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Approaches to Sustainable Land Use System

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Introduction

Global populations are increasing at a rate of 1.6 to 1.7 per cent resulting in almost 90 million more consumers of agricultural products annually. The world's population is likely to reach 9 billion by the middle of this century. The Food and Agriculture Organization of the United Nations (FAO) believes that 60 per cent more food will be needed by 2050 to sustain all these people. Where possible, this food should be produced where it is needed – in developing countries. These countries will have to increase their production substantially to reach this goal, and this will have implications for the limited natural resources on which farming depends, particularly water for irrigation and livestock farming, land for growing crops and grazing, and limited nutrients, such as phosphate.

In the upcoming 25 to 50 years, rural areas will need to supply two to three billion more people than today with food (World Bank, 2003). Providing this growing population with food will be the predominant role of farmers.However, as natural resources become scarcer, additional contributions of agriculture to society become recognized as merits. So far, the growing demand for food has largely been satisfied by agriculture through intensifying production systems and expanding the areas under cultivation. But this in a sense positive development has also caused negative effects. Overgrazing and inappropriate cropping have caused soil fertility to decrease in many places; large areas under agricultural production have been completely lost due to soil degradation. The expansion of agricultural land has increasingly come up against ecological limits. Consequences of current production methods include a loss of biodiversity, overexploitation of natural resources and contamination of soil, water and air, as well as other devastating environmental impacts.

In many places, soil has already suffered lasting damage while water resources are often overused or polluted by fertilizers and pesticides. Agricultural biodiversity has

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dwindled as farming has become industrialised. These negative effects have heightened global awareness of the fact that agriculture does more than simply produce food, animal feed and energy. It also has impacts on the climate, human health, and global ecosystems.

Agriculture has been and always remains the most important sector of a national and global economy which provides the ultimate in essential food and fibre for the world's population. No industrial substitutes have yet been found to replace food requirement. Thus the long term survival of mankind, will depend on the sustainability of the global agricultural economy. Demand for higher agricultural productivity is ever increasing in the developing countries but a narrower or even none considerations for sustainability of this sector. Thus, conservation and preservation of basic natural resources has been threatened.

Sustainable land use system would be a potential solution for avoiding degradation, and saving natural resources such as soil, water and environment instead of conventional approach in agriculture. Sustainable agriculture bears set values from ecological and social reality perspectives. Sustainable agriculture systems are designed to take maximum advantage of existing soil nutrient and water cycles.

Sustainable agriculture:

The term sustainable agriculture means an integrated system of plant and animal production practices having a site-specific application that will, over the long term:

- satisfy human food and fiber needs
- enhance environmental quality and the natural resource base upon which the agricultural economy depends
- make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls
- sustain economic viability of farm operations
- enhance quality of life for farmers and society as a whole.

Criteria of sustainability:

- **Ecologically sound:** Which means that quality of natural resources is maintained and the viability of the entire agro-ecosystem from human beings, crops and animals to soil organisms is enhanced. This is the best ensured when the soil is managed and the health of crops, animals and people is maintained through biological processes.

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- **Economically viable:** Which means that the farmers can produce enough for self sufficient income and gain sufficient returns? Economic viability is measured not only in terms of direct produce but also in terms of functions such as conserving resources and minimizing risks also.
- **Socially just:** Which means that the resources and power are distributed in such a way that the basic needs of all members of society are met and their rights to land use, adequate capital, and technical assistance are assured. All people should have opportunity to participate in the decision making.
- **Humane:** Which means that all forms of life (plant, animal, human) are respected? The cultural and spiritual integrity of the society is preserved.
- **Adaptable:** Which means that the rural communities are capable of adjusting to constantly changing conditions for farming, population growth, national policies and market fluctuations?

Approaches to sustainable agriculture:

Various approaches are being advocated to achieve sustainable agriculture systems. True approaches to sustainable agriculture systems emphasize a number of practices including soil and water resource conservation, conservation tillage, soil fertility management, efficient crops and cropping systems, integrated disease and pest managements and other agronomic manipulations.

1) **LEISA (Low External Input Sustainable Agriculture) or LISA (Low Input Sustainable Agriculture):**

While sustainable agriculture is based on long term goals but not a specific set of farming practices, it is usually accompanied by a reduction of purchased inputs in favour of managing on-farm resources. A good example is reliance on biologically-fixed nitrogen fertilizers. Low-input agriculture is one of several alternative farming systems whose methods are adaptable to sustainable agriculture.

The term low-input agriculture has been defined as a production activity that uses synthetic fertilzers or pesticides below rates commonly recommended by the Extension Service. It does not mean elimination of these materials. Yields are maintained through greater emphasis on cultural practices, IPM, and utilization of on-farm resources and management.

LEISA refers to those forms of agriculture that;

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- Seek to optimize the use of locally available resources by combining the different components of the farm system, i.e., plants, animals, soil, water, climate and people, so that they complement each other and have the greatest possible synergetic effects;

- Seek ways of using external inputs only to the extent that they are needed to provide elements that are deficient in the ecosystem and to enhance available biological, physical and human resources. In using external inputs, attention is given mainly to maximum recycling and minimum detrimental impact on the environment.

2) Conservation Agriculture:

Conservation agriculture is "a management system that maintains a soil cover through surface retention of crop residues with no till/zero and reduced tillage".

Principles of Conservation Agriculture:

1. **Minimal soil disturbance:** Direct seeding or Planting (as much as possible avoiding turning of the soil surface in order to allow natural processes to build soil structure)
2. **Soil cover:** Permanent soil cover, especially by crop residues and cover crops to reduce erosion and build soil organic matter
3. **Crop rotation:** The rotation should involve at least three different crops.

3) Alternate Land Use System: A pattern of land use that is different from the existing or conventional can be described as an alternate land use system (ALUS). The term ALUS is applicable to all classes of land to generate assured income with minimum risk through efficient use of available resources. The lands which are degraded to very low productive levels are not only **uneconomical** for arable crops but also **causing serious imbalance** in the ecosystem. An ALUS must increase the development and adaption of agricultural practices that are ecofriendly, economically sound and socially supportable.

Types of Alternate land use system (ALUS)

- **Agro-forestry:** It has been defined as sustainable land management system which increases yield of land combines production of crops, forest plants and/or livestock together simultaneously or sequentially on the same piece of land and applies management practices that are compatible with the cultural practices of local population."

Classification of Agro-forestry

- Agri-silviculture

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- Silvipasture
- Agri-horticulture
- Alley cropping
- Agri-silvi-pastoral system
- Horti/silvi-pastoral system
- Silviculture
- Apiculture with trees
- Agrisilviaquaculture

- **Tree farming:** Trees can flourish and yield abundantly where arable crops are not profitable. A no. of multipurpose tree systems (MPTS) has been tested for their suitability and profitability under different situations.
- **Ley farming:** This system involves rotation of legume forages with cereals. A rotation system which includes pasture (ley) for grazing and conservation is called alternate husbandry or mixed farming. Such a system aids in soil conservation besides improving soil fertility.

4) Biodynamic farming:

Biodynamic farming was spawned by the late anthropologist, Rudolf Steiner and has grown and developed since 1922. The term biodynamic is taken from the Greek words bio meaning life and dynamic meaning energy. Hence, biodynamic farming refers to "working with the energies which create and maintain life".

In a nutshell, biodynamic can be understood as a combination of "biological and dynamic" agriculture practices. "Biological" practices include a series of well-known organic farming techniques that improve soil health. "Dynamic" practices are intended to influence biological as well as metaphysical aspects of the farm (such as increasing vital life force), or to adapt the farm to natural rhythms (such as planting seeds during certain lunar phases).

The Biodynamic Preparations:

The original biodynamic (BD) preparations are numbered 500−508. The BD 500 preparation (horn-manure) is made from cow manure (fermented in a cow horn that is buried in the soil for six months through autumn and winter) and is used as a soil spray to stimulate root growth and humus formation. The BD 501 preparation (horn-silica) is made from powdered quartz (packed inside a cow horn and buried in the soil for six months through

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spring and summer) and applied as a foliar spray to stimulate and regulate growth. The next six preparations, BD 502−507, are used in making compost.

The BD compost preparations are listed below:

- No. 502 Yarrow blossoms (Achilleamillefolium)
- No. 503 Chamomile blossoms (Chamomillaofficinalis)
- No. 504 Stinging nettle (whole plant in full bloom) (Urticadioca)
- No. 505 Oak bark (Quercusrobur)
- No. 506 Dandelion flowers (Taraxacumofficinale)
- No. 507 Valerian flowers (Valerianaofficinalis)

Finally, there is BD preparation 508 which is prepared from the silica-rich horsetail plant (Equisetum arvense) and used as a foliar spray to suppress fungal diseases in plants.

5) Organic farming:

Organic farming is basically a holistic management system, which promotes and improves the health of the agro-ecosystem related to biodiversity, nutrient bio cycles, soil microbial and biochemical activities. Organic and bio-dynamic farming emphasizes management practices involving substantial use of organic manures, green manuring, organic pest management practices and so on. It has also come to mean that it is a system of farming that prohibits the use of artificial fertilizers and synthetic pesticides.

The British botanist Sir Albert Howard is often referred to as the father of modern organic agriculture. The term organic farming was coined by Lord North Bourne in his book *Look to the Land (written in 1939, published 1940). From his* conception of "the farm as organism," he described a holistic, ecologically balanced approach to farming.

Organic farming is a production system, which avoids or largely excludes the use of synthetic organic fertilizers, pesticides, growth regulators and livestock feed additives (USDA 1980).

Organic farming system largely depends on crop rotations, crop residues, animal manures, green manures, off-farm organic wastes, mechanical cultivation, mineral bearing rocks and aspects of biological control to maintain soil productivity, supply plant nutrients and to control insects, pathogens and weeds.

Principles of organic farming:

1) Principle of health:

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Organic Agriculture should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible. Healthy soils produce healthy crops that foster the health of animals and people.

2) Principle of ecology:

Organic Agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them.This principle roots organic agriculture within living ecological systems.It states that production is to be based on ecological processes, and recycling. Organic management must be adapted to local conditions, ecology, culture and scale.

3) Principle of fairness:

Organic Agriculture should build on relationshipsthat ensure fairness with regard to the common environment and life opportunities. This principle emphasizes that those involved in organic agriculture should conduct human relationships in a manner that ensures fairness at all levels and to all parties - farmers, workers, processors, distributors, traders and consumers.

4) Principle of care:

Organic Agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment. This principle states that precaution and responsibility are the key concerns in management, development and technology choices in organic agriculture.

6) Crop residue and its recycling:

The crop residue is the material left after the harvesting of crop and by-product of agriculture based industry. Two types of residue:

- **Field residues:** Field residue are materials left in an agricultural field or orchard after the crop has been harvested. These residues include stalks and stubble (stems), leaves and seed pods.
- **Process residues:** Process residues are those materials left after the processing of the crop into a usable resource. These residues include husks, seeds, bagasse and roots. They can be used as animal fodder and manufacture of organic manure *viz*. vermicompost.

Recyclable resources:

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Agricultural residues	Crop residues like wheat straw, rice straw, sugarcane trash etc. Forest litter and aquatic weeds like water hyacinth
Livestock wastes	Cattle waste, poultry waste, piggery waste, goat and sheep excreta
Agro industry waste	Oil cakes, by products of sugar industry, vegetable and fruit processing wastes.
Municipal solid wastes	House wastes, market wastes etc.
Industrial wastes	Tannery, textile, distillery and paper mill effluents, wastes from mineral processing, fly ash etc.

Uses

- Traditionally crop residues have numerous competing uses such as animal feed, fodder, fuel, roof thatching, packaging and composting.
- Cereal residues are mainly used as cattle feed. Rice straw and husk is used as domestic fuel.
- The uses for various residues are different in different states. Farmers use residue either themselves or sell it to other landless households or intermediaries, who in turn sell the residues to industries.
- Sugarcane tops in most of the areas is either used for feeding of dairy animals or burned in field for ratoon crop.
- Cotton, pulses, Coconut shell, stalks of rapeseed and mustard, jute and sun flower are used as domestic fuel.
- Coconut generates about 3 mt of husk annually and about 1.2 mt is utilized for making coir and 1 mt burned as fuel.

5) Natural farming:

Beginning to doubt the wisdom of modern agricultural science, microbiologist, farmer and phi- losopher Masanobu Fukuoka, born in 1913 in Japan, looked for alternatives. Around 1940 he worked out an answer, which aims at the reestablishment of the natural ecosystem. It is based on the insight that nature is intrinsically in harmony with itself as long as there is no interference of man. Known as natural farming, it is also referred to as Fukuoka method or, in India, as Rishi Kheti meaning agriculture adopted by the sages.

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The concept aims at reproducing natural conditions that improve soil productivity and growth of plants. It surprises perhaps most because of its simplicity. It does not entail entirely new or innovative methods of growing. It disagrees with the general dictums of modern agricultural science. And it says that if you want to grow crops and vegetables in harmony with nature what you actually need is very, very little.

- **No pesticides:** Natural farming is opposed to the use of pesticides. Apart from killing insects and other organisms, pesticides enter the soil and fruit and cause serious health problems when absorbed by humans.
- **No herbicides:** In this method, weeds are used rather than killed. Wild growing grass such as rye and clover are grown for mulching. Natural farm orchards are green with grass growing between the trees. The grass prevents soil erosion, holds moisture, propagates microorganisms, produces organic fertilizer, improves soil ventilation and suppresses pests.
- **No fungicides:** Natural farming recognizes that indigenous microorganisms and fungi are an integral part of the ecosystem. They have an important role to play and hence, instead of eliminating them, they need to be respected and protected.
- **No tillage:** Land is not being ploughed. Instead, earthworms and small animals dig through the soil if they are not disturbed. And while mechanized ploughs drawn by tractors can plough up to 20 cm deep, fragile tiny earthworms dig a surprising 7 meters deep. The key to their services is to allow them towork by not interfering with them. The excretions of earthworms turn into the best soil. Because of the absence of tillage the grass seeds in the soil do not come up to the surface as they germinate and die. There are less weed problems than on tilled land.
- **No chemical fertilizers:** Nitrogen, phosphorous, potassium, calcium and other common elements of chemical fertilizers are substituted with inputs from exclusively natural sources. For instance, fish amino acid provides nitrogen, eggshells supply calcium and animal bones provide phosphoric acid. These inputs are not only cheap but highly effective.

Natural farming takes into account the nutritive cycle and identifies the growth stages of plants and animals. Fertilizers, soil improvers, pest controls, disease cures – all made by

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the farmers using natural materials – are supplied as and when needed. Farmers make what they need with ingredients available in nature. Nothing needs to be bought.

Future thrusts:

For future, policies need to be addressed, the following reorientations (based on papers presented for vision 2000 World Conference on Food, Agriculture and Environment held at International Food Policy Resource Institute, Washington DC during June, 1995) are suggested:

1. Invest more in research and extension and increase farmer input and feedback into technology generation and the dissemination process.
2. Shift fertilizer policy from an emphasis on increasing the level of use to improving efficiency of nutrient balance and timing and placement of fertilizer.
3. Shift crop protection policy from dissemination of chemical pesticides to use of integrated pest management.
4. Shift emphasis in irrigation policy from investment in new system to improvement of water-use efficiency and productivity in existing systems.
5. Adopt appropriate economic incentives through price policies that keep domestic prices in line with long-term price trends.
6. Reform trade and microeconomic policy regimes that penalize agriculture to stimulate production by improving short-term input-use-efficiency and encourage long-term investment and technology change in the agriculture sector.

Conclusion:

Sustainable agriculture is possible and is already being practiced successfully in many places around the globe. It has the potential to boost yields and feed the world's growing populations for a century or more without destroying the resources we need for our survival. Rising awareness of sustainability among policy-makers, entrepreneurs and consumers is essential if sustainable agriculture is to be implemented in both developed and developing countries. Moreover, the required knowledge must be shared with farmers and the right framework conditions must be in place. Policy-makers must commit to sustainable agricultural development, associations and civil society must be strengthened, and markets and market access must exist. All of these things are feasible if there is the will to act.

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