SUSTAINABLE AGRICULTURE

Publications of the Author:

- Modern Physics 1972
- Our Environment 1994

SUSTAINABLE AGRICULTURE

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Foreword

Conventional Agriculture covering food production has been the main stay of the peasantry which constitutes the larger majority of the population. Until the early 1960s paddy cultivation which was the major pre-occupation of the peasant farmer remained low yielding with low external inputs at subsistence level. The agricultural practices based on tradition remained sustainable with minimum or marginal interference with nature. In the '60s decade market oriented paddy production and other field crops were encouraged with high yielding hybrid seed varieties utilizing external inputs including chemical fertilizer as well as pesticides. It enabled high yields to be obtained which in turn was expected to deliver the farmers from abject poverty to higher income levels.

The continuous use of chemicals to obtain high yields had its adverse impacts on both the natural environment as well as the economy of the farmer in the medium term. The shift from Low External Input and Sustainable Agriculture (LEISA) to High External Input Agriculture (HEIA) was proved to be neither sustainable nor high income yielding in the longer term. It is in this context that attention was focused on the need for LEISA generating higher yields. Towards this, Integrated Pest Management (IPM) practices and use of organic manure replacing or minimizing the use of chemical fertilizer came to be experimented with from around mid 1980's.

In Mahaweli System 'C' LEISA was introduced and popularized from around mid 1990's by the project known as Promoting Multi-functional Household Environment (PMHE) where Mr. D.B. Rambodagedera functioned as the Agronomist. It was a pilot project which the Mahaweli Authority encouraged during my period of service as its Director General. It is with great pleasure that I note that Mr. Rambodagedera has decided to document his experiences gained from participation in this Project. The PMHE interventions covered a range of activities conducive for LEISA with Participatory Decision Making at grass root level and Institutional Development among farmers through Institution building interventions strengthening Framer Organization elevating them from mere water management focused organizations to cover the broader range of activities of the farmer and his life.

While congratulating Mr. Rambodagedera for documenting his experiences in regard to Sustainable Agriculture, I look forward to a similar documentation from him on his experience in capacity building of Farmer Organizations to transform them into organizations with wider perspectives.

S.W.K.J. Samaranayake
Executive Director
18th August 2006 Institute for Participatory Interaction in Development (IPID)

INTRODUCTION

This book is about Low-External Inputs and Sustainable Agriculture (LEISA). It is included the technical, social and economic options open to farmers who seeks to improve productivity and income in a ecologically friendly way. Low-External Inputs and Sustainable Agricultural principals teach us the optimal use of local resources and natural processes and if necessary the safe and efficient use of external inputs such as chemical fertilizer and artificial pesticides. One of the objectives of writing this book is to empower the farmers by using participatory methodologies to strengthen their capacities to improve Agricultural practices. LEISA seeks to combine indigenous and scientific knowledge and to influence formulation of plans conducive for its future development.

Appropriate and desired plans to achieve sustainability while maintaining productivity at optimum level based on personal preferences are essential for farmers to get self satisfaction and socio-economic benefits. The role of extensionists, researchers and trainers is to facilitate the farmers to improve productivity and farm income, through reducing dependency on external inputs and increasing use of local available resources.

We anticipate that it is timely to prepare a guideline on sustainable farm planning for extensionists and trainers for planning and implementing their programmes using participatory approaches. This guideline is written to fulfill this purpose.

Ancient man had received all his living needs from the forest and led an independent and healthy life. His needs increased with the advancement of civilization and to satisfy the food requirement he started cultivating. Thereafter, throughout the generations, agriculture based on his knowledge and experience continued uninterrupted.

I offer my heartfelt thanks to the National Science Foundation for selecting this book on **"Sustainable Agriculture"** for publication. I am grateful to Mr. Jayatissa Samaranayake, the Executive Director of the Institute for Participatory Interaction in Development (IPID) for writing a valuable Foreword for this book. I wish to place on record my deep gratitude to Ms. Ganga Kaluarachchi, Ms. Iresha Fernando and my daughters Anuradha, Malathie and Senani for the very great help gave me in the compilation of this book.

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18th August 2006

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1.0 THE ORIGIN OF AGRICULTURE

Agriculture can be defined as follows:

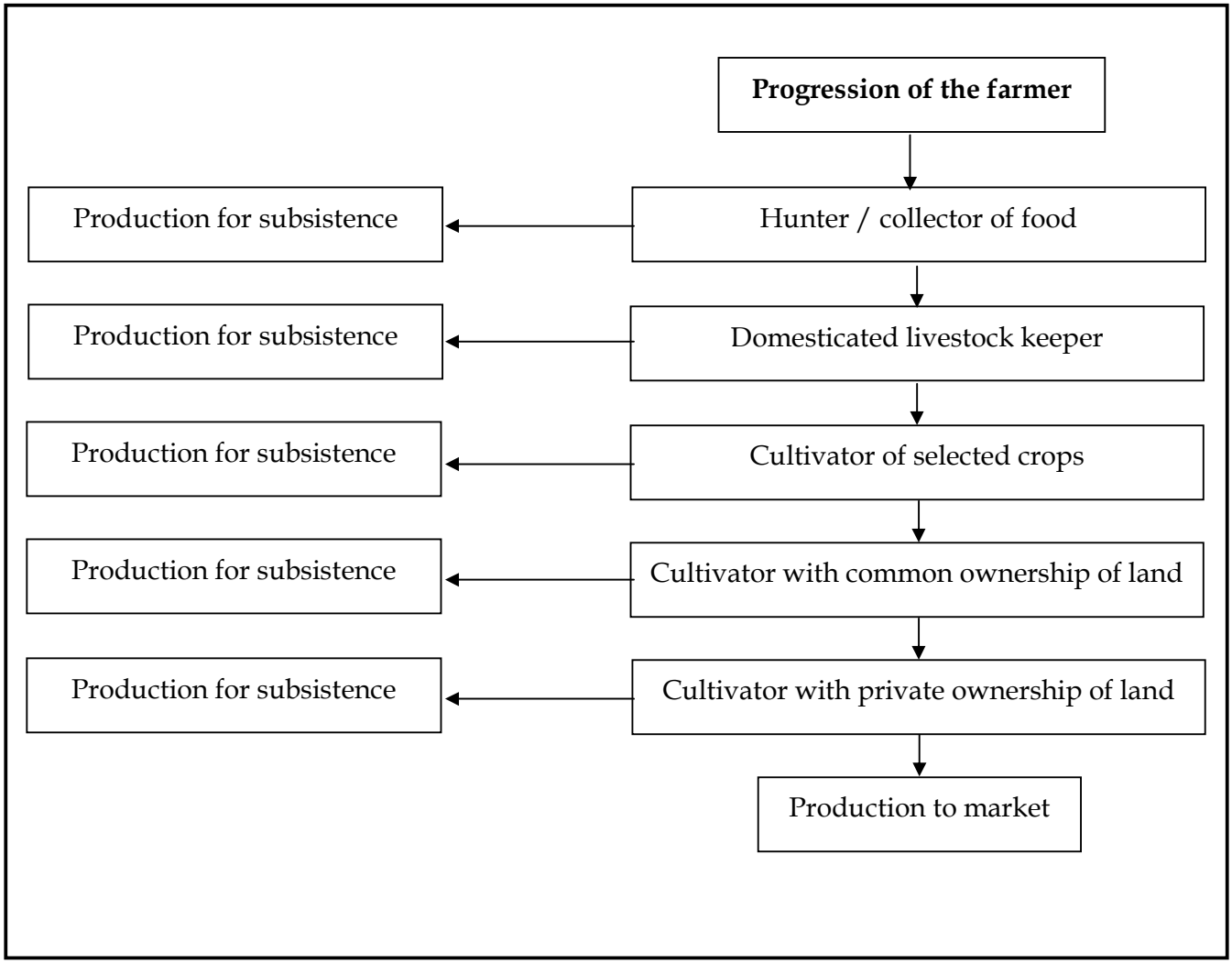
- Science of utilization of lands to fulfil basic human needs
- Science of cultivation of crops and rearing of selected animals for subsistence and markets

Primeval man who lived in jungles as a hunter and a collector of food was highly susceptible to his environment. Therefore he could exist in his bio community successfully facing the challenges in his environmental system although he was relatively not strong. In this situation what was specially beneficial for him was his organizational capabilities, superior intelligent and the skills in the decision making process.

Along with the civilization of the man, the division of labour took place. Those who were engaged in vocations such as production of weapon, weaving of cloth and molding of pots were not required to possess knowledge about the environment. Knowledge about environment was required for those who were engaged in agriculture. The most important environmental success achieved by man was the domestication of selected animals and crops. In this domestication process, it was expected that increase in production, would save time and effort and minimize the risk in subsistence. The agricultural history of about ten thousand years has considerably changed the life style of the man. He built permanent dwellings, organized for needs and turned to trade. He felt the need of an environmental knowledge with an integration of plants and animals.

With the commencement of formal agricultural activities there were radical changes in the utilization of lands in different parts of the world. Settlements were started with the commencement of agricultural activities, in the fertile valleys of Indus, Euphrates, Tygris, Nile etc. The jungles were cleared and turned out to be agricultural farms. Opening up of grass lands for sustenance of selected animals caused massive transformation of environment.

Box I


Progression of the farmer
Hunter / collector of food
Domesticated livestock keeper
Cultivator of selected crops
Cultivator with common ownership of land
Cultivator with private ownership of land
Production to market
Production for subsistence
Production for subsistence
Production for subsistence
Production for subsistence
Production for subsistence

2.0 TRADITIONAL AGRICULTURE

As a result of advancement of civilization and evacuation of the man from the jungle, he entered the farming age. He gradually adopted farming methods using the traditional knowledge gained through generations and observing his environment. The man who made his livelihood by collecting food from the jungle commenced a systematic cultivation of crops and rearing of animals. As the time passed, the man had to face problems with regards to cultivating fruits, vegetables, grains etc. He learnt by making mistakes and using traditional knowledge on how to do prepare the land adequately, perceiving fertility of the soil, controlling pests and diseases of different crops and managing crops providing suitable spaces. The knowledge gained through experience was transferred from generation to generation. The information generated by man using the traditional knowledge and the new knowledge gained through experience had disseminated during several thousand years.

When man realized that the land he cultivated had become unfertile after several years of repeated cultivation of mono crop, he shifted his farm to a new land. Such shifting was possible as the lands were available in abundance for cultivation. This process was the origin of chena cultivation.

The major patterns of traditional agriculture were:

1. Chena or shifting cultivation
2. Forest gardens
3. Low land cultivation (paddy cultivation)

2.1 Chena Cultivation (shifting cultivation)

The traditional chena cultivation in Sri Lanka as an agricultural practice has a long historical background. In many other countries in the world this type of rotational agricultural systems still exist. Chena cultivation is a method of land utilization by allowing the land to exist as forests for a long period of time and subsequently converting it into agricultural land for a short period. This land use pattern was regularly rotated. A plot of land, which is slashed, cleared, burnt and cultivated, is called a chena. The ash resulted in burning trees in a chena is used as a manure to enrich the soil. Only the planting material including seeds are brought from out side to establish a chena. During the first and second season the productivity level of a chena is at peak but gradually productivity reduces due to high uptake of nutrients by crops. The soil is not enriched by recycling of resources. Therefore the chena system becomes unstable after one or two seasons. In chena which was cultivated during several seasons the productivity diminishes and a variety of pest and

diseases invade the system. This type of situation is an alarming signal to abandon the land. The farmer then tends to move to another plot of land in the forest to establish a new chena.

It was tradition to abandon the land used as a chena until it becomes a part of the forest again. When the land is a part of the natural forest the farmers consider converting it to a chena again.

If a crop rotation system was practiced in a chena the problem of nutrient deficiency could be solved to a certain extent. In chena, like in other agricultural system the requirement of nutrient by various crops is different. If a farmer cultivate the same crop in a chena repeatedly it will result in nutrient deficiencies and consequently the system become unstable for cultivation. Even though the farmers used their traditional knowledge in chena cultivation it was not a sustainable agricultural system due to the following reasons.

- Continuos removal of nutrient takes place without adding any nutrients to the soil. The recycling process was not sufficient to give back adequate nutrients
- Bio-diversity was restricted as a result of cultivating only a few selected crops
- Animal husbandry was not integrated with chena cultivation
- Measures were not taken to conserve resources like, moisture and soil, resulting wastage of many resources in different ways
- Inability to maintain the liveliness of the soil, due to direct exposure to wind, rain, and sunlight

2.2 Forest Gardens

Particularly the traditional home gardens in the wet zone are examples for forest gardens. Mostly the perennial crops are cultivated in these gardens. Fruits, timber, firewood, economic crops like tea, rubber, coconuts, vegetables, and medicinal crops are cultivated in forest gardens. In most instances animal husbandry is also integrated in the system. The socio-economic researches carried out in forest gardens have revealed that there are hundreds of plants specie in a forest garden. Due to this, higher degree of Bio-diversity existing in the system while close interaction between plants/ plants, plants / animals, animals/animals help to stabilize the system. A large quantity of Bio-mass continuously adds to the surface increasing the humus content of the soil. The humus enriches the soil with nutrient by activating soil Micro-organisms to ensure higher level of productivity and sustainability. The forest gardens are analogous to natural forest in many aspects. There is an efficient resource management in traditional forest gardens.

2.3 Low Land Cultivation

Traditional farmers were able to achieve self sufficiency in food production to a great extent. Production was at subsistence level and it was diversified to assure balance diets for the family. The uplands were used for chena cultivation and garden crops while lowlands were utilized mainly for paddy cultivation. A network of reservoirs was constructed to provide supplementary irrigation facilities during the dry season. Many techniques of traditional knowledge were used to conserve resources.

They made terraces to arrest the erosion soil. Kitchen waste, animal waste, green manure and plant residues were added continuously to upgrade the soil in the lowlands in order to keep the productivity at optimum level. The traditional farmers did not use artificial fertilizer and pesticides in farming. They had adequate managerial capacity to maintain these farms as sustainable units.

Traditional agriculture which was carried out purely for subsistence had to face problems with the population explosion. Steps had to be taken to increase production and to bring more lands under cultivation. The chena cultivators were compelled to reduce interval between cultivation seasons. These factors affected adversely on the sustainability of traditional agriculture. Apart from Sri Lanka many developing countries had to face this situation.

Foreign intervention too affected the changes in traditional agricultural practices. Tea, rubber, coconut, cinnamon, coffee and cocoa were introduced as mono-crops to fields which were under multiple crops over a long period of time. In large extent of lands where mono-crops had been cultivated natural recycling process was restricted and the eco-system became unstable. In order to keep the productivity of these lands at optimum level the cultivators had to use chemical fertilizer and artificial pesticides extensively as external resources. Subsequently new plantation crops spread even to traditional home gardens in the wet zone. A large area of forest also cleared and converted into large-scale plantations resulting an inflow of some peasant labour to the plantation sector.

2.4 Case Study

The farmers of Sarugama village were traditional chena cultivators. Lands cultivated once were abandoned for natural regeneration and subsequent enrichment of soil and sustainability of the system. As there were plenty of lands for cultivation this type of land use were practicable. But with the increase of population pressure access to fertile land was a problem for chena cultivators. They were compelled to violate the traditions enforced by traditional agricultural practices.

The fundamental principle of traditional agriculture was to provide a fallow period to lands, which were cultivated in one or two seasons due to population pressure. This fallow period was shortened and the growers turned to cultivate the same piece of land repeatedly. This situation was aggravated with the time due to pollution pressure. With a view to solving this problem there was a tendency towards clearing the natural forest for cultivating them to agricultural fields.

Consequently the evergreen forest became pasture land and shrub jungles. The medicinal plants required by men were scared. Rainfall pattern was changed due to reduction of forest cover. The cultivators faced the problem of selecting the suitable time period for cultivation as the weather pattern was changed. The rivers and natural water streams were drying.

One day a village leader who had tolerated this calamity for a long period exclaimed impatiently.

“The sun is hotter than what it was in 20 years ago. Rains are not coming as usual. The occasional rains accompanied by heavy winds take away even the roof of our houses. The merciless winds had removed the topsoil of our lands. Only the rocks and furrows are remaining now. The god destroyed us. If immediate and effective measures are not taken our grand children will face extinction. What shall we do to overcome this calamity ?”

What do you propose for villagers in Sarugama to do to regain prosperity and sustainability?.

3.0 HIGH EXTERNAL INPUT AGRICULTURE (HEIA)

The basic aspect of conventional agriculture was to maintain subsistence level production by using locally available resources. All resources had been naturally recycled and reused without wasting. But due to pressure of increasing population in developing countries steps were taken to expedite food production deviating from the traditional pattern.

The pressure of world population explosion exerted more on the people of developing countries. In order to confront the pressure of world population explosion the farmers as well as the Researchers and Extensionists were compelled to join the "Seed – Manure" revolution born with the label "Green Revolution" The aim of this "Revolution" was to provide food for the increasing population by enhancing the harvest per unit and the intensification of the number of cultivation seasons. The "Green Revolution" introduced during the early part of the 6^{th} decade of the 20^{th} century accelerated food production of Sri Lanka.

The cropping intensity is defined on the basis of number of cultivations per year. If a land is cultivated 2 times a year (Yala and Maha seasons) the cropping intensity is 200%. If it is cultivated only in one season the cropping intensity is 100%. In response to the "Green Revolution practices, introduced in late 1960s our agricultural production increased significantly.

High yielding hybrid seeds which were introduced by Green Revolution were new to our environment. The growers had to practice new techniques to get higher production. Due to the fact that hybrid seeds were more sensitive to nutrients the growers were encouraged to use chemical fertilizer in large qualities as external inputs. As the new crops were foreign to the environment they were susceptible to pests and diseases. Consequently the necessity arose to apply chemicals, which became an additional burden to growers. Application of chemical fertilizer and pesticides increased the cost of production.

The hybrid varieties were dwarf in nature and could not compete with weeds Application of weedicides or manual weeding was essential to mitigate the competition between hybrid varieties and weeds. From land preparation to harvesting all agricultural practices, related to hybrid varieties were more labour intensive.

Mechanization was an integral component of Green Revolution. To increase the working efficiency of the production system machinery like tractors have been introduced. These machines required mineral fuel. The water consumption of new crops was also higher. Therefore it was necessary to improve irrigation facilities. The external resources were used

extensively in this agricultural system many of the resources used in High external input Agriculture were not recycled. This system failed to add anything to enrich the soil. Many resources were wasted and were beyond the control of the growers.

As Long as external resources are pumped into the system the hybrid varieties gave maximum yields. Once the provision of resource is stopped the system collapsed and became unproductive. Therefore to maintain long term sustainability of the systems regular application of external inputs was essential.

3.1 The advantages of High External Input Agriculture (HEIA)

- Agricultural Production could be rapidly increased to meet the demand for food for the increasing population.
- As a result of availability of adequate food stuffs many problems related to diseases caused by mal-nutrition and deficiency were prevented or reduced.
- New improved varieties gave yields within a short period of time.
- Mechanization solves the problem of Labour shortage.
- Income and profit margins of the products were increased
- Productivity of land increased.
- Increased market facilities for production.

Disadvantages of (HEIA)

- Collapse of environmental balance due to lack of biodiversity by planting a few cash crops.
- Increase in soil erosion due to constant furrowing by machinery.
- Dependence on imported machinery, chemical fertilizer, pesticides, hybrid seeds and other inputs.
- Extensive use of pesticides disturbed the natural mechanism of controlling pest and diseases as the artificial pesticides kill both pests and their natural enemies.
- Use of artificial agro-chemicals adverseyl affected the soil P^H , cation exchange capacity, soil structure, soil texture and soil organisms. Consequently the microbial activities of the soil tend to reduce forming dead soil.
- Although the need for high capital investment, the large scale farmers benefited while small scale farmers who were short of capital ran into debt.
- Neglecting environmenta friendly traditional varieties of seeds and their genetic resources faced extinction due to introduction of hybrid varieties. Conventional agricultural knowledge and techniques were neglected and extinguished.
- The farmers in developing countries had to encounter a series of environmental, social economic and political problems as a result of the use of High External Input

Agricultural practices. The following case study taken from an Indian experience illustrates the problems faced by farmers who practiced high external input Agriculture.

Box I

As a result of mechanization, use of new improved seed varieties and provision of irrigation. Water, the Agricultural production in Panjab pradesh of India increased tremendously. Simultaneously many Problems cropped up. Frequent irrigation facilities had to be provided to the new improved varieties of crops due to their inability to withstand shortage of water. The farmers pumped water from agricultural wells. Excess pumping of water caused lowering of ground water table. Consequent upon frequent puddling of soil an impenetrable layers adjacent to the surfaces was formed and prevented sucking of water and nutrients.

Due to this restriction the farmers had to use more chemical fertilizer on this soil surface Subsequently inbalance of nutrients and deficiencies of micro nutrients in the soil became a problem, excessive use of pesticides for plant protection caused contamination of food and plant residues threatening the health of human and animal lives.

Although the production had increased rapidly the demand for excess agricultural production in the market had not commensurately increased. The growers encountered with the problems in selling of their products and at the same time prices of food items were reduced.

As explained in this case study it could be stated that the developing countries had not reached at sagacious decisions before the introduction of the Green Revolution into these countries.

The possible problems of the farmers which would come out in future were not anticipated in planning.

The following are some of the short comings of the Green Revolution.

- Failure to foresee the fall of prices of surplus agricultural commodities due to the increase in production caused by the use of chemical fertilizer, fuel, pesticides, hybrid seeds etc., which were costly.
- Failure to realize long term dependency of the farmers on pesticides and chemical fertilizer and the consequent effect on ecology and human life.

- Quick response for growth and production and relatively lesser quantities required for one application promoted farmers to apply artificial manure. But the farmers were not aware of long terms consequences of chemical fertilizer.
- The efficiency of chemical fertilizer was below the expected level. It is found that 40% - 50% of Nitrogen in the chemical fertilizer applied in the tropical countries is wasted. This wastage further aggravates due to factors such as high rainfall, severe droughts, soil erosion and low content of organic matter in the soil.
- The chemical fertilizer directly affects on the nutrient balance and the biological activities of the soil. It disturbs the soil structure and expedites decomposition of soil organic matter. Application of acidic Nitrogen fertilizer like Ammonium Sulphate decreases the soil PH value and reduces the ability to use phosphorus by plants.
- Continuous application of Nitrogen, phosphorus and potassium fertilizer creates micro nutrients deficiencies in the soil. The plant display deficiencies of Zinc, Iron, Copper, Magnesium, Manganese, Molybdenum and Boron. The reasons for this is the barrier imposed by chemical fertilizer for micro nutrients to enter into the soil. This situation results in the reduction of crop production and susceptibility to pests and diseases.

  In addition as a result of using chemical fertilizer the developed and developing countries face global problems. The Nitrous oxide gas emitted enters into the atmosphere. Nitrous oxide gas so entered into the atmosphere adversely affects the ozone layer and the Green House effect.

Pesticides

The role of pesticides is killing and controlling plants and animal pests and pathogens. It is reported that in the year 1985 about 2300 Million Kgs of pesticides had been used all over the world. About 15% of this quantity was used by developing countries. Even though pesticides had immensely helped to sustain the High External Input Agriculture, the following adverse consequences could be observed.

- Annually a large portion of the world population becomes victims of pesticide poisoning. A major portion of them are in the third world countries.
- Some pests build up resistance to pesticides when the same pesticide is continuously applied. The necessity arises to introduce new pesticides to overcome this problem.
- Pesticides kill not only the targeted pests but also their natural enemies thereby creating biological inbalance in the system.
- Water, air, soil and food are contaminated by pesticides.

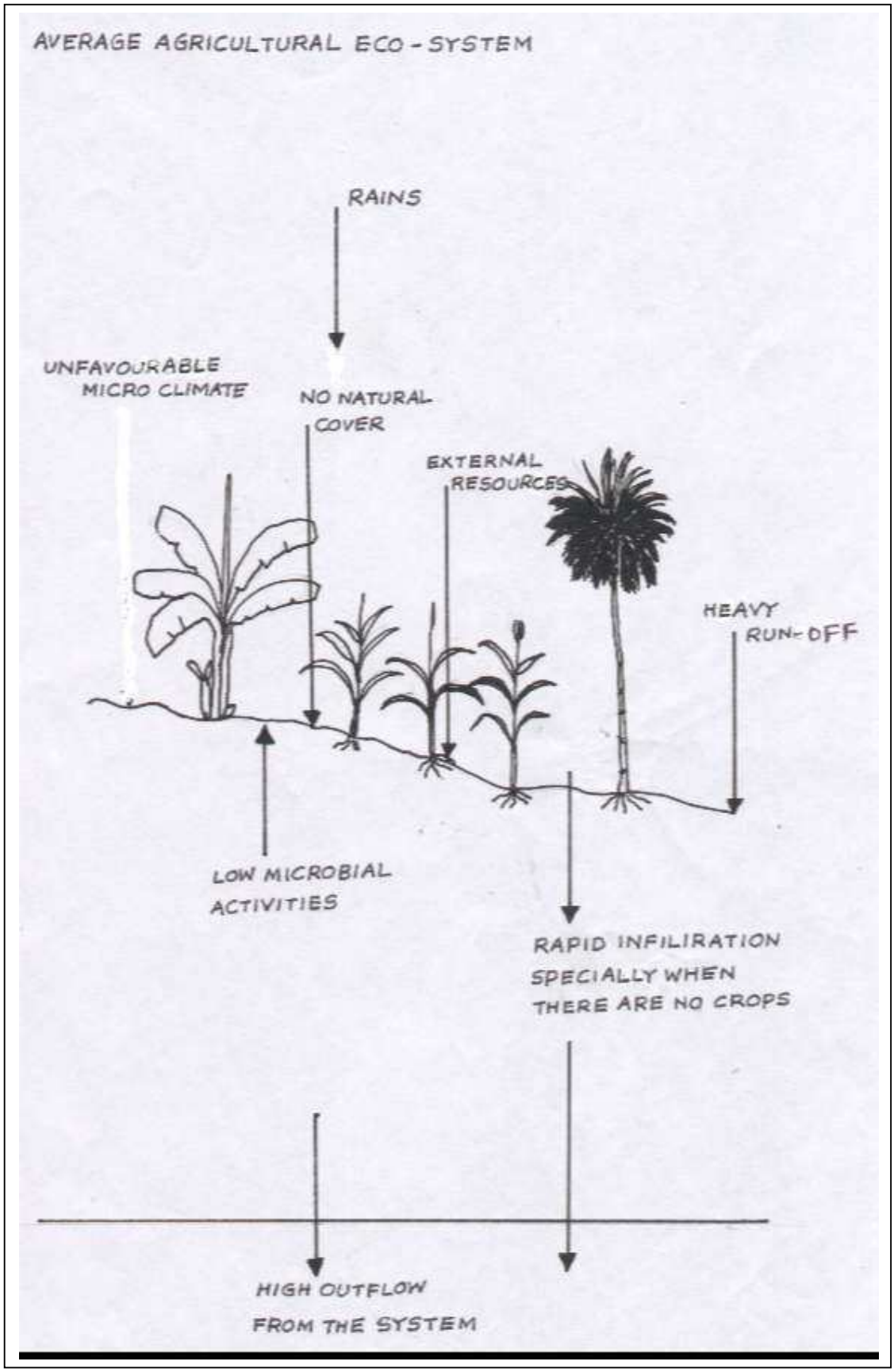
- Pesticides enter into the food chains and food webs causing threat to human lives.

Box 2

During the period 1961 to 1985 the High external input Agriculture has contributed for an increase of 41%, 45% and 70% in respect of paddy, maize and wheat respectively. On the other hand a large extent of agricultural lands are becoming unsuitable for cultivation due to various reasons such as non adoption to appropriate soil conservation measures, soil erosion, by winds, and water, increasing acidity, salinity and alkalinity in the soil, deterioration of organic matter and weakening of soil structure and texture.

At present many advantages gained from High external input agriculture are progressively diminishing and the yield per unit is decreasing. Therefore the farmers, Researchers and Extensionists are compelled to contemplate towards a sustainable agricultural system free of high external inputs.

Figure 1


AVERAGE AGRICULTURAL ECO - SYSTEM
RAINS
UNFAVOURABLE MICRO CLIMATE
NO NATURAL COVER
EXTERNAL RESOURCES
HEAVY RUN-OFF
LOW MICROBIAL ACTIVITIES
RAPID INFILIRATION SPECIALLY WHEN THERE ARE NO CROPS
HIGH OUTFLOW FROM THE SYSTEM

4. 0 SUSTAINABLE AGRICULTURE

The word “Sustainability” is extensively used in the development forum in the modern world. The term “Sustainability” refers to uphold a continuous effort the ability to last and keep from falling. In the context of agriculture sustainability basically refers to the capacity to remain productivity while maintaining the resource base. The Technical Advisory Committee of the consultative group on International Agricultural Research has defined sustainable agriculture as follows:

“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.”

There is no other system that contains sustainability than the natural forest. Sustainability could be clearly understood by concentrating on the behavior of the forest for its existence.

The agricultural systems which fulfills human needs is said to be sustainable if it has the following characteristics.

4.1 Ecologically sound

This connotes that the quality and quantity of natural resources are conserved. In other words the vitality of the entire agro-eco-system, from human, crops and animals to soil organisms is protected and maintained. This is best ensured when resources are efficiently used and conserved through natural biological processes (recycling). Local resources are used in a way that minimizes losses and avoid pollution.

4.2 Economically viable

The farmers should be satisfied with the produce from agricultural operations and the return shall commensurate with the labour and investment. In sustainable agriculture it is not only the feasibility in the increase in production that should be considered but also the conservation of resources and the risk factors.

4.3 Socially justifiable

Opportunities shall exist for utilization of resources to meet the needs of all the members in the society. Technology and market opportunities etc., shall be commonly available to all stakeholders.

4.4 Human Factor

All forms of life such as human, plants and animals shall be treated as important and should be protected. All forms of actions and interactions of living organisms are necessary to keep the sustainability of the agricultural system.

4.5 Adaptability

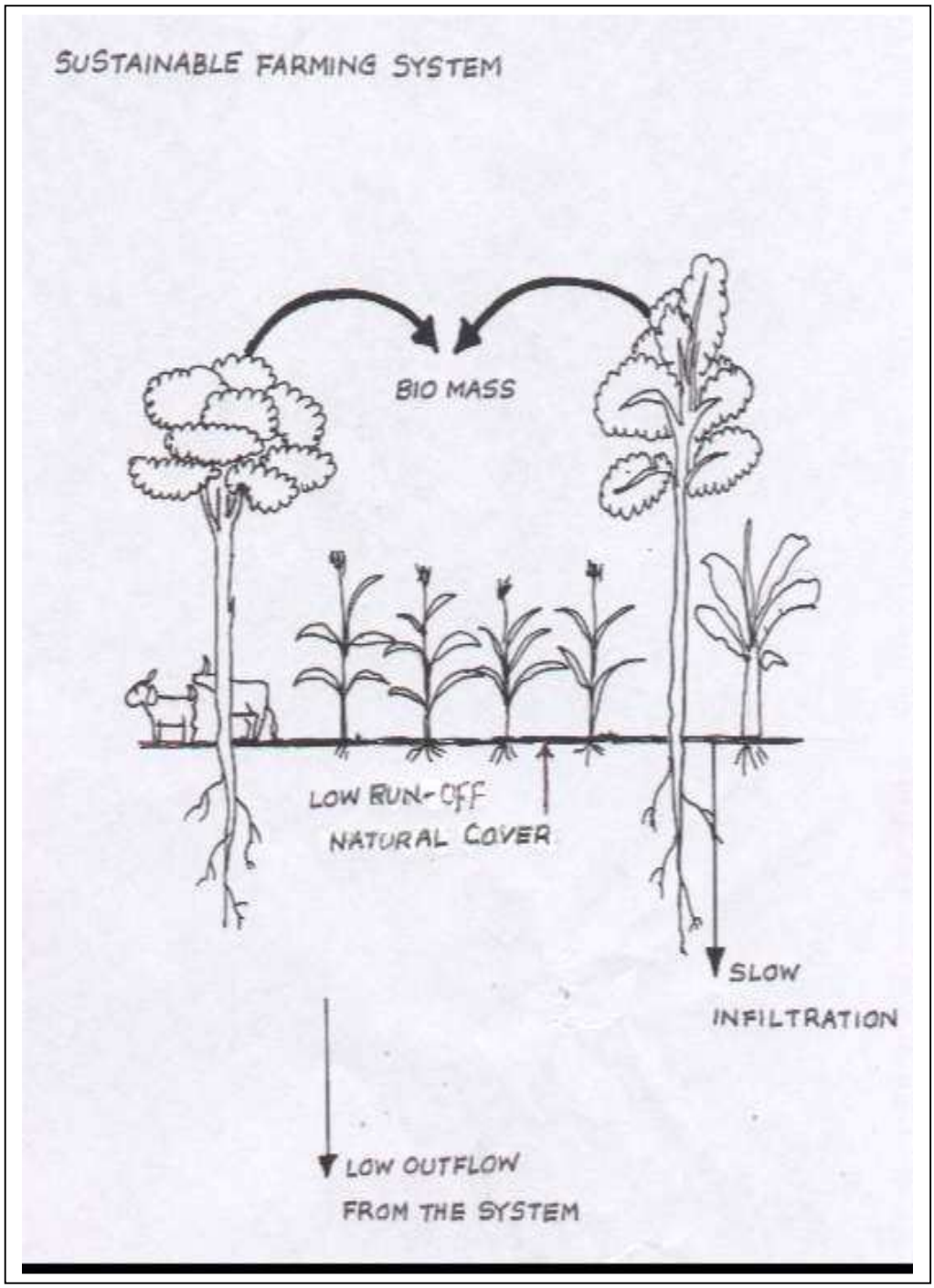
Community engaged in sustainable agriculture shall be competent to adjust themselves to the constantly changing conditions such as growth of population and increase in market demands.

The environmental problems of developing countries are largely due to over exposition of lands to sunlight, rains and winds, continuous extension of cropping and deforestation. There is no possibility of maintaining sustainable production due to reasons such as increase in salinity in vast extents of lands cultivated with irrigation. Increased use of pesticides has resulted in decreasing population of natural enemies of serious pests and creating biological in balance of the environment. A large area of cropping lands has become unsuitable for cultivation due to excessive use of chemical fertilizer.

Inadequate organic matter alarmingly diminishes the humus content in the soil. This results in susceptibility of easy soil erosion caused by winds and rain. Pumping under ground water for lift irrigation has created problems in several parts of the world. The excessive water uptake has resulted in lowering the ground water table.

The problems related to sustainability are arising mainly in rain-fed upland agriculture. Lack of conservation measures for continuous cultivation of rainfed agricultural lands in the modern world, soil erosion or loss by wind or water, salinity or alkalinity, depletion of plant nutrients and organic matter. Deterioration of soil structure and pollution has led to loss of 544 million hectares of crop lands. Out of these 10%, 16.5%, 29%, 30% and 34% are respectively in South America, Africa, South –West Asia, Central America, and South – East Asia. In addition a large extent of remaining lands will also lose fertility due to loss of top soil.

Figure 2


SUSTAINABLE FARMING SYSTEM
BIO MASS
LOW RUN-OFF
NATURAL COVER
SLOW
INFILTRATION
LOW OUTFLOW
FROM THE SYSTEM

5.0 THE NATURAL FOREST AS A SUSTAINABLE SYSTEM

"The forest is a bestowing living creature with unlimited kindness and compassion. It provides shelter and protection to all living things without demanding anything in return. Provides shelter even to a person who comes with an axe in hand to destroy it"

- Lord Buddha-

The forest is the most sustainable natural eco-system in the world. As long as it is externally undisturbed it remains as a sustainable system forever. The forest is self sustaining and does not demand any thing from outside. It is always devoted to protect the quality of the environment and to fulfill the needs of the plants and animals. Study of forest and its sustainable nature is a pre-requisite, foundation for development of farms towards sustainability.

Deforestation due to agricultural and settlement purposes, damaging forest for firewood and timber and extraction of different resources have resulted in the decrease of forest coverage in the world. The annual loss of forest coverage is 18-20 million hectares. The large-scale loss of forest is taken place in developing countries between the tropics. The loss of forest coverage causes a lot of adverse consequences. The impact on global environment is a major consequence. Large scale destruction of forest resulting in the loss of greenhouse coverage caused global warming. The loss of forest resulted in the loss of genetic resources and permanently deprived certain species of floura and fauna. Destruction of genetic resources is a threat for the continuance of Bio-diversity. The destruction of forest is also an obstacle for the maintenance of natural carbonic cycle, water cycle and nitrogen cycle.

Thinness and shrinkage of the natural forest canopy resulting in severe soil erosion has degraded the resources required for feeding all living organisms, The rivers, springs and water causes, which emanated from the forest are gradually drying causing adverse micro climatic conditions. The rainfall pattern and intensity is rapidly changing. Land slides are threatening the life and assets of the people who live in affected areas.

5.1 A Lesson from the Forest

Meticulous observations are required for the study of the sustainable existence of the natural forest. You will be able to learn many things once you enter the forest and walk across making close observations.

- Immediately on entering a forest cool fresh air and a unique perfume smell of Microorganisms could be experienced.
- Forest conserves its resources, minimizing losses. It does not waste even a falling leaf or a drop of rain water.
- It does not obtain any external resources other than sunlight, rains and air which are naturally derived.
- Component members in a forest have adjusted for convenient perform of different activities. In a forest many organisms belong to different species are living together interacting with each other. We call this “Bio-diversity”.
- The micro and macro organisms living in the forest soil maintain a living soil
- All living and non-living components in the soil contribute to perform recycling process in the soil in the forest. The falling parts, waste and dead bodies of living organisms decompose in the soil to give nutrients ensuring sustainability in the system.
- All members always maintain mutual interactions.

5.2 Conservation of Resources

In a forest the tree canopies are distributed in several stratas minimizing disturbances to the forest resources including soil by rain and winds. The speed of raindrops is retarded when they fall on different levels of tree canopies. The raindrops finally fall on the ground slowly and as small droplets. This mechanism helps to reduce soil erosion. The organic matter in the soil absorbs more rainwater allowing slow infiltration of water into the soil. This process leads to minimize the out flow of forest resources. In a forest the gully erosion is also controlled satisfactorily.

The organic matter, soil organisms, nutrients and the soil as a whole in a forest is well protected and conserved by natural processes existing. The widely and deeply spread root system of forest trees are capable of absorbing nutrient and water from deep soil layers. This process ensures absorption of nutrient and water infiltrated into the soil and to minimize losses from the system.

The rain water which is absorbed by organic matter is conserved and released when there is water stress in the soil. The small rootlets spread in the soil surface absorb nutrient and water more efficiently. The humus act as a binding agent to aggregate soil particles forming stronger soil structures. Soils with good structures are capable of retaining more nutrients and water.

5.3 Bio-diversity

A wide range of bio-diversity exists in a forest. All animals plants and micro-organisms have responsibilities to perform different activities so as to maintain the forest as a sustainable eco-system. Each component in a forest do this task both individually and collectively. If some members are unable to perform their roles others will fill the gaps assuring sustainability. For instance, all trees with green leaves manufacture food. If some trees are dead it will not affect adversely on the survival of the eco-system. The soil micro-organisms will continuously decompose organic matter to form humus. The weak plants like creepers are supported by hard trees for climbing up for existence. Epiphytes and parasites depend on other members for their survival. The animal depends on trees always helps to propagate seeds. As all members have allocated functions among them food chains and food web relationships are functioning effectively. Out breaks of pests and diseases are controlled by biological mechanism operating in the system.

5.4 Recycling

The nutrient cycle in a forest is closed. All trees, leaves, flowers, fruits, barks, trunks dead bodies and excreta of animals fallen on the ground in a forest contribute to form a mulch on the soil surface. This mulch which is few centimeters in thickness subject to decomposition by microbial actions to form humus. The humus provides nutrients to the soil and are absorbed by trees. Parts of plants serve as food for sustenance of animals. This process takes place continuously as a cycle. If a forest is deforested this process will collapse. In areas where deforestation takes place there is a shortage of organic matter obstructing the natural recycling process. As the soil surface is exposed directly to sunlight, rains and winds, soil erosion takes place rapidly removing nutrients. The ultimate result of this is the shift of fertile soil into barrenness. The legume trees in a forest facilitate fixing Nitrogen in the soil. If factors contributing to the sustainability of forests are made to us as far as possible a farm can be made sustainable and prevent breakdown.

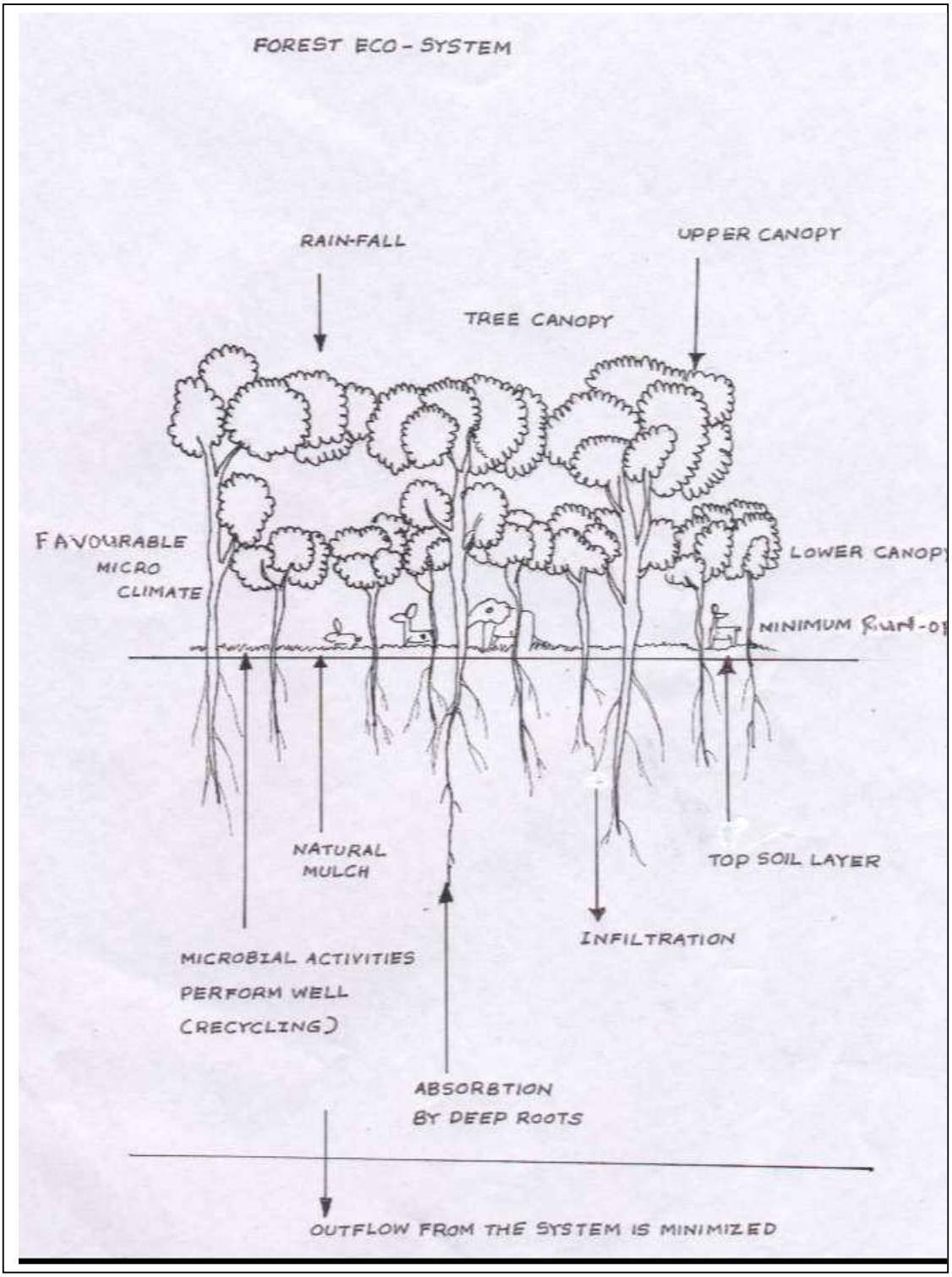
The forests always take care of maintaining sufficient rainfall for its survival. In a deforestrated areas the ground water table tends to go down. Deforestation affects on the intensity and patterns of the rainfall. The forest releases water into the atmosphere through evaporation and transpiration and got them back as rains. It is estimated by scientists that about 2500 gallons of water per day is released to the atmosphere, by one acre of land through evaporation and transpiration. Deforestation affects adversely on the water cycle and water flows over the land causing losses and damages.

"If you want a farm for one year plant, grain crops. If it is for two decades plant fruit trees.

If it is for several hundred years plant forest trees."

- A Cinese Proverb -

Figure 3


FOREST ECO - SYSTEM
RAIN-FALL
UPPER CANOPY
TREE CANOPY
FAVOURABLE
MICRO
CLIMATE
LOWER CANOPY
MINIMUM
NATURAL
MULCH
TOP SOIL LAYER
INFILTRATION
MICROBIAL ACTIVITIES
PERFORM WELL
(RECYCLING)
ABSORBTION
BY DEEP ROOTS
OUTFLOW FROM THE SYSTEM IS MINIMIZED

6.0 LOW EXTERNAL INPUT AND SUSTAINABLE AGRICULTURE (LEISA)

The world food production tremendously increased as a result of High External Input Agricultural practices introduced by the Green Revolution. But as a result of the need for excessive capital, unsustainability of the systems and negative impact on environment, the growers had to face many problems. Therefore development of an agricultural system using lesser external inputs, less expensive and environment friendly has become a need of many countries. Agricultural practices with lesser inputs have been developed by integrating selected traditional basic principles with new technological knowledge.

This system which is abbreviated as LEISA is frequently used for low external input and Sustainable Agriculture. The term which will be referred to as LEISA in the books follow an integrated agricultural system consisting of Bio-dynamics, Environmental, Natural, organic and regeneration sub systems.

6.1 LEISA is based on the following ecological principles

- Creating a favourable condition for growth and sustenance of plant-by stimulating of soil micro organisms as far as possible and adding organic matter sufficiently.
- Maintaining nutrient content at optimum level assuring the balance of nutrients in the soil by Nitrogen fixation, utilization of nutrients available in the deep soil layers, promotion of recycling process and addition of external fertilizer as and when necessary to complement deficient nutrients.
- Controlling the micro climatic conditions to minimize loss of resources, due to sunlight, air and water. Use of biological and mechanical methods to prevent soil erosion.
- Minimizing loss of resources caused by pests and diseases. Integration of pest control methods giving priority to natural biological control of pests by natural enemies on the principle that prevention is better than eradication.
- Promoting biodiversity and complexity
  Stimulating synergetic and symbiotic conditions between plants/ plants and plants/animals.

In agricultural activities the foregoing principles could be utilized by means of different technologies and methods.

The objective of LEISA system is to maintain the agricultural production at an optimum level using less external inputs in a eco-friendly environment. To achieve this objective the LEISA practices concentrated heavily on the following factors

1. Maintaining a living soil
2. Creating of bio-diversity
3. Recycling of resources.
4. Natural pest Management

6.2 Maintaining a living soil

Maintaining Biological characteristics of the soil. The climate, animals, plants and human being influence on the physical, chemical and biological characteristics of the soil. Adequate amount of water, air and nutrients in the soil is essential to maintain crop production at a sustainable level.

Favourable soil structure is essential to retain water, nutrients and the growth of root systems of the plants. The soil temperature should exist for maintenance of living soil. It is important that soil should be free from poisonous substances.

The soil contains clay, gravel, air, water, organic matter and humus. Biological activities including breeding of many micro and macro organisms taking place in the soil is an important characteristic.

6.2.1 Soil organisms

All animals and plants living in the soil are considered as soil organisms. Based on the sizes the soil organisms can be classified as follows.

Microflora - Bacteria, fungus and Algae
Microfauna - Protozoa
Mesofauna - Nematodes
Macro animals - Weevils, Centipede, Termites, Rats, Worms, Snakes

Box 1

In an extent of one hectare, top 10 cm thick layer with 1% organic matter has about 15 tons of organic matter. The weight of worms, bacteria, snails, furigus, algae and other plants and animals in this layer is about 25 tons. This is equivalent to the weight of 4-6 cows.

Functions of micro-organisms

- Decomposing soil organic matter into humus. The micro organisms depends on the organic matter and provide cost free labour to farmers converting organic matter into humus.
- Mineralization of humus into nutrients. There are freely available nutrients to plants.
- Helping nitrogen fixation.
- Converting non-soluble phosphate into soluble forms.
- Helping plants to absorb nutrients
- Maintaining soil sanitation
- Protecting plants from harmful micro organisms, keeping the population of micro organisms at balance. Eg. Control of the spread of fungus by bacteria.
- It can be observed that micro-organisms are absent or present at minimum level when soil is continuously cultivated without proper management. Such soils are unsuitable for cultivation due to nonfunctioning of microbial activities or functioning at minimum level.

6.2.2. Humus

Soil organic matter is decomposed and ultimately converted into humus by soil micro organisms. Humus Performs a wide variety of tasks. The smaller soil particles are aggregated by humus to form clusters of soil particles improving the soil structure. These clusters of soil provides adequate space to retain air and water in the soil. This situation facilitates plants to survive even in a prolonged drought conditions. In addition humus improves the chemical properties of the soil. The soil nutrients are absorbed by humus and acts as a store for the plants for theirs consumption as and when necessary. Humus acts as a pool of plant nutrients minimizing nutrients losses through infiltration. The humus acts as a binding agent of micro nutrients. Therefore a soil with adequate quantity & humus will not show any nutrient deficiency. In a sustainable agricultural system it is necessary to assure availability of adequate quantity of humus in the soil.

In order to maintain productivity in a soil at optimum level the amount of nutrients removing from the soil should not exceed the in-flow of nutrients into the soil. This means that there should be mechanisms to maintain nutrient balance in the soil. The natural recycling process does it perfectly if the process is not disturbed by external agents. This process could be induced by nitrogen fixation, integrating organic manure with chemical fertilizer using appropriate crop rotation system and integrating animal husbandry into crop production. It is also important to minimize nutrient loses from the soil.

Box 2

Food of soil organisms

Food / Organism	Vegetables	Organic matter	Bacteria	Fungus	Algae	Protozoa	Nematodes	Mites	Insect larvae	Termites	Centipede	Spiders
Bacteria	✔	✔ ✔	✔	✔ ✔								
Algae	✔	✔ ✔			✔ ✔	✔	✔ ✔					
Fungus		✔					✔ ✔		✔ ✔			
Protozoa		✔ ✔	✔ ✔	✔ ✔	✔	✔	✔					
Nematodes	✔	✔ ✔	✔	✔ ✔	✔	✔ ✔	✔					
Mites	✔	✔ ✔	✔			✔ ✔	✔	✔ ✔				✔ ✔
Insect Larvae	✔	✔ ✔			✔ ✔		✔	✔	✔			
Termites	✔	✔ ✔		✔								
Ants								✔	✔			
Centipede							✔		✔ ✔		✔	
Spiders										✔	✔	
Earth Worms	✔	✔ ✔		✔	✔							

✔✔	More desired food
✔	Desired food

6.3 Soil enrichment and conservation

The forest demonstrates the natural method of receiving nutrients into the soil. The soil obtain the most of nutrients through recycling of plants and animal parts and wastes. Soil micro organisms are continuously active for decomposition of organic matter into humus.

In a farm it is necessary to provide conditions to stimulate microbial activities to decompose organic matter into available forms to plants. In addition provision of partly or completely decomposed nutrients to the soil in sufficient quantities is necessary for rapid growth of the plants and to keep up soil fertility.

6.4 Application of green manure

In conventional agriculture, green manuaring was one of the major activities carried out to enrich the soil. Particularly in paddy cultivation green manure was used to improve physical, chemical and biological properties of the soil. Besides providing nutrients green manure helps to conserve moisture.

Live fence, wind blockade trees, alley crops, and cover crops can be used as sources of green manure in farms.

Box 3

A. Lopping of hedge row plants in one hectare of land provide 40-60 tons of organic manure into the soil. Thereby the soil can get about 120-160 Kgs of Nitrogen.

B. Legume cover crops provide 5-30 tons of organic matter and 200 Kgs of Nitrogen to the soil.

Box 4

Nitrogen contents in green manure

Green Manure Trees	Moisture Content In Green Material(%)	Nitrogen (%) at 100^0C
1.Gliricidia	58.0	3.63
2.Albizzia	56.4	3.19
3.Dadap	76.2	4.39
4.Wild Sunflower	77.1	4.36
5.Sunhemph	61.2	4.32
6.Tephrosia	54.5	4.53

6.5 Animal waste

From the ancient times animal wastes have been used to enrich soils. Partly or completely decomposed animal wastes are used to conserve soil moisture, to get nutrients and to stimulate microbial activities.

Availability of quantities of NPK from livestock in a farm is depicted in the following table.

Box 5

Type of animals	Availability of NPK in one year (kg)		
	N	**P**	**K**
One dairy cow	60	4	18
One Pig	08	1	2
One Fowl	0.7	0.3	0.2

6.6 Cultivation of Nitrogen fixing plants

The legume crops grown in farms fix Nitrogen in the soil. Green gram, cowpea, soya, ground nut and beans are suitable legume crops for Nitrogen fixation. Gliricidia and wild sunflower are suitable legume trees for live fences and wind blockades.

Box 6

Legume crops in one hectare of land can fix about 40-200 Kgs of Nitrogen

6.7 Compost fertilizer

The fertilizer produced from the decomposition of residues of plants and animals is called compost fertilizer. Composting is done by micro organisms in the soil. Efficiency of the system depends on the maintenance of moisture air and temperature at optimum level.

Micro organisms obtain oxygen and moisture from the atmosphere and food from organic matter and release carbon dioxide and energy. The energy released in the process is used to increase the temperature of compost and to perform biological activities of micro organisms. The increased temperature affects on organic matter to undergo a series of changes to form humus. The ultimate product is a complex mixture of humus, undecomposed organic matter, dead soil organisms and living organisms.

Biological restructuring of organic matter takes place in the composting process. The micro organisms can conveniently utilize the sugar in organic matter and cellulose and hemicelluloses decompose slowly through enzymic activities.

Methods of compost preparation

- Pit system – This system is more suitable to prepare compost in dry seasons.
- Heap system – In rainy seasons this system is better than the pit system.

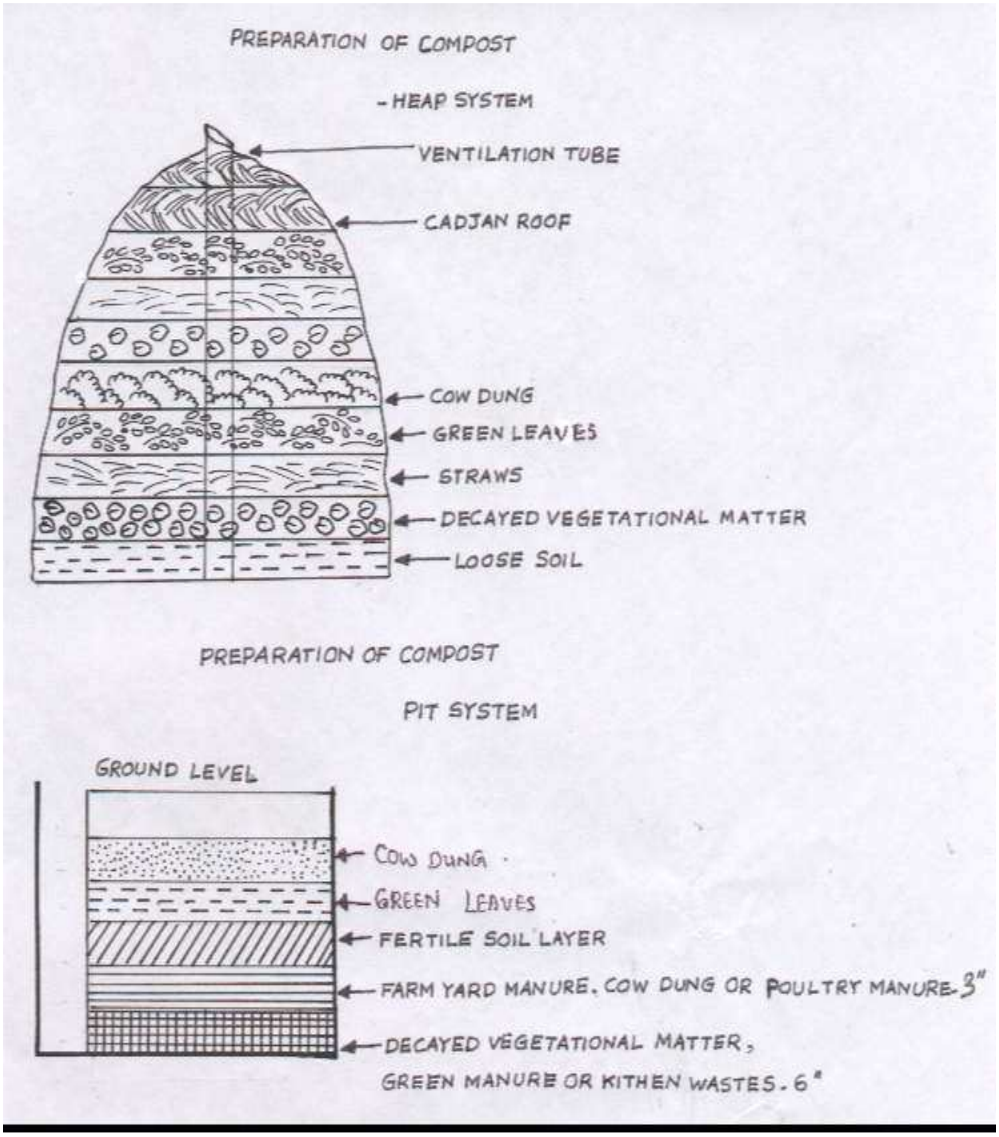
Both in pit and heap systems it is better to arrange organic matter up to 1.5 meters (5 feet) high, on a base of about 37 sq. Meters (400 sq.feet) It is possible to get about 5-8 tons of compost fertilizer from a preparation of above dimensions.

The composition of raw materials suitable for making compost fertilizer is given below.

Box 7

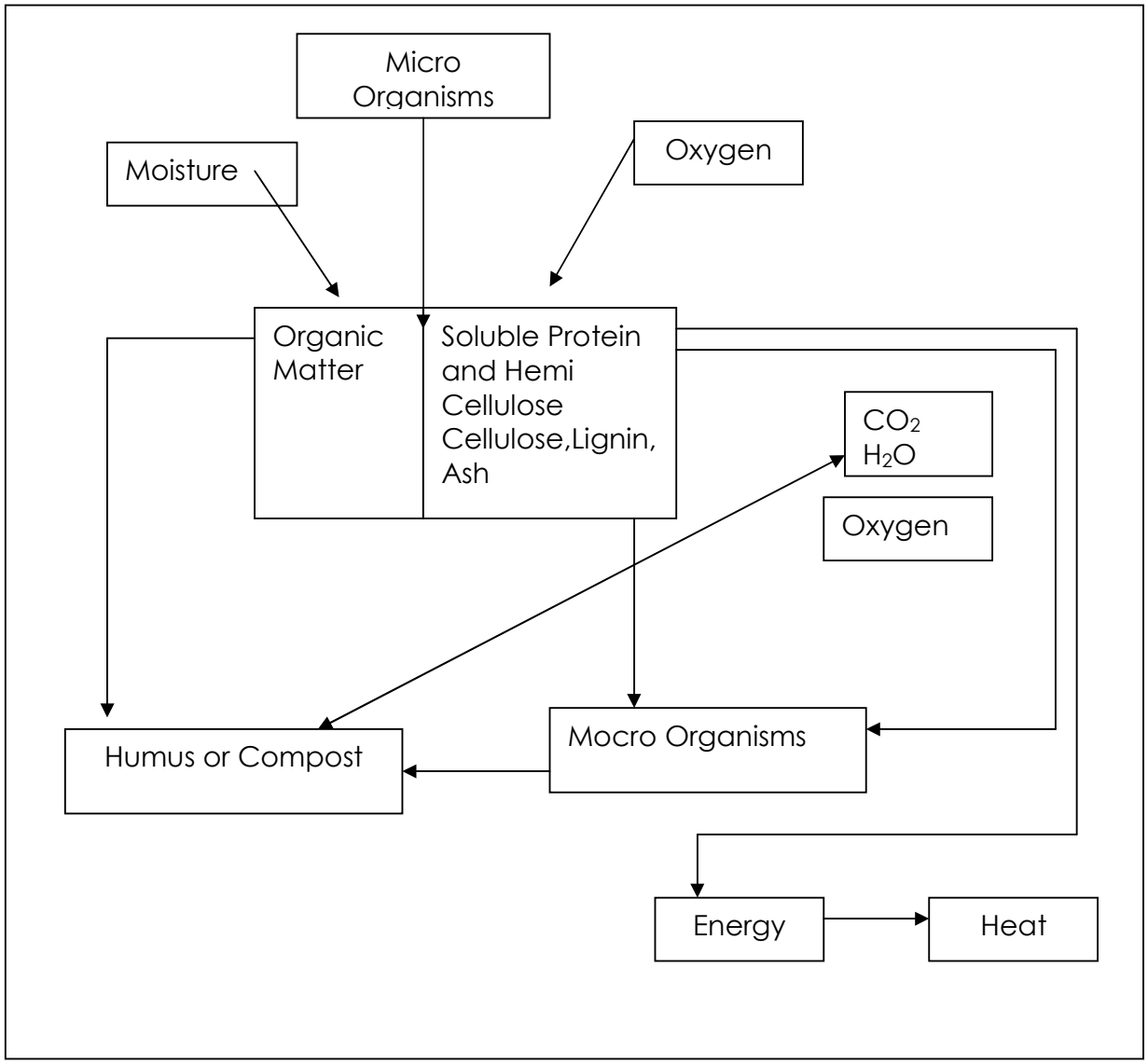
Material	**N% on dry weight**	**C/N Ratio**
Urine	15-18	0.8
Grass	4	20
Farm yard manure	2.2	14
Pigeon pea crop residues	0.7	70
Paddy straws	0.4	100
Wheat straws	0.6	80
Coir dust	0.5	300
Decomposed Leaves	0.4	45
Molases	0.3	150
Decomposed saw dust	0.2	200
New saw dust	0.1	500

Figure 4


PREPARATION OF COMPOST
- HEAP SYSTEM
VENTILATION TUBE
CADJAN ROOF
COW DUNG
GREEN LEAVES
STRAWS
DECAYED VEGETATIONAL MATTER
LOOSE SOIL
PREPARATION OF COMPOST
PIT SYSTEM
GROUND LEVEL
COW DUNG
GREEN LEAVES
FERTILE SOIL LAYER
FARM YARD MANURE. COW DUNG OR POULTRY MANURE-3"
DECAYED VEGETATIONAL MATTER,
GREEN MANURE OR KITHEN WASTES. 6"

Process of Composting

Box 8



6.8 Conserving soil resources

In order to ensure sustainability of living soil, attention should be paid for methodical protection of soil particles, air, moisture, organic matter, humus, micro organisms and energy. Biological and physical methods could be used to keep a living soil with optimum fertility. The methods of protecting soil fertility are explained under different headings.

Mulching

Mulching is the use of plant or non living materials to cover the soil surface with the objective of protecting the soil from the adverse impact of rainfall, and sunlight, controlling weeds or moisture loss and fertilizing the soil. Mulching is not suitable for the soils where moisture content is too high. Generally 3.4 tons of mulch over for one hectare of land is suitable. There are different methods of mulching in agriculture as described below.

Insitu mulching

The residues of cultivated crops and weeds can be used as a mulch to protect the soil from erosion and over exposure to sunlight. When there is no competition between the existing crop and the root systems of the previous crop, the remaining parts of the previous crop can be used as a mulch.

Eg:- Using paddy straw and stubble as a mulch Residues of maize crop.

Cover Crops

Cover crops are extensively used in agriculture to give protection to the soil. Selected categories of annual legume crops are more suitable for cover cropping. In addition to covering the soil, legume crops fix nitrogen in the soil. These crops also add organic matter into the soil.

Calopogonium mucunoids and Centrosema pubescens are examples of legume cover crops. When the fields are in fallow period sunhemp (sesbania) seeds can be sown in the field. At the flowering stage sunhemp crop is ploughed or cut into pieces and incorporated to the soil. This crop fix Nitrogen in the soil in addition to providing organic matter.

In mix cropping live mulches are often used. Legume cover crops are cultivated as runner crops with the main crop. Eg. In rubber and coconut plantation legume cover crops are used. However the cover crops should be selected considering their less competitiveness with the main crop for moisture, space, sunlight and nutrients.

Good cover crops should have the following characteristics

- Convenience in cultivation, having horizontal growth, ability to cover the soil surface rapidly.
- Ability to compete with weeds
- Ability to provide a dense mulch
- Ability to fix Nitrogen
- Inacting as a host plant of pests and diseases of the main crop.
- Tolerance to shade.
- Ability to produce seeds for the next cultivation.

Examples for cover crops

Pueraria phaseoloids, Centrosema pubescens, Phaseolus radiatus. Calopogonium mucunoids, Desmodium gyroides.

Alley cropping farming

Alley Cropping means growing annual or seasonal crops between rows of trees or shrubs, often leguminous. Before planting annual crops in the space between rows the vegetative parts of the trees and shrubs are pruned to use as much around annual crops and also as fodder and fuel wood. During the dry periods the trees and shrubs provide shade to annual crops and help to maintain favourable micro climate.

Characteristics of good trees and shrubs in alley cropping.

- Rapid growth
- Rapid regrowth after pruning
- Ability to provide more organic matter at least 5 tons of biomass per hectare per prune if the trees and shrubs are planted at the space of 4-5 meters between rows and 0.5 meters in the row.
- Ability to fix Nitrogen

Suitable trees and shrubs for alley cropping

Eg: Gliricidia maculata, Tephrosia noctiflora, Tephrosia vogelii , Sesbania cannabina

Advantages of mulching

- Create bio chemical and physical changes in the soil. Stimulate the soil micro organisms.
- Conserve soil moisture, reduce runoff and wind erosion. Reduce evaporation and facilitate infiltration of water into the soil.
- Help to maintain soil temperature at optimum level. In mulched soil, temperature is 5 –10^{o} C lesser than in exposed soils.
- Control weeds, reduce competition between weeds and growing crops.
- Improve soil structure
- Improve cation exchange capacity

6.9 Physical and Biological methods of soil conservation

Soil erosion can be defined as the removal of soil from ground or the loss of fertility in the soil due to human activity. Sustainability of soil can be preserved by using physical and biological methods to prevent soil erosion. The wind and rains are the major factors of soil erosion. Soil structure, texture, gradient of the land and the intensity and frequency of rainfall in the area are the major factors to be considered in designing a sustainable soil conservation plan for an area.

Construction of stone bunds

Bunds across the slope or along the contours could be erected using stones to prevent soil erosion in a land. The space between two bunds could be used to grow annual or seasonal crops. This method is more suitable for lands with steep slopes.

Construction of contour drains

Contour drains can be constructed to reduce soil erosion by harmful rainwater. These drains reduce the speed of runoff water.

Construction of soil bunds

The soil bunds are more suitable to conserve the soil in lands with less gradients, located in areas where rainfall is less. Soil bunds are also constructed along the contours, to prevent soil erosion. Some farmers use soil bunds for cultivation of crops such as yams, legumes and grains on the bunds.

Hedgerow contour planting

Hedgerows are one of the simplest erosion control practices on sloping lands. Planting trees or grass along the contours is somewhat similar to construction of stone bunds along the contours. The trees and grass are allowed to grow to reduce the speed of flowing rainwater and trap soil to gradual formation of natural terraces. The hedgerow trees provide organic matter and conserve moisture in addition to preventing soil erosion.

Box 9

Soil erosion in agricultural Lands

Description	Removal of soil Tons/Ha/year
• **Wet zone, Mid country (Peradeniya)**	
Soil Type: Reddish Brown Latosols	
Seedling tea without	
Conservation measures.	40.00
Tea Lands with conservation measures	00.24
Kandyan Forest gardens	00.05
• **Wet zone –Upcountry (Talawakelle**)	
Soil Type – Red yellow podsols	
Exposed tea lands	52.60
• **Mid country intermediate zone (Haguranketha)**	
Soil type – Unmatuared Brown Loam	
Tobacco cultivation without Conservation	70.00
Capsicum cultivation	38.00
Carrot cultivation	18.00
• **Low country dry zone (Mahailluppalama)**	
Soil type Reddish Brown Earth	
Sorghum/Pigeon pea (without mulch)	21.30
Sorghum/pigeon pea (Mulched)	03.90
Cotton cultivation	22.00
Cotton cultivation with mulch	02.00
• **Mid country chena cultivation**	
Tobacco cultivation in more than 45% slope lands	200.00
• **Virgin natural forest**	00.005

Source : Stokins 1986

6.10 Formation of biodiversity

At the time of growing different parts of a tree, such as roots, leaves, flowers, fruits etc., are formed for fulfilling varied functions. Animals also directly or indirectly influence on activities performed by trees Eg. Bees help pollination of flowers. Each and every parts of trees carryout diverse activities and maintain inter relationships. The principle of diversity abide by plant for performing activities efficiently.

The diversity in an ecosystem depends not only on its plants and animals of different species but also on the mutual relationships among them. While each member in the system carryout more than one activity for the benefit of the system, the same activity is performed by several members in the system. Any ecosystem with higher diversity maintains a web of interactions with different organisms. If one or several members of the system fail to perform activities in a system, others continuously fill the gap and prevent break down of the process.

The long term sustainability and diversity in a farm can be achieved by introducing a variety of cropping systems. Integration of crops and livestock in a farm also helps for sustenance of the system.
The following methods are suggested to maintain the sustainability in a farm.

- Multiple cropping instead of mono cropping.
- Integration of crops and livestock
- crop rotation.
- Establishment of forest trees.

Multiple cropping

In traditional agriculture in the world many crops are cultivated in the same field including perannial, annual and seasonal crops. But in commercial cultivations emphasis is on mono cropping eliminating multiple cropping pattern causing economic and environmental problems.

Growing two or more crops in the same field in one year at the same time or one after the other is meant by multiple cropping. Multiple cropping is most suitable for small scale farming than large-scale farming. This system offers several benefits to farmers. It reduces risk and uncertainty and unlike in mono cropping labour is utilized more effectively and efficiently.

The biodiversity associated with multiple cropping influences the sustainability of the farm. However when too many crops and livestock are introduced to one farm problems with regard to complexity will arise. The farmers should have a sound knowledge for selection of suitable crops and livestock for multiple cropping systems. The level of interaction between different members in the multiple cropping system should be considered in selecting crops.

Different systems of multiple cropping

Multiple cropping can be chronologically determined for successive crops or simultaneous inter cropping determined by intervals of space. Most often a combination could be implemented.

Successive cropping

Successive cropping is the cultivation of different crops at different times of the year in the same block of land. This system reduces the competition between different crops. Once one crop is harvested other crop is commenced.

It is possible to cultivate one, two, three or even four crops per year in the same field. But the frequency depends on the life spans of selected crops.

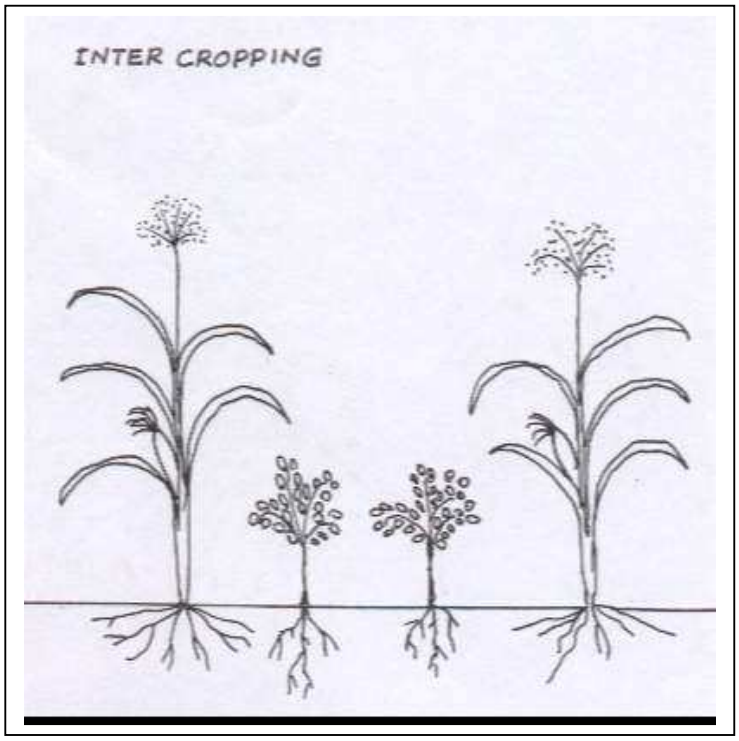
Eg. Cultivation of paddy in Maha season and chillie in yala season. Select less water sensitive crops for yala (dry) season and more water sensitive crops for maha (wet) season.

Ratoon cropping

After harvesting the existed crop, the root system is undisturbed for re-growing. The residue parts of the crop will give rise to another harvest

Eg. Ratoon crops of sugarcane and paddy.

The disadvantages of this system is low yield of ratoon crops. As there is no chance for crop rotation for long periods the soil fertility will be reduced.



Inter Cropping

Inter cropping is the growing two or more crops in the same field at the same time. Cropping is intensified in terms of both time and space. The competition between crops exists through out the whole life time of the crops or for a part of the life time. The crops should be selected and the space should be given to minimize the competition between crops.

Mixed intercropping

Mixed intercropping is the cultivation of several crops at the same time without giving proper space between crops, beds` or rows.

Eg: Cultivation of different species of grass in the same field. Sowing Kurakkan with millet in the same field.

Row intercropping

Several crop species can be planted in separate rows in the same field at the same period of time. Eg. Cultivation of beat in one row and carrot in the alternative row. It is easy to maintain different crops in row intercropping giving specific treatments and harvesting separately.

Strip intercropping

Strip intercropping is the cultivation of two or more crops simultaneously in the same land. Different crops independently grow with existence of inter relationships. This system of cultivation is beneficial for micro climatic conditions. It is also need for preventing soil erosion. In order to reduce the soil erosion the crops for different stripes should be selected carefully. The crops which facilitate more soil erosion and the crops which do not facilitate soil erosion should be grown in alternative stripes. Eg. Grass in one stripe and potato in the alternative stripe. This system is more suitable for sloping lands.

Patch intercropping

This system is very much similar to strip inter cropping. But the crops are cultivated in different patches instead of in stripes. This type of patch intercropping is practiced in chena cultivation.

Eg. Creepers and other crops can be cultivated in patches. The wooden sticks are placed to climbing for creepers.

Relay cropping

Growing two or more crops within their living cycle is called relay cropping. The second crop is planted before the first crop is harvested. The introduction of the second crop should be done at a later stage of vegetative growth or at the reproductive phase of the first crop. Relay cropping is a system in which time and space can be utilized effectively.

Growing annual crops as wind breaks

This connotes planting of tall trees in contours and the shrubs in between and providing for wind breaks. The tall plants and shrubs provide protection from wind to short plants and thereby prevent soil erosion. This system is favourable for integrated pest management and for keeping micro climate at optimum level. It is possible to use crop residues of wind break trees as organic matter, mulch and fodder for livestock. If a crops like pigeon pea is cultivated as a wind break it fix nitrogen in the soil.

Rotation of wind break trees and crops is desirable for sustainability of the system. Sugar cane, maize, sorghum, pigeonpea, sunflower are some of the crops suitable to grow as wind breaks. Soya beans, groundnuts, green grams, cowpea, and vegetables are suitable to grow in between wind breaks.

Advantages of Multiplier cropping systems

Following are the agricultural and socio-economic benefits achievable from multiple cropping.

- Multiple cropping systems provide better opportunities to Utilize resources like sunlight, air, nutrients and moisture more efficiently than in mono cropping.

- As crops are established close to each other the soil erosion is minimized. Rains are intercepted by tall plants of the system and thereby rain drops are placed on the soil surface slowly. This mechanism is favourable for better infiltration of rain water and for controlling runoff. The system can maintain good soil structure.

- Weed controlling is easy

- The root system of different trees penetrate into different depths of the soil and facilitate absorption of nutrients and water from deep soil layers.

- As resistance and susceptible crops are grown together pests and diseases are controlled better than in mono cropping.

- There are favourable inter-relationships between different crops. Eg. Tall plants and dwarf plants.

- Help weak plants to climb up.

- Multiple crops assure better yield and income. This system affects favourably on the sustainability of the farm.

- Multiple cropping system reduces risks and uncertainty. If one crop is failed other crops will produce successfully using more resources and space.

Criteria for selection of crops for multiple cropping

- Select crops from different plant families

- Select crops with different morphological characteristics. Plants with horizontal leaves are more suitable for under corpping.

- Lands for planting crops should be selected according to the sensivity of plants to sunlight.

Eg. Establish crops which preferring shade at the lower part and more photo sensitive plants at the upper parts of the farm.

- The peak growth stage of one crop should not coincide with the flowering stage of other crops.

- Select crops with different life spans.
  Eg. Plant 4 month varieties with 3 month varieties.

- Select crops which have different nutrients requirements.

- Select different water consumptive crops, for averting risk associated with availability of water.

- Select plants with different types of root systems.

- Select crops which have different capacities to resist pests and diseases.

Examples of suitable crops

- Crops which have different life spans.
  Eg. Maize (3 months) with sorghum (6 months)

- Different morphological characteristics. Maize with ground nut, soya green gram, cowpea.

- Annual crops with seasonal crops – Green gram, soya and groundnuts with sugar cane.

- Coffee cocoa or plants of citrus family with groundnuts, cowpea, greengram, and maize. Banana and Pigeon pea also can be cultivated.

6.11 Integration of crops with livestock

Integration of crops with livestock can minimize use of external inputs. Inter relationship between livestock such as cattle, pigs, poultry, goats and ducks and the crops can be promoted.

The urine and excreta of animals improve the soil fertility and nutrient level. Animal husbandry associated with crop production leads to diversification of the farm. In many instances farm animals are used for traction and transportation of farm inputs and outputs.

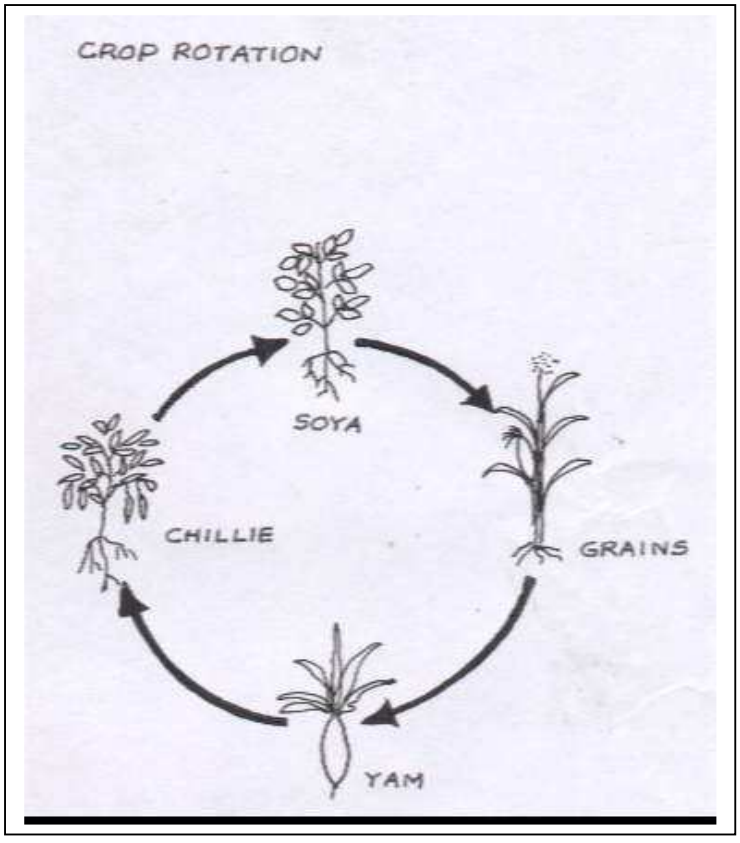
Examples of crops livestock integration

Fish culture in paddy fields, rearing cattle in coconut plantations, poultry/ducks/fish ponds and crops integration.

6.12 Crop Rotation

Crop rotation is the variation of the growing different crops in the same field at different seasons.

Figure 6



Crop rotation enables to maintain nutrients of the soil in an equilibrium level. Crop rotation has positive impact on natural pest management. The pests and diseases of a particular crop will not be able to withstand the life cycles as the existing crop will be replaced by new crops of different species. If the crops are integrated with livestock, crops livestock rotation is also possible.

Inclusion of forest trees in the farming system

The natural forest ecosystem is strongly sustainable. The objective of planting forest trees in a farm is to induce sustainability prevailing in a forest. The tree species which have ability to grow widely and vigorously could be selected to plant. Economic and food values also should be considered in selecting trees Eg. Jack, Mango, Teak, Halmilla ,Albezzia are suitable. The following benefits can be achieved from forest trees planted in a farm.

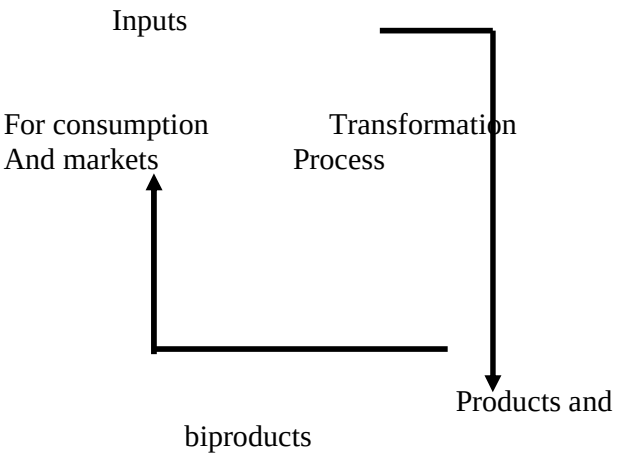
- Large trees provide different canopy levels and help to slow down the speed of the drops of rain fall, reducing the soil erosion
- Wind erosion is controlled as the soil is covered.
- The natural much, which is formed by falling parts of trees activates the soil micro organisms to decompose organic matter.
- As the root systems of large trees penetrate into deep soil layers the system is in a position to absorb more nutrients and water minimizing wastages of resources.
- Favourable micro climate is maintained.
- Large trees provide shelter and food to animals like birds and improves biodiversity.
- In addition to environmental conservation these trees produce food, timber and fuel wood.

6.13 Cycling and recycling process in a farm

The natural forest ecosystem does not use external resources other than sunlight, air and water. In such systems the wastage of resources is minimized and instead the resources are being used again and again. Leaves, fruits, flowers, trunks and other vegetative and reproductive parts of plants together with animal wastes and dead bodies are decomposed to

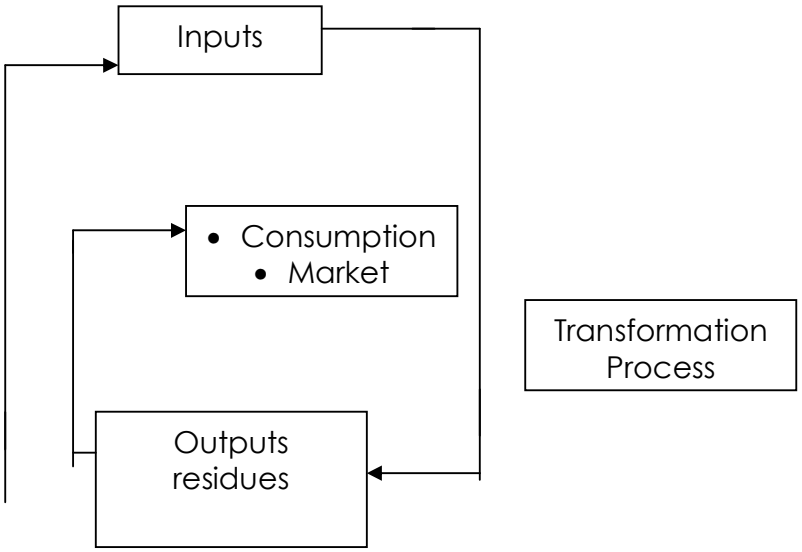
form humus. Humus provide nutrients to plants. If there are no external influences this process will continue for ever. In a paddy field the paddy straw can be recycled to give nutrients. Promotion of recycling process will help to maintain the sustainability of the farming system.

The relationship between inputs and outputs in a high external input agricultural system is depicted below.



This process does not occur in a circular form either output nor the residues are used as inputs in to the farm.

In a sustainable farm a recycling process of inputs and outputs exists as depicted below.

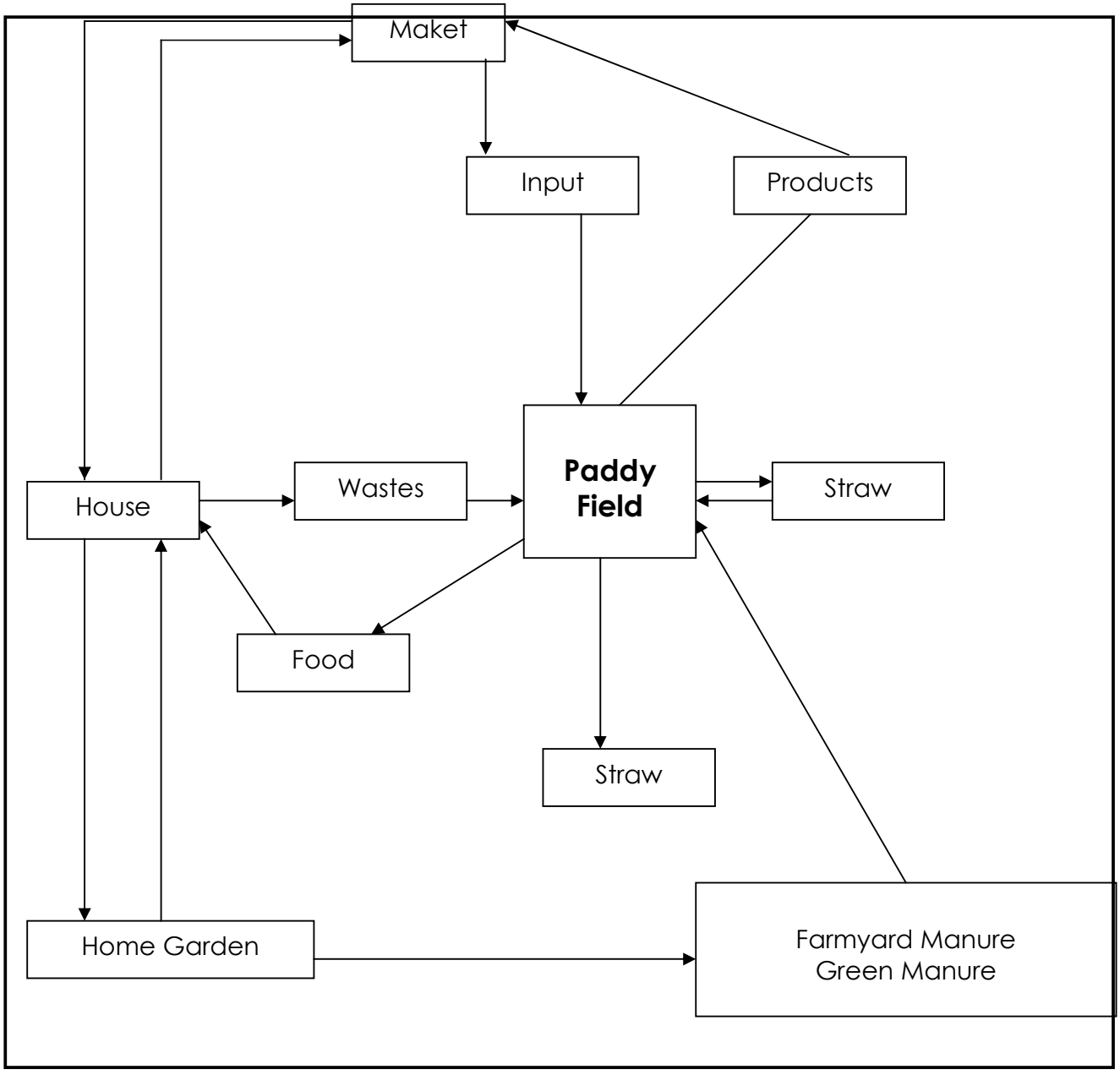


In sustainable farms some outputs and residues (wastes) are used as farm inputs. As an example, in maize cultivation, after harvesting the crop, most of the residues are recycled to give nutrients. In paddy cultivation paddy straw is recycled to enrich the soil fertility instead of burning them.

Minimization of external inputs is of paramount importance in sustainable agricultural system.

Another example of this process is farm where dairy farming and crops are integrated, the animals feed on grass converting grass into milk and flesh. Animal exeata and urine is a manure for growth of grass. The wastes of one member of the system becomes input to another member because of the recycling process. Promotion of recycling process in a farm influences on the sustainability.

Box 10



Nitrogen cycle and water cycle are good examples for natural recycling processes.

A network is formed among the different components of a farm market and external environment. This process is very important to keep up of sustainability

Some times it may necessitate to use external resources like chemical fertilizer in minimum quantities to enhance sustainability of the system.

Natural crop protection methods

A series of actions such as reduction, prevention, extermination and controlling of pest attack can be used.

The seeds and planting materials should be treated to destroy, Pathogens, before planting them in the field. Sometimes hot water treatment will be sufficient for this purpose. Use of wood-ash and sun drying also possible. It is advisiable to use farm implements hygienically as there are possibilities of transmitting pests and diseases. Through them. Infested fruits, plants leaves ratoon crops and host plants of pests and diseases should be kept away from the farm.

Cultivation of resistance varieties

The crops resistance to pests and diseases should be selected for cultivation as far as possible. Natural pest control by predators is promoted in multiple cropping, where a variety of crops are integrated.

Pest control methods

Although there are several methods of pest control in sustainable agriculture, Priority is given to prevention of pests. Integrated pest control measures are given below.

- Biological methods
- Mechanical methods
- Use of natural pesticides
- Use of artificial pesticides

Biological methods

The pest population is controlled by using natural enemies in biological methods. The small scale farmers can control pests by cultivating a mixture of crops in the farm, where the pest population is balanced by natural enemies avoiding economic damage to crops.

Mechanical methods

In conventional agricultural practices mechanical methods are extensively used to control the pest population hand picking trapping and removing the infested parts of crops are common mechanical methods.

Natural pesticides

According to the mode of action natural pesticides can be classified as follows.

- Attractive : - the pests are attracted by odour, colour and taste of some parts of plants. Eg. Paramous can be used to kill fruit.

- Repulsive:- Repulsive means keeping away the pest from reaching plants and stored products. Some plants contain substances which do not alow pests to reach and eat them. Some plants reduce the appetite of pests as soon as they start eating the plant Eg. Neem leaves, Eg of natural pesticides: garlic, Big onion, Pepper, Tobacco, Neem.

Box 11

Dissolve 04 cups of wheat flour and half cup of sour curd in 20 liters of water. Spray this mixture to Control mites. The mites get stuck into leaves and die because of this mixture.

Mix 1 Liter of Milk with 9 Liters of water and spray once in 10 days to conrol yellow mosaic virus of tomato, tobacco and sugarcane.

As long as sustainable agricultural systems using ecological principles are maintained well needs will not arise to use artificial pesticides to control the pest population. Artificial pesticides which are less poison may be used only when other pests control methods do not succeed.

Box 12

Diversity of agricultural systems

Description	High external input, agricultural system	Less external input & sustainable agricultural system	Traditional Agriculture
Productivity	High	High	Average
Sustainability	Low	High	High
Farming system	Simple	Complex	Complex
Diversification	Uniform	High	High
Production Objective	Market	Consumption Market	Consumption
Use of external resources	High	Low	Low
Use of fertilizer	Inorganic	Inorganic and organic	Organic
Crop protection	Controlling Killing Inorganic	Prevention Organic	Prevention Organic

7.0 SUSTAINABLE FARM PLANNING WITH FARMER FAMILIES

Figure 7

Step (1)

Objective To enhance knowledge and understanding of the farmer families on sustainable agriculture.

Method Lecture, discussion, brainstorming

Training aids Black board/white board/chalks, markers

Venue Open space or common hall

Session guide

The extensionist invites farmers to meet at the selected venue at proper time to conduct the session. This session should be open to enthusiastic male/female members of the farmer families in the village unit.

Discuss the main problems encountered by farmers in farming activities. List out the problems which came out in the discussion on the black board/white board. Discuss the causes of problems and suggestions of farmers in solving problems.

Box 1

The following problems may arise in the discussion

Problem	Reasons
1. Declining fertility of the soil	Soil erosion, use of inadequate fertilizer, increased acidity, alkalinity, deficiency of organic matter
2. Low Productivity	Weak plant growth, abundance of pests and diseases, less response to fertilizer, Lack of fertilizer
3. High cost of cultivation	Increased prices of pesticides and chemical fertilizer, increased labour Wages, Increased cost of farm power.

- Discuss how the farmers maintain soil fertility in traditional agriculture.
- Discuss the advantages and disadvantages of agricultural practices introduced by Green Revolution.
- Discuss how to adopt a system to maintain soil fertility reducing use of external inputs for achieving sustainability.
- Define the terms sustainability and sustainable farming
- Build up confidence of the farmers on achieving sustainability through planning activities for the farm by themselves.
- Decide the date, venue and time-for the next session and conclude the session inviting interested farmers to attend the next session.

Box 2

Sustainability

- Long term existence
- Ability to maintain a process or productivity without half way breakdown.

Sustainability in Agriculture
Ability for uniform maintenance of production at a decisive level with optimum use of external inputs and preserving the resource of the farm

Step (2)

Objective Learning sustainability in a forest

Method Field visit to forest, group exercise, observation, Presentation and discussion

Training aids Natural forest or a land with well grown big trees.

Session guide

Inform the selected group of participants that understanding sustainability in a forest is a basic prerequisite for sustainable farm planning. So observing a natural forest is most appropriate. Suggest a visit to the nearby forest. Inform participants that our ancestors lived in the jungles and our outing is a visit to our relations. If there is no natural forest, suggest to visit a land which is covered with widely grown trees.

If a forest or a land with big trees are not available in the surrounding, facilitate a brainstorming session for participants on what is happening in the forest to maintain a sustainable ecosystem.

Divide farmer group into sub groups and ask each sub group to observe the forest and record main features related to sustainability and chemical, biological and physical properties of the forest soil or the soil under big trees.

After visiting the forest ask each group to discuss and present findings.

Box 3

The following are possible observations

- The environment in the forest is cool and fresh.
- There are many species of trees (Biodiversity)
- There are many species of animals (Animal diversity)
- Interactions between plants/plants, plants/animals and animals/animals
- Complexity in the system
- Soil and moisture conservation
- The mulch formed on the soil surface as a result of decomposition of organic matter
- Decomposition of organic matter by ants, termites, earth warms, fungus etc.,
- The forest does not take inputs from outside. The resources existing in the forest are recycled.
- Natural mechanism to control pests and diseases.

Box 4

Forest soil

- Reddish brown in colour.
- Contains decaying animals and plant parts (Organic matter)
- Moisture is conserved
- Erosion is minimized
- Good soil structure and texture
- Extremely favourable for cultivation
- Biological activities takes place
- A living soil exists in the forest

Built up confidence of the farmers that it is possible to induce the sustainability existing in a forest to agricultural farms. Decide the date and venue for the next session. Explain briefly the objective of the next session before concluding the session.

Step (3)

Objective To enable farmers to identify the existing resources and opportunities in the farm before preparation of plans.

Method Discussion and group exercises

Session guide Summon farmer group to gather at one of the farms selected for planning This place should be decided by the farmer group. Facilitate farmer group to observe the farm, walk across and record the weaknesses and good characteristics of the farm in line with sustainability, based on lessons learned from the forest. Allow adequate time for observation and recording. Subsequently moderate a discussion related to the following topics.

- Living soil /Dead soil
- Biodiversity
- Utilization of farm resources conservation of resources, water/soil/nutrients
- Recycling process of the resources
- Use of external inputs
- Suggestions to improve sustainability of the farm.

Write the outcomes of the discussion on the black board/white board or demy papers and review findings.

Discuss the planning process and necessary information for planning.

Information to be collected

- **Resources presently available in the farm and with the farmer family**
  No. of labour units in the family
  Agricultural knowledge/ Experience.
  Nature of soil, texture, sandy/loam/clay/stony, colour of the soil
  Farm resources – Animal power, Machineries.

- Opportunities – Livestock, market, storage facilities, credit facilities, opportunities for crop diversification.

- Limitations -- Marketing problems, availability of capital, Labour scarcity, Problems relating to inputs, social problems, services, extension and veterinary facilities.
- Crops - Permanent/Timber/Fruits, Other field crops other plants/medicinal plants

- Farm Income (Annual)
  From Livestock
  From Crops, services, other sources

- Requirements of the farm
  What requirements are provided in the farm, requirement of external resources

- Preparation of maps to depict the present situation of the homestead and the paddy field. The maps can be drawn on Bristol boards or old calendar papers with pastal or coloured pencils.

- Preparation of daily routine charts of the family members who involve in farming.

- Preparation of seasonal calendar based on rainfall pattern and suitable time periods for establishment of crops.

All diagrams and charts should be prepared by farmer families. The role of extensionist is to facilitate the process. All other farmers will observe the planning process and contribute their ideas.

At the end of the session, instruct the other farmers to collect information on the existing situation of their farms. Prepare maps, daily routine charts, and seasonal calendars. Decide the next date to meet at the same farm for conducting the planning session. Request all farmers to bring the following information, records, charts when they attend to next session.

Box 5

- Resources, Opportunities and limiting factors in the farm. Resources own by farmer family, required resources from outside
- Maps to depicts the existing situation at the homestead and the paddy field.
- Daily routine chart – of the farmer family
- Seasonal calendar.

Step (4)

Objective To enable farmers to prepare sustainable plans for their farms based on the existing situation.

Method Group exercises

Session guide Request farmer group to meet at the farm where the previous session was conducted. Request the farmers to present the documents prepared and information gathered by them on their farms as agreed in the previous session. Moderate a discussion on preparation of each farmer and make suggestion for improvements.

Explain briefly what is a plan, importance of making plans, short term plans and long term plans. Request farmers to give examples to short term and long term plans, taking the farm where all have gathered as an example. Facilitate the farmer family to prepare long

term plan and shorterm plan for their homestead and the paddy field. Instruct other farmers to look on and observe the process. Facilitate farmers to make the formats necessary for planning. There after plan activities based on the objectives of the farmer family. After demonstrating the prepared long term and short term plans request other farmers to make plans for their farms following the same procedure. Discuss the possible problems that will arise when planning activities.

Box 6

What is a Plan : A series of logical steps taken to achieve an objective.

Planning : Preparation of activities in each step to achieve objectives.

Farm planning : Is a tool, that can be used by farmer families to manage their farm resources efficiently.

Characteristics of a good plan

- Having a definite objective
- Start from the existing situation
- Make improvement of the existing situation
- Objective could be achieved
- Can be divided into phases or stages
- Use Opportunities and capabilities to get maximum output.
- Focus to solve existing problems
- Flexibility is essential.

Box 7

Long term plan

A series of steps determined to achieve objective are in the long term plan. The activities to be carried out over the years are included in a long term plan. There is a definite time frame for each activity.

Short term plan

Short term plan contains activities prepared to achieve objective during a season or in one year. There is a definite time frame for each activity.

Long term and short term plans should contain a time frame for each activity,

Cost estimates and required resources, responsibility for conducting activities and monitoring see annex 1 and 2

Box 8

Factors to be considered in planning sustainable farms

- Creating a living soil

  Add more organic matter, mulching the soils, planting cover crops, planting forest trees, alley cropping.
- Resource conservation

  Minimize soil erosion, plant forest trees, establish wind breaks, reduce gradient of the land, construct bunds and drains, introduce alley crops.
- Improve biodiversity

  Integration of a large quantity of plants and animal species
  - Multiple cropping
  - Inter cropping
  - Crops and livestock integration
- Promote recycling process

  Re-using farm resources, minimizing external resources.

ANNEXTURES

1. **Long term plan for sustainable farming**
2. **Short term plan for sustainable farming**
3. **Present situation of the Home garden**
4. **Present situation of the Paddy field**
5. **Future situation of the Paddy field**

Annex 1

Long term plan for sustainable farming

No	Activity	Time frame year or season					Monitoring	Evaluation

Annex 2

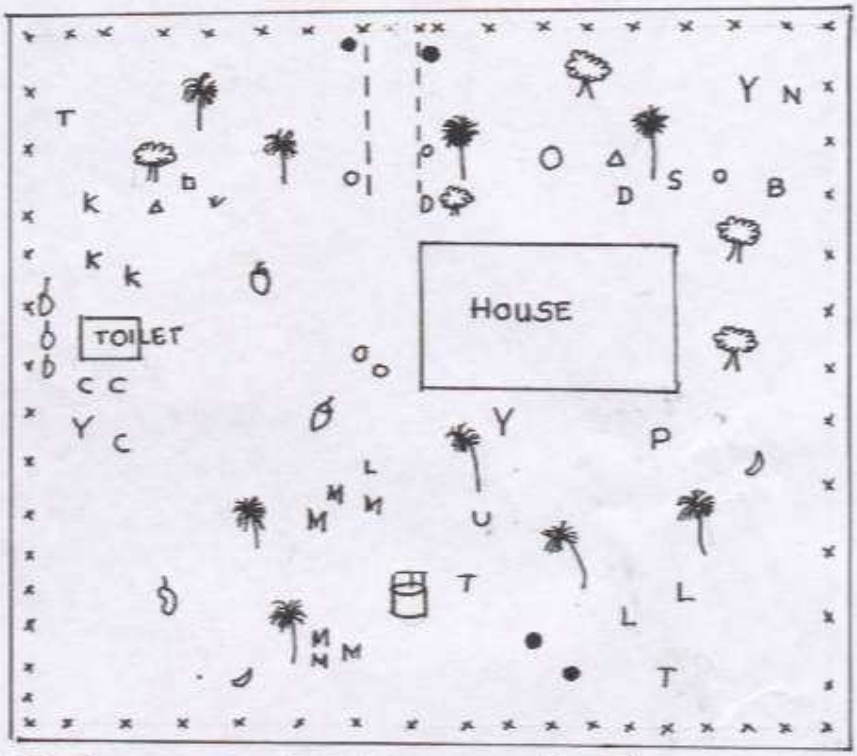
Short term plan – for sustainable farming

Activity	Present Situation	Future Situation	Resources	Estimated cost	Responsibility	Support	Time Frame						Monitoring

Annex 3

PRESENT SITUATION OF THE HOMEGARDEN

(PLAN PREPARED BY A FARMER FAMILY)



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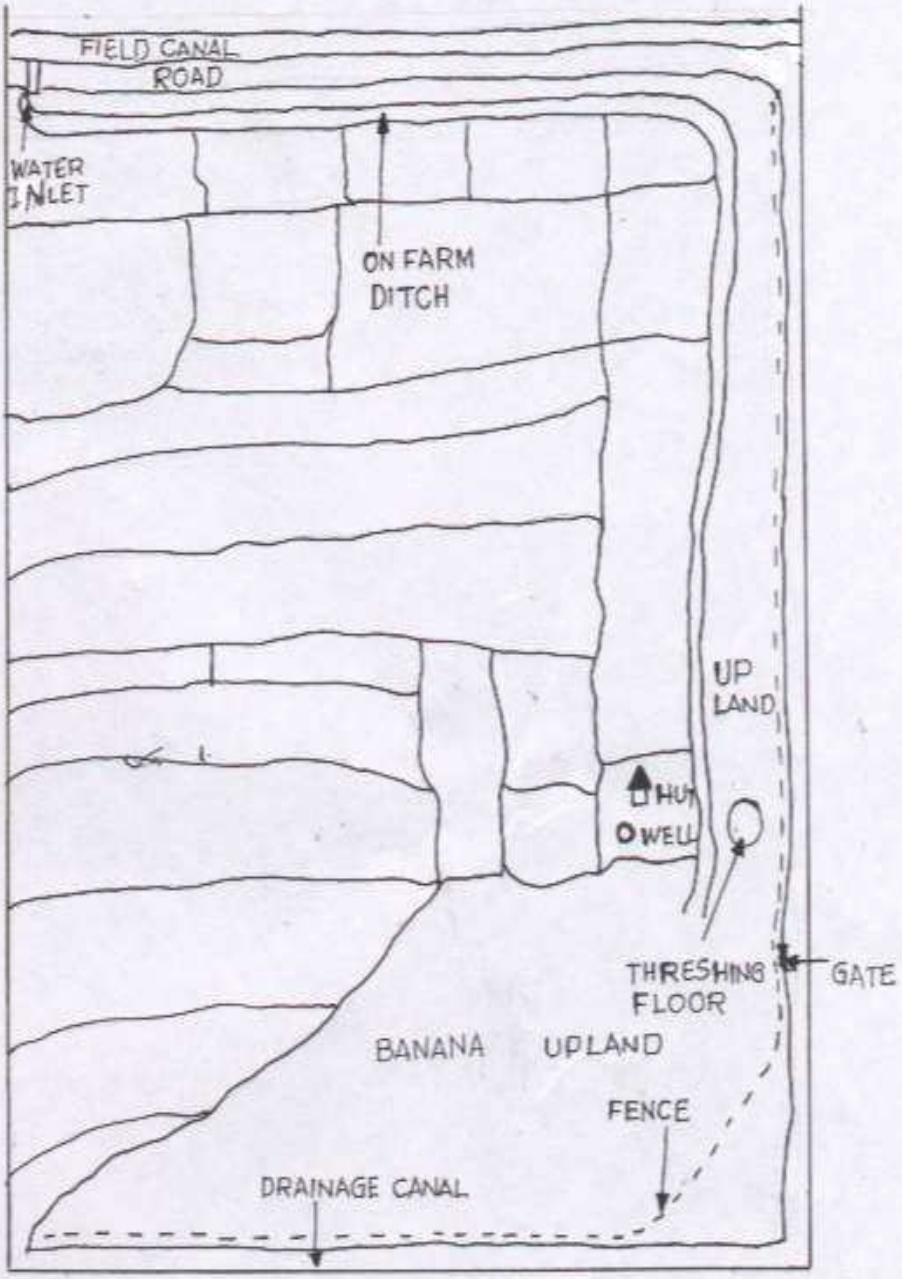
ð	KING COCONUT	v	AMBARELLA	B	BELI
🌳	MANGO	k	KOTTAMBA	u	WOOD APPLE
ð	JACK	c	COFFEE	D	POMEGRANATE
ð	ORANGE	T	TEAK	Y	PAPAVA
				N	DRUMSTICKS
				S	SOURSAP

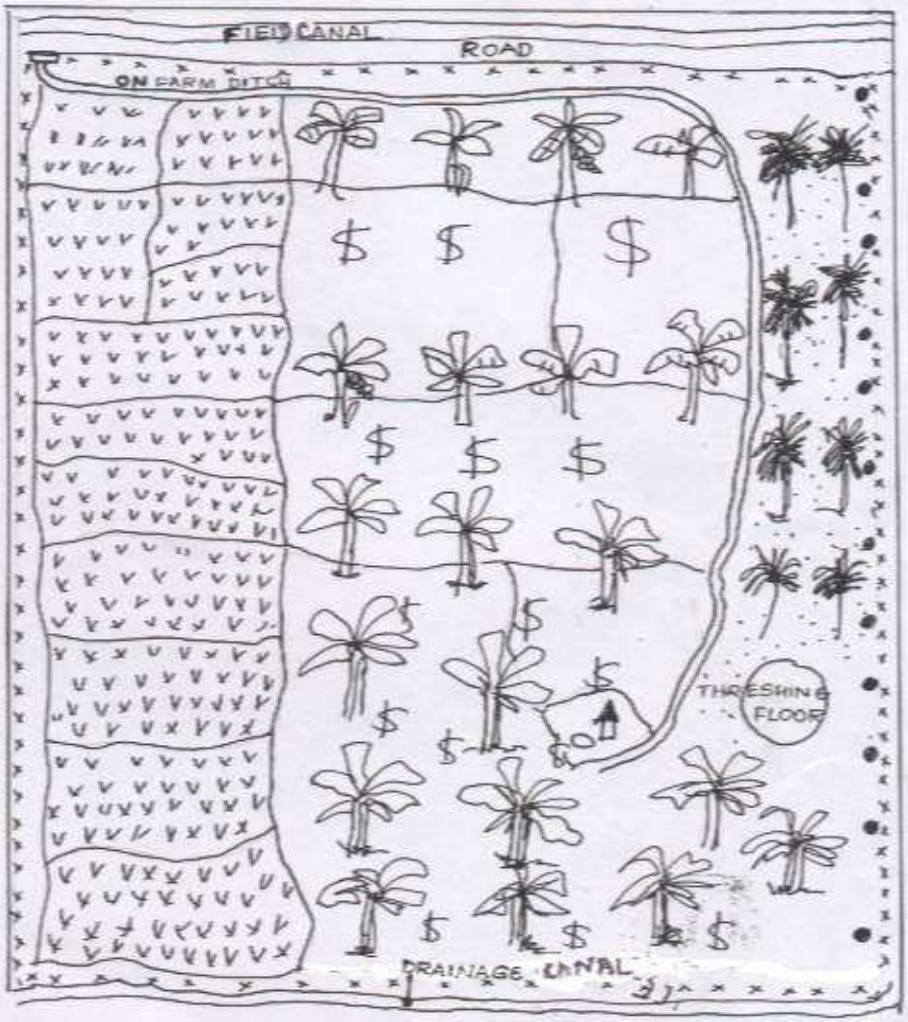
PRESENT SITUATION OF THE PADDY FIELD

(PLAN PREPARED BY A FARMER FAMILY)



FUTURE SITUATION OF THE PADDY FIELD

(PLAN PREPARED BY A FARMER FAMILY)



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