to know clearly what sustainable agriculture means, and they must see proof of its profitability. One of the most effective methods for communicating practical information about sustainable agriculture is through farmer-to-farmer networks. Because such networks have aroused growing interest and proved effective, the land grant community should try to promote their development. Some scientists and environmentalists have recommended levying taxes on fertilizers and pesticides to offset the environmental costs of agrichemical use, to fund sustainable agricultural research and to encourage farmers to reduce excessive use of agrichemicals. Agriculture is a fundamental component of the natural resources on which rests not only the quality of human life but also its very existence. If efforts to create a sustainable agriculture are successful, farmers will profit and society in general will benefit in many ways.

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