1. Introduction

The growing human population and the intensive agriculture practices with the use of synthetic agro-chemicals like fertilizers, pesticides etc., is exerting great pressure globally on the natural resources used for farming. In the last decade a series of questions are raised which warrants attention in order to produce food, fodder, fibre and other agricultural commodities to the burgeoning population by restoring the natural resources. Some of the concerns are:

- The cost of intensive agriculture has eroded the biological potential of the soil and depleted the underground water resources.

- In intensively cropped areas, more energy in the form of mineral fertilizers, chemical pesticides and farm machinery is required each year to produce the same quantity of grain, or other farm products.

- Increase in damage caused by pests and disease worsening.

- Scientific studies reveal that the modern agricultural system increases the volume of the 'green house gases' in the atmosphere.

- Genetic heterogeneity of earlier agricultural systems is replaced by genetic homogeneity in crops and animals, thereby making them more vulnerable to biotic and abiotic stresses.

- Large subsidies provided in developed and developing countries to encourage farmers to increase productivity.

- Residual toxicity in the food chain and increasing concerns on human health and nutrition.

- Sustainability of agriculture in consonance with economics, ecology, equity, energy and socio-cultural dimension.

These apprehensions have led to a new concept in agriculture where technology development has to pay attention to ecological sustainability along with economic efficiency. Sustainable or alternative agriculture is a new type of agriculture, rich in technology and information and less intensive in the use of energy and market-purchased inputs (Swaminathan, 2006). Sustainable agriculture is a unifying concept, which considers ecological, environmental, philosophical, ethical and social impacts, balanced with cost effectiveness. In other words, ***a system of farming which is ecologically sound, economically feasible and socially just, is the need of the hour.***

1.1 Sustainable Agriculture

Sustainability is defined considering different dimensions, ranging from the narrow focus on economics or production to the incorporation of culture and ecology. In scientific literature sustainability is usually understood in a more holistic way. The International Union for Conservation of Nature (IUCN), United Nations Environment Program (UNEP) and World Wildlife Fund (WWF) defines sustainable development as 'improving the quality of human life while living within the carrying capacity of supporting ecosystems'. This necessitates the conservation and improvement of natural ecosystems through research, training, technology, community co-operation and public policies. The World Bank describes the requirement for sustainable agricultural systems as being "environmentally sound, financially and economically feasible and socially acceptable". (www.worldbank.org)

During rhe earth summit in Rio de Janeiro in 1992, the UN Food and Agriculture Organization (FAO) defined sustainable and rural development as follows:
'Sustainable development is the management and conservation of the natural resource base and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development (in agriculture, forestry and fisheries sectors) conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable'.

In 1995, FAO defined sustainable agriculture and rural development more specifically as a process that meets the following criteria:

- ‘Ensures that the basic nutritional requirements of present and future generations, qualitatively and quantitatively, are met while providing a number of other agricultural products.

- Provides durable employment, sufficient income and decent living and working conditions for all those engaged in agricultural production.

- Maintains and where possible, enhances the productive capacity of the natural resource base as a whole and the regenerative capacity of renewable resources, without disrupting the functioning of basic ecological cycles and natural balances, destroying the socio-cultural attributes of rural communities, or causing contamination of the environment and

- Reduces the vulnerability of the agricultural sector to adverse natural and socio-economic factors and other risks, and strengthens self -reliance’

FAO’s Committee on Agriculture states in “The place of Agriculture in Sustainable Development”, 2001, that “Sustainable Agriculture must address issues of economic efficiency, social responsibility and environmental quality. Focus only on environment without considering farmers’ social or economic problems is unlikely to succeed.” It is important that these goals have to be applied to all sectors of the production chain, from production and processing to marketing and consumption.

Over a long period efforts were made internationally to crystallize and implement the concept of sustainability within agriculture. Recently this is being approached through the development of a concept for Good Agriculture Practices (GAP) by FAO, which is intended to tackle major challenges of agricultural production concerning environmental, social and economic benefits. It is difficult to determine priorities between economic, ecologic and social aspects in terms of their impact on the sustainability of farming systems in certain complex situations. Can higher economic benefits compensate ecological or social inadequacy? Can a farming system with a focus on ecological concerns than on economic problems be considered sustainable in the future? These questions are region specific and needs to be answered looking into the local situations.

1.2 Why Sustainable Agriculture?

The importance of sustainable agriculture in comparison to the conventional agriculture (synthetic chemical based like use of fertilizers and pesticides, hormones etc.) can be envisioned through three dimensions, ecological, economic and social.

1.2.1 Ecological Sustainability

Conventional agriculture is not ecologically sustainable as the usage of lot of fossil energy has a direct impact on the natural resources, reducing soil fertility, causing soil erosion and contributing to the global climatic change. The principles and practices of sustainable agriculture are ecologically sound and has many advantages,

Soil fertility

The use of synthetic fertilizers and pesticides has a detrimental impact on the fertility of the soils. Sustainable agriculture improves the fertility of the soils by promoting the development of earthworms and soil flora and fauna. The utilization of the crop residues and weeds into soil through appropriate composting technologies improves the organic matter and avoids acidification, improve soil structure, percolation and soil aggregate stability which in turn prevents soil erosion.

Water

The main threats posed by conventional agriculture on quality of water are, use of fertilizers, lack of protective soil cover, narrow crop rotations and frequent tillage, high levels of available nitrogen after harvest and contamination of water by application of synthetic pesticides. Sustainable agriculture practices improve the organic matter of the soil which in turn enhances the percolation and retention of the ground water resulting in increased ground water recharge thereby reducing run-offs.

Biodiversity

The major reason for the destruction of the biodiversity is the conversion of multifunctional, integrated ecosystems into production units - ‘factory farms’ wherein monoculture is practiced. It not only reduces the crop diversity but the numerous varieties of an individual crop reduce drastically. In addition, the use of synthetic agrochemicals wipes off the indigenous population of organism such as mycorrhizal fungi, actinomycetes and thus disturbs the nutrient cycling of the soil eco-system. Sustainable agriculture rejuvenates the biodiversity in agro-ecosystems.

Pollution

Conventional agriculture pollutes the ecology and the food, leading to a series of health hazards and pollution problems. Such hazardous chemicals are not used in sustainable agriculture, instead various herbal products, biological and agronomic practices are adopted to manage the pests.

Landscape

The rural landscape is clad with agriculture and forestry. Inappropriate use of landscape causes erosion, landslides and flooding, clogs irrigation channels and reduces the ability of land to support the local population. Impoverished rural people migrate to the cities creating slums which further destroy the landscape. Rehabilitating ecologically damaged areas needs huge investments which few countries can afford. Sustainable agriculture avoids these problems by improving productivity, conserving the soil, avoiding the expansion of farming into unsuitable areas and preserving rural jobs.

Climate

The modern agriculture contributes significantly to the global climatic change. Such impacts can be reduced significantly by adopting sustainable agriculture.

1.2.2 Economic Sustainability

The long term economic viability is vital for the sustainability of agriculture.

Export Vs domestic

Governments tend to view export-oriented production systems as more important than those that supply domestic demands. Focusing on exports alone involves hidden costs in transport, in assuring local food security etc. Policies should treat domestic demand and in particular food security (either by farmers producing food for themselves, or by selling produce for cash they can use to buy food) as equally important to the visible balance.

Debt

Conventional agriculture which depends on expensive inputs put the farmers into debt trap. On the other hand, technologies which promote sustainability rely heavily on knowledge as a substitute for capital. Farm produced inputs as substitutes for market purchased ones.

Risk

Concentrating on specific commodities seems to promise high economic returns. But market production implies certain risks like volatile market changes and fluctuating international prices.

Niche markets

Organic agriculture is one of the strongest ways to farm in an environmentally sustainable way. The demand for certified organic products is increasing quickly, opening opportunities to expand sales of such products and to explore not only the niche markets but slowly and surely make available to a wider spectrum of the market.

Employment

Farming is the main source of employment for the rural people. Trends towards specialization and mechanization may increase narrowly measured 'efficiency', but they reduce employment on the land. The welfare costs of unemployment must be taken into account when designing national agricultural support programmes. Sustainable agriculture, with its emphasis on small-scale, labour saving technology, helps overcome these problems in Bhutan.

1.2.3 Social Sustainability

The social sustainability of farming techniques is related to the ideas of social acceptability and justice. Ignoring these risks result in losing valuable local knowledge and provoking political unrest.

Justice

Development cannot be sustainable unless it reduces poverty for a large mass of people. Programs should be designed in such a way to enable the rural poor to benefit from agriculture development.

Political unrest

Gaps between ‘haves’ and ‘have not’s’ feed a feeling of social injustice and among those who feel neglected and excluded from development opportunities, as well as from better-off sympathizers. The result is a climate favourable to political opposition and even violence.

Local acceptance

Many new technologies fail because they are based on practices or assumptions from outside. Sustainable agricultural practices usually are based on local social customs, traditions, norms and taboos, so local people are more likely to accept them and adapt them to their own needs.

Indigenous knowledge

Sustainable agricultural practices often rely on traditional know-how and local innovation. Local people have a wealth of knowledge about their environment, crops and livestock. They keep locally adapted breeds and crop varieties. They have social structures that manage and conserve common resources, help people in need, and maintain the social fabric. Rather than ignoring or replacing this knowledge, sustainable agricultural development seeks to build on it and enrich it with appropriate information from outside.

Gender

In modern conventional farming, men often benefit the most: they control what is grown and spending of the resulting income. Sustainable agriculture attempts to ensure that the burdens and benefits are shared more equally between men and women. Thereby, reintroducing practices where women played a crucial role in seed saving and production.

Food and Nutritional Security

Sustainable agriculture improves food security by improving the quality and nutritional value of the food and producing a wider range of produce throughout the year (GTZ Sustainet,2006).

1.3 Background of Organic Agriculture

Among the various alternatives, organic farming is gaining acceptance through out the globe as it has a potential to provide pragmatic solution to mitigate the sequel of maladies of conventional modern farming. In Asia, the Hindu, Buddhist and Jain monks visualized the sustainability of agriculture through the non-violent approach, before facing the onslaught of chemical farming, which is apt at present.

Organic agriculture is getting popular globally due to the unprecedented demand for natural foods in the developed world and growing awareness regarding the health and environmental hazards related to the conventional chemical agriculture. Decline in food production, degeneration in native soil fertility and deterioration in environmental quality have emerged as the biggest problems facing global agriculture today. The tremendous demand for organically produced food at the international market is evident from the growing retail sales of the organic products in the developed countries. U.S, Europe and Japan are the biggest markets for the organically grown products. The retail sales of organic products in US and Europe are to the tune of $ 8 billion and $ 8.4 billion respectively. Japan is also a major importer of organic products. The growing awareness on healthy food and increasing demand of organic products in the international market has led to the creation of new export avenues for the developing countries.

Organic farming is a production system, which excludes the use of synthetically compounded fertilizers, pesticides and growth regulators. It relies on organic manures produced from farm wastes and other biomass. It also encompasses a conglomeration of various techniques and practices like intercropping, mulching, cover cropping, trap cropping etc. Organic farming also employs various biological pest control methods, which eliminates the use of synthetic chemicals even at the storage levels.

A thorough understanding of agro ecological parameters of the locality is required to make organic farming a sustainable and feasible production system. Eventually, this helps to adopt the locally suitable methodologies with a proper and appropriate combination of various resources available on the farm. Being a holistic production management system, organic farming will promote and enhance environmental quality including biogeochemical cycles and soil floral and faunal activities. The stress is on improving the on-farm management rather than off-farm external inputs.

Though there is a growing demand for safe food products in the international market, the aim of organic agriculture is not exports alone. It has a great role in improving the livelihoods by reducing the cost of production of the poor small and marginal farmers who have small land holdings. With the increasing cost of inputs like fertilizers and pesticides farming is not economically feasible. The only option left is to identify low cost agriculture technologies which not only reduce the cost of production but also brings in sustainability to agriculture. The most important factor in low cost agriculture is that all the inputs have to be prepared in the farm and the off-farm inputs have to be reduced to the extent possible.

1.4 Low-cost Organic Agriculture Systems

Different low-cost organic agriculture systems are being practiced all over the world. Some of the systems which are most popular are mentioned below.

1.4.1 Vedic Agriculture

Vedic agriculture pertains to the knowledge of farming which is presented in the age old Indian scripture the 'Vedas' about 10,000 years ago. The ancient (Vedic) Indian culture taught to venerate the earth as mother, sky as father, air as *prana* (soul), the sun as energy and the water streams as life sustaining veins (Thimmaiah,2006).This system of farming makes use of various forms of inputs and it is not just some preparations made for providing nutrition or managing problems. The Vedic way of agriculture comprises of :

(a) Farming operations

(b) Yajnas and Ishtis.

Farming operations include the biological practices of cultivation. But the unique feature in the Vedic system is performing the cultivation practices at a right time. There is a lot of significance of the Panchamahabhutas *i.e.* the five basic elements prithvi (Earth), aap (Water), tejas (Fire or light), vayu (Air) and akasha (Space). Bhutas means the living creatures. Mahabhutas are prior and superior to living beings since the very existence of the latter is totally dependent on them. The Mahabhutas are the primary natural resources essential for all agriculture. These Panchamahabhutas have a significant effect on all living beings including plants. In Vedic agriculture, all the activities of farming are prescribed to be done at a specific time. The time bound nature of activities helps to harness the maximum positive effect of the Panchamahabhutas. This can be achieved by synchronizing all the activities as per the Panchang or the planting calendar. Planting calendar is a very important and a no cost input which can be easily adopted.

Second emphasis is on the importance of Cow in vedic agriculture. It is said in the Indian scriptures that all the deities reside in different body parts of the cow. A variety of preparations can be made from the cow dung, cow's urine, cow's ghee, cow's milk, and curd or yoghurt made out of cow's milk. The preparations which are commonly made from these products and are widely use as inputs in agriculture are:

(i) Panchagavya

(ii) Amrit Pani

(iii) Matka Khad

In addition, a variety of preparations for nutrition, pest and disease management are made by utilizing various medicinal herbs and other plants. Medicinal herbs like Shatavari (*Asparagus spp.*), Bhallataka (Marking nut), Ashwagandha (Winter cherry), Kana (Long pepper), Guggulu (*Comniphora mukul*), Asana (*Terminalia tomentosa*), Shatapushpa (Dill seeds), Triphala, Karanja (*Pongamia glabra*), Adathoda etc. and other plants like Haridra (Turmeric), Ginger, Oleander, Karavira (*Nerium*), Tulasi (*Ocimmum spp.*), Tobacco, Langli (*Gloriosa superba)*, Arka (*Calotropis*) and Sami (*Prosopis spp.*) are used in plant protection.

Yajnas or Ishtis are the second major component of the vedic farming. Yajna is an offering of specific ingredients into fire prepared from specific materials in a pyramid pot of copper or earth or altars of specific shapes at stipulated timings. Yaga, Homa, Ishtis and Agnihotra are different names or forms of Yajna. Yajna is operated in different procedures and as such is known by different names. Yajna, Homa and Istis are performed at specific occasions. The special feature of Homa farming lies in generation and utilization of subtle energy released by Agnihotra for the activation of organic manure and bio-energy. It is based on the principle that you heal the atmosphere and the healed atmosphere heals you. It replenishes the nutrients that pollution robs from the environment. Agnihotra is gaining lot of popularity by the farmers in Germany, Poland and Latin American countries like Peru, Venezuela, and Ecuador.

1.4.2 Organic Agriculture

Organic agriculture as widely known also involves the basic cultural practices of farming and the use of certain inputs for providing nutrition and protection to the plants. USDA defines organic farming as a system that is designed to produce agricultural products by the use of methods and substances that maintain the integrity of organic agricultural products until they reach the consumer. The basic practices include crop rotation, mixed cropping, intercropping, strip cropping, trap cropping, mulching, tillage operations, use of natural predators *etc*. These practices help to manage the problems of pests to a larger extent. In addition, the inputs used in organic farming are:

(i) Vermicompost

Vermicompost serves a dual benefit of providing good quality manure with natural nutrients for the soil and plants as well as solve the problem of wastes at the farm.

(ii) Biofertilizers

Biofertilizers have a tremendous potential of providing nutrients to the soil and plants by converting the nutrients from the non-available to the available form by the biological process of nitrogen fixation and phosphate solubilization *etc*. The microorganisms widely used singly and in combinations for these purposes are *Azotobacter, Azospirilium* and Blue green algae, Azolla *etc*. These can meet the nitrogen requirements of the crops to a larger extent. However, there are many other microbes which mobilize the nutrients and improve the quality of soils by different ways and their efficiencies should be tapped under sustainable agriculture.

(iii) Botanicals (Bio pesticides)

Botanicals are the preparations made from specific plants for managing the pest and disease problems of the plants. A wide base of a variety of plants exist, different parts of which can be utilized in making the botanicals. A few to list are *Adathoda zeylanica, Adathoda vasica, Agave americana, Allium sativum, Anacardium occidentale, Argemone mexicana, Azadirachta indica, Brassica campestris, Capsicum frutescens, Cassia tora, Cinnamomum verum, Ocimum sanctum, Parthenium bysterophorus, Sesamum indicum, Annona squamosa, Melia azadiract, Hardwikia binata* *etc*.

1.4.3 Biodynamic Agriculture

Biodynamic Agriculture is a holistic system of farming developed by Dr. Rudolf Steiner in 1924. This system of farming is based on the lines of traditional systems being practiced in India since ages. It is based on systematic and synergistic harnessing of energies from cosmos, earth, plant and cow. It includes certain dynamic practices in addition to the basic biological practices of cultivation. The inputs utilized in this system are:

i) Biodynamic (BD) preparations numbered from 500-508

ii) Liquid manures

iii) Cow Pat Pit manure (CPP)

iv) Biodynamic stem paste

The biodynamic preparations are numbered from 500 to 508. Preparation 500 and 501 are made by using cow dung and quartz silica. The other seven preparations are made by fermenting parts of certain herbs in a peculiar manner. These herbs are yarrow, chamomile, stinging nettle, oak bark, dandelion, valerian and equisetium respectively. These preparations are called the compost preparations and are utilized in making the biodynamic compost. These preparations activate synthesis of different nutrients in the final biodynamic compost. These are the components of biological agriculture, capable of affording long-term sustainability to agriculture and particularly to the ecosystem.

Other preparations like liquid manures, CPP and biodynamic stem paste are utilized for a number of cultural practices in farming. Another unique feature in biodynamic agriculture system is the use of biodynamic planting calendar for various farm operations. Efforts are made to enliven the soil and restore its fertility in the form of humus, increase the living system of soil by skilful application of appropriate crop rotation (Thimmaiah and Anjali 2004).

1.4.4 Permaculture

The word "permaculture" was coined in 1978 by Bill Mollison, an Australian ecologist, and one of his students, David Holmgren. It is a contraction of "permanent agriculture" or "permanent culture."

Permaculture is about designing ecological human habitats and food production systems. It is a land use and community building movement which strives for the harmonious integration of human dwellings, microclimate, annual and perennial plants, animals, soils, and water into stable, productive communities. The focus is not on these elements themselves, but rather on the relationships created among them by the way we place them in the landscape. This synergy is further enhanced by mimicking patterns found in nature (Mollison and Holmgren, 1987).

The central theme in permaculture is the design of ecological landscapes that produce food. Emphasis is placed on multi-purpose plants, cultural practices such as sheet mulching and trellising, and the integration of animals to recycle nutrients and graze weeds.

However, permaculture entails much more than just food production. Waste water treatment, recycling, and land stewardship in general, are other important components of permaculture. More recently, permaculture has expanded its purview to include economic and social structures that support the evolution and development of more permanent communities, such as co-housing projects and eco-villages. As such, permaculture design concepts are applicable to urban as well as rural settings, and are appropriate for single households as well as whole farms and villages.

Permaculture principles focus on thoughtful designs for small-scale intensive systems which are labour efficient and which use biological resources instead of fossil fuels. Designs stress ecological connections and closed energy and material loops. The core of permaculture is design and the working relationships and connections between all things. Each component in a system performs multiple functions, and each function is supported by many elements. Many of the appropriate technologies advocated by permaculturists are well known. Among these are solar and wind power, composting toilets, solar greenhouses, energy efficient housing, and solar food cooking and drying.

Farming systems and techniques commonly associated with permaculture include agro- forestry, contour plantings, hedgerows and windbreaks, and integrated farming systems such as pond-like aquaculture, aquaponics, intercropping and polyculture. Gardening and recycling methods common to permaculture include edible landscaping, companion planting, trellising, sheet mulching, solar greenhouses, spiral herb gardens, and vermicomposting. Water collection, management, and re-use systems like rain catchment, constructed wetlands, aquaponics (the integration of hydroponics with recirculating aquaculture), and solar aquatic ponds play an important role in permaculture designs.

1.4.5 Effective Microorganisms (EM)

For many years, soil microbiologists and microbial ecologists have tended to differentiate soil microorganisms as beneficial or harmful according to their functions and how they affect soil quality, plant growth and yield, and plant health. Beneficial microorganisms are those that can fix atmospheric nitrogen, decompose organic wastes and residues, detoxify pesticides, suppress plant diseases and soil-borne pathogens, enhance nutrient cycling, and produce bioactive compounds such as vitamins, hormones and enzymes that stimulate plant growth. Harmful microorganisms are those that can induce plant diseases, stimulate soil-borne pathogens, immobilize nutrients, and produce toxic and putrescent substances that adversely affect plant growth and health. A more specific classification of beneficial microorganisms has been suggested by Higa which he refer to as "Effective Microorganisms" or EM.

The concept of effective microorganisms (EM) was developed by Professor Teruo Higa, University of the Ryukyus, Okinawa, Japan. EM consists of mixed cultures of beneficial an naturally-occurring microorganisms that can be applied as inoculants to increase the microbial diversity of soils and plant. Research has shown that the inoculation of EM cultures to the soil/plant ecosystem can improve soil quality, soil health, and growth, yield, and quality of crops. EM contains selected species of microorganisms including predominant populations of lactic acid bacteria and yeasts and smaller numbers of photosynthetic bacteria, actinomycetes and other types of organisms. All of these are mutually compatible with one another and can coexist in liquid culture.

EM is not a substitute for other management practices. It is, however, an added dimension for optimizing our best soil and crop management practices such as crop rotations, use of organic amendments, conservation tillage, crop residue recycling, and biocontrol of pests. If used properly, EM can significantly enhance the beneficial effects of these practices (Higa and Wididana, 1991).

1.4.6 Natural Farming

The concept of natural farming was developed by Masanobu Fukuoka, a Japanese ecologist. Natural farming advocates a ''do-nothing' approach to agriculture. Fukuoka's approach has similarities to organic agriculture and permaculture, but also has many features that are unique such as not preparing compost and using seed balls instead of sowing or planting seedlings. The four basic tenets to natural farming are,

a) No cultivation - that is, no ploughing or turning the soil, the earth should be left to cultivate itself naturally by the penetration of plant roots, and the activity of micro-organisms and earthworms.

b) No chemical fertilisers - left alone the soil can maintain its own fertility through the cycle of plant and animal life. The only manure used is a light layer of poultry manure on top of the straw and clover mulch and this is usually provided by ducks and chickens roaming free.

c) No weeding by tillage or herbicides – weeds play a part in building soil fertility and should be controlled by mulch and other natural means rather than eliminated.

d) No pesticides – the best approach to disease and insect control is to grow sturdy crops in a healthy environment. Natural predators should be encouraged to take care of any unwanted pests.

1.5 Principles of Organic Agriculture

The main principles of Organic agriculture are

1) Principle of Health

The health of the human beings and communities cannot be separated from the health of the ecosystems. Always healthy soils produce healthy crops and create healthy environment.

2) Principle of Ecology

Organic agriculture should attain ecological balance through the design offarming systems, establishment of habitats and maintenance of genetic and agricultural diversity. The management practices must be adapted to the local conditions, ecology, culture and scale.

3) Principle of Fairness

Fairness is characterized by equity, respect, justice and stewardship of the shared world both among people and in their relations to other living beings. Organic agriculture should provide food sovereignty, reduction of poverty and good quality of life to all.

4) Principle of Care

Precaution and responsibility are the key concerns in management, development and technology choices in organic agriculture. Along with scientific understanding practical experience, traditional wisdom, indigenous knowledge which are time tested provide valid solutions to ensure agriculture is healthy, safe and ecologically sound (IFOAM Brochure, 2007)

All the 4 broad principles are befitting the rich culture and heritage of the people of Bhutan.

The above principles of organic farming are achieved by :

i. protecting the long term fertility of soils by maintaining organic matter levels, encouraging soil biological activity, and careful mechanical intervention.
ii. providing crop nutrients indirectly using relatively insoluble nutrient sources which are made available to the plant by the action of soil micro-organisms.
iii. nitrogen self-sufficiency through the use of legumes and biological nitrogen fixation, as well as effective recycling of organic materials including crop residues and livestock manures.
iv. weed, disease and pest control relying primarily on crop rotations, natural predators, diversity, organic manuring, resistant varieties and

limited (preferably minimal) thermal, biological and chemical intervention.

v. the extensive management of livestock, paying full regard to their evolutionary adaptations, behavioral needs and animal welfare issues with respect to nutrition, housing, health, breeding and rearing.

vi. careful attention to the impact of the farming system on the wider environment and the conservation of wildlife and natural habitats.

1.6 Bhutan – The Land of Thunder Dragon

The Kingdom of Bhutan is located in the eastern Himalayas and landlocked between India and China. The Bhutanese call their country 'Druk Yul' or the Land of Thunder Dragon. It has a geographical area of 38,394 square kilometres. The country is mostly mountainous and the elevation ranges from 150 meters above the mean sea level in the south to 7,550 meters in the north, resulting in extreme variation of climate, geography and bio-diversity. About 72% of the area is under forest cover, 10% of the land is covered by snows and glaciers, about 8% is used for agriculture and human habitation and the remaining areas are under pastures or meadows, lands used for tseri or shifting cultivation or barren rocky areas. (RoGB, 2002).At present considering the non-sustainability of tseri or shifting cultivation it is not encouraged by the government of Bhutan.

There are many languages and ethnic groups within the country, the *Lhotsampa (of Nepali origin)* in the south, the *Ngalongs* (or *Drukpas*) in the west and the *Sharchops* in the east are the three main ethnic groups. Except Nepali language, most of the dialects belong to the Tibetan-Burmese origin. The national language of Bhutan is *Dzongkha*. The country is divided into 20 dzongkhags (districts) which in turn are divided into 201 geogs (blocks). Each dzongkhags is administered by the Dzongkhag administration.

Economic progress in Bhutan started from 1961 after the economy was opened to the rest of world after a self imposed isolation which marked the end of period of barter economy and beginning of the state-led development. This included building and development of government institutions to propel the growth in infrastructure, education, agriculture, forestry, hydro-power and market economy with an overall aim to achieve self-reliance. In spite of late entry into the arena of economic development, Bhutan has made a remarkable progress in achieving a per capita GDP of USD 51 in 1961, USD 835 in 2002 and USD 948 in 2004, higher than the neighboring countries like India, Nepal and Bangladesh. Bhutan's approach to development is quite unique which is guided by a concept of 'Gross National Happiness' (GNH) enunciated by His Majesty King Jigme Singye Wangchuk in the late1980's. This holistic approach comprises of four pillars like, Good governance, Sustainable use of natural resources, Protection and conservation of environment and Preservation and Promotion of Cultural Heritage.

The total population of Bhutan as of May 2005 is 634,984 and the country's population density is 16.5 persons per square kilometer which is one of the lowest in the world. Largely and agrarian country, about 80% of the population live in rural areas who directly depend on agriculture and livestock as their livelihoods. Nearly 65,000 farming households are scattered in small and remote villages. Each village comprises of a dozen to hundred households or families. Land is fairly distributed in the country. According to the RNR census 2000, nearly 14% of the households own less than 1.0 acre and 56% of the households have land holdings between 1.00 and 5.00 acres, while 2.6% of the rural households do not have any agricultural land and they earn their livelihood by working as agricultural laborers (Statistical Yearbook of Bhutan, 2004).

There is a strong, direct relationship between agricultural productivity, hunger and poverty. Food insecurity is looked in terms of availability of food, access to food and utilization of food. Availability of food refers to production and physical availability of food in a given area which is a community level concern. Accessibility refers to economic access to food reflecting the purchasing power of people concerned which is a household level concern. Utilization is the proper usage and consumption of food commanded by a household and its members for their entitlement which is an individual level concern. Most poverty is concentrated in the rural areas, especially amongst small and marginal farmers and landless households. In Bhutan poverty in the rural areas comprises about 38% against the urban poverty about 4 percent. According to BLSS 2003, agricultural activities constitute 95% of the income of the rural poor. The task of reducing poverty and food insecurity is quite challenging for Bhutan and calls for urgent need for strategies that better target the areas where poor people live and the activities on which their livelihoods depend.

The moot questions are, how to develop sustainable livelihood systems that would facilitate the rural poor? And what are the requirements of small and marginal farmers to adopt sustainable agriculture on a large scale?

1.6.1 Agriculture

In Bhutan different types of farming systems exist like, dryland farming, wetland for rice cultivation, tseri or shifting cultivation. Community based agriculture utilizing the forest areas are also into vogue, the leaf litter from the forest are collected and used in farming which is commonly referred as ‘Sokshing’. In some cases, the marginal land is cultivated and is referred as ‘Pangshing’.

The country is mostly agrarian with 80% of the population depend directly on small scale mountain agriculture and livestock farming for their livelihoods. The total arable land available for farming is about 8% of the geographical area due to mountainous terrain. Only few households have enough land to meet their needs by farming alone. A majority of the farmers depend directly on off-farm livelihood sources like forest produce, while the remaining migrate to towns and cities. Due to small land holding and limited availability of cultivable land, poor soil quality coupled with low productivity, low cropping intensity, labour shortage in farms, wildlife problems and shift in the production of cereals for self consumption to production of cash crops, the food production does not meet the food requirements of the country therefore the yearly imports are on the rise to fill up the gap. Bhutan imports 30% of the cereals mainly rice, 75% of edible oil and 50% of pulses to meet its domestic requirements (MoA and WFP, Bhutan, 2005).

The Bhutanese people for centuries have been living in co-existence with nature with a perfect harmony between man, plants, animals and the habitat. Living in isolated areas, agriculture is a way of life for the farming community. The customs, traditions and rich folklore nurtured in the lap of nature, in the forests and valleys of rivers coursing down from the mighty Himalayas, imbibed with a deep sense of oneness with all things natural.

Agriculture in Bhutan

Several aspects of traditional knowledge systems are relevant, such as knowledge of farming practices and the physical environment, biological folk taxonomic systems, or use of low- input technologies. By understanding ecological features of traditional agriculture, such as the ability to bear risk, production efficiencies of symbiotic crop mixtures, recycling of materials, reliance on local resources and germplasm, exploitation of full range of micro-environments, etc., it is possible to obtain important information that may be used for developing appropriate agricultural strategies tailored to the needs, preferences and resource bases of specific peasant groups and regional agro-ecosystems.

1.6.2 Buddhism and Agriculture: A communion

Agriculture has a strong influence on the customs and rituals of Buddhism. According to Buddhism, the life patterns of all living organisms are woven into the cosmic rhythms. The present scientific world may not accept the fact regarding the influence of the cosmic rhythms and the constellations on the life forms. Human life, as well as animal and plant life, is strongly dependent on the rhythms of the earth. The plant and animal life is instantly influenced by the sidereal and synodic relationships of the sun, earth, moon and other planets. On the basis of such influences the agricultural operations are planned accordingly in Bhutan. For instance, the sowing of seeds and the ploughing of land was carried out nearing the full moon, while felling of timber was undertaken during the no moon.

Culture in Agriculture

Many rituals are followed by farmers in farming. Some of the rituals are done at the time of sowing and transplanting, others during the crop growth or after the harvest of the crop. A ritual popularly known as 'Jingse' is still followed by the farmers in many parts of Bhutan. The lamas are invited by the villagers and they burn wood of some special trees along with the incense and chant the prayers. The ash is distributed in the field as a potentized preparation. Jingse is also practised when there are pest problems in the field. Many farmers claim the success of this method in managing the pests. Documentation of this method and scientific research is necessary to validate the results. Many festivals in Bhutan are so well timed, which mark the sowing or harvest of crops.

Seed conservation and sharing of seeds is an integral component of agriculture. In many situations seeds are gifted or exchanged amongst neighbouring villages and friends. Crops like chillies, maize, garlic are tied in bunches and hung in the house facing the east direction. The fruits and pods which are bigger in size are set aside for conservation and storage. It is a common practice to keep seeds for two planting seasons. This is a wonderful system of seed sharing and conservation which is imbibed in the rich culture and heritage which needs to be nurtured. The fresh produce of rice, after the harvest are also gifted to the friends.

Seed Conservation

Organic agriculture is a non-violent farming system which facilitates living in tandem with nature in consonance with the ancient Buddhist wisdom. Delineation from the rich culture and heritage has led to the poor understanding of the science behind the religious practices. Buddhism prohibits violence.

In agriculture, the use of synthetic agro-chemicals like fertilizers and pesticides etc which destroy the soil, beneficial microbes, insects and every biota is contradictory to Buddhist way of life. This is not a mere philosophy but has a strong scientific basis. Even today large numbers of farmers in Bhutan avoid killing pests like insects and wild animals with the use of pesticides which is a perfect beginning for sustainable agriculture.

There is a wide range of traditional scientific knowledge on how to practice sustainable agriculture; the daunting challenge is appropriate steps needed to implement these techniques on a larger scale. With pristine condition of nature and strong policy for nature conservation, Bhutan holds a great potential towards sustainable agriculture by choice and design.

2. Standards, Regulations and Certification

To protect the interest of consumers regarding the quality of organic farm produce some regulatory measures have been adopted in production and marketing of such products. These measures ensure quality production of the products. Certain regulatory measures are developed by the national governments while others by the consumers or farmer federations. In Bhutan, there is a necessity to develop national standards and appropriate regulatory mechanism. Some of the regulatory mechanisms which have become very popular are furnished below

2.1 Good Agricultural Practices (GAP)

The concept of Good Agricultural Practices (GAP) has evolved in recent years in the context of a rapidly changing and globalizing food economy. In addition, the concerns and commitments of a wide range of stake holders on food production and security, food safety and quality and the environmental sustainability of agriculture have also promoted the concept of GAP. These stakeholders include governments, food processing and retailing industries, farmers and consumers.

According to the Food and Agriculture Organization (FAO), GAP is the application of available knowledge to address environmental, economic and social sustainability for on-production and post-production process resulting in production of safe and healthy food and non-food agricultural products. Many farmers in developed and developing countries already apply GAP through sustainable agricultural methods such as integrated pest management, integrated nutrient management and conservation agriculture. These methods are applied in a range of farming systems and scales of production units, facilitated by supportive government policies.

Now GAP is formally recognized in the international regulatory framework for reducing risks associated with the use of pesticides, taking into account public and occupational health, environmental and safety considerations. There are many codes of practice in line with GAP which are designed by the producers organizations e.g. Comite de Liaison Europe, Afrique, Caraibes, Pacifique

(COLEACP), importers and retailers consortia e.g. British Retail Consortium (BRC), Fresh Produce Consortium (FPC), Euro-Retailer Produce Working Group (EUREP) and government bodies representing consumers e.g. UK Food Standard Agency. In UK many supermarkets have their own codes of practice for the suppliers in addition to GAP. This increasing trend of acceptance of GAP by the consumers and the retailers provides incentives to the farmers by paying a premium wherein farmer would find alternatives to reduce the contamination right from the sowing of crop to harvest. GAP applies to a wide range of food/agricultural commodities that include fruits and vegetables, dairy products, medicinal and aromatic herbs, ornamentals, aquaculture etc.

2.1.1 Risk Minimizing Measures

Some of the risks minimizing measures in GAP are mentioned below

2.1.1.1 Pre-planting Measures

Site Selection

Land or site for agricultural production selected is on the basis of land history, previous manure applications and crop rotation.

Manure handling and field application

Proper and thorough composting of manure, incorporating it into soil prior to planting and avoiding top dressing on plants are important steps to be followed.

Manure storage and sourcing

Manure is stored in shade with sufficient aeration. It is important that during the aerobic composting process, high temperature to be achieved to kill most harmful pathogens.

Timely application of manure

Manure to be applied at the end of the season to all planned vegetable ground or fruit orchard. If applied at the start of a season, then it should be spread two weeks before planting, preferably to grain or forage crops.

Selection of appropriate crop

A variety of crops adapted to the local area to be cultivated in an area.

2.1.1.2 Production Measures

Irrigation Water Quality

Irrigation water should be free from pathogens and pesticide residues. Surface water is tested quarterly in the laboratory for any contaminations. Farmers can filter or use the settling ponds to improve water quality.

Irrigation Methods

It is always advisable to use drip irrigation to reduce the contamination because the edible parts of most crops are not wetted directly. It also enhances the water use efficiency.

Field sanitation

Great care to be taken to prevent the spread of human and animal pathogens. Animals especially poultry are not allowed to roam in the field especially close to the harvest time.

Worker facilities and hygiene

The farm workers are provided with hygienic well maintained toilet facilities around the farming areas. Farmers should get proper training to make them understand the relationship between food safety and personal hygiene. These measures are to be monitored and enforced.

2.1.1.3 Harvest Measures

Clean harvest Aids

Baskets, bins and all crop containers have to be washed and rinsed properly. They should be properly covered when not in use to avoid contamination by birds and animals.

Worker hygiene and training

Good personal hygiene is very important during the harvest of the crops.

Employee awareness, meaningful training and accessible rest room facilities with hand wash stations encourage good hygiene.

2.1.1.4 Post-harvest Measures

Worker hygiene

Packaging area should be clean and sanitized. The worker should be clean and use disposable gloves on packing lines.

Monitor wash water quality

Potable water should be preferably used in all washing operations. Use chlorinated water to wash the fresh produce.

Sanitize packing house and packing operations

Loading, staging and all food contact surfaces should be cleaned and sanitized at the end of each day. Care taken to prevent rats and rodents, in the packing house. Packaging material, to be stored in a clean area.

Pre-cooling and cold storage

Harvested produce to be quickly cooled to minimize the growth of pathogens and maintain good quality. Refrigeration room should not be overloaded beyond cooling capacity.

Transportation of produce from farm to produce

Cleanliness of the transportation vehicles to be maintained. For traceability norms, it must be ensured that each package leaving the farm can be traced to field of origin and date of packing.

The above mentioned Good Agricultural Practices (GAP) can be followed in Bhutan if the farmers organize themselves as a consortia or federation. It will not be possible for an individual small farmer to follow all the guidelines due to many limitations. Nonetheless, GAP ensures food safety from the farm to fork.

2.2 Standards and Regulations for Organic Products

Organic market growing by leaps and bounds warrants stringent regulation to assure quality and prevent fraud. This is amply illustrated by the variety of labels claiming organic in innovative ways like, Natural, organically grown, chemical free, etc. However, for consumers who have no access to the farms where the produce is cultivated "certified organic" serves as a product assurance. On the other hand, certification is a marketing initiative aimed at regulating and facilitating the sale of organic products to consumers. Being able to put the word "organic" on a food product is a valuable marketing advantage in today's consumer market and makes life easier for the discerning consumer. Under the certification rules, a product made with fully organic ingredients can carry the mark"100% organic". Products with 95% organic ingredients can use the word "organic" and those that contain a minimum of 70% organic ingredients can be labeled as "made with organic ingredients" In addition the products may carry the logo of the certification agency that has approved them. These rules are generally applicable in all nations. In general all businesses directly involved in organic crop/food production can be certified whether they are seed suppliers, farmers, food processors, traders or retailers.

Standards are the expected level of attaining various components and levels of implementation, achievements, and adherence of organic farming as may be defined by the authorities, like FAO, IFOAM, European Union, USDA etc. The organic standards have been enunciated and enshrined in various documents such as Codex Alimentarius and IFOAM charter and adapted by various countries. Together, the IFOAM Basic Standards for Organic Production and Processing (IBS) and the IFOAM Accreditation Criteria for Bodies Certifying Organic Production and Processing (IAC) constitute the IFOAM norms. These norms are the basis for IFOAM's organic guarantee system. This system unites the world through a common set of standards, verification and market identity. The accreditation program is a service offered to certification bodies.

Each country has its own set of standards .In the European Union (EU) the legislation is known as EU 2092/91. In United Kingdom (UK) it is handled by a number of organizations, of which the "Soil Association" and "Organic

Farmers and Growers" are the largest. All the certifying bodies are subject to the regulations of the United Kingdom Register of Organic Food Standards (UKROFS) which itself is bound by EU legislation. In Sweden, it is handled by the private corporation KRAV.

In the US, it is the National Organic Program (NOP). Certification is handled by non-profit and private agencies that have been approved by the US department of Agriculture (USDA). Quality Assurance International (QAI) a private US Corporation with a partner in Japan, Ecocert-QAI Japan Ltd is the largest certification body in the US.

In Japan, the Japanese Agricultural Standard (JAS) has been implemented since 2001. In Canada, the government has a national organic standard and certification is provided by private companies. In Australia, the certification system is administered by the Australian Quarantine and Inspection Service (AQIS). As of 2006 there are seven AQIS approved certifying agencies the largest being Australian certified Organic which is a subsidiary of Biological Farmers Australia, the largest organic farmers collective in the country. In Switzerland it is Bio-Suisse and in Germany, there are local labels such as Naturland. India has developed National Organic Standards in 2001 online with international standards namely EU. Recently, the Indian standards have been harmonized with the international standards like EU, NOP and JAS.

The largest certification organization for biodynamic farms is Demeter International and has its national member organizations. Other certifying organizations exist who are responsible for the Demeter system in the U.S. and for the trademarked term *biodynamic.*

These standards cover not only all aspects of agriculture but also plant breeding methods and materials, animal husbandry ,aquaculture production, processing of textiles, bee keeping, forest management, food processing, input packing, labeling and trading (refer Appendix for Codex Alimentarius and Basic Organic Agriculture Standards).

2.3 Organic Certification

With the organic market growing steadily, organic certification and regulation associated with it is becoming increasingly stringent and mandatory. Organic certification is a certification process for producers of organic food and other organic agricultural products. In general, any business directly involved in organic food production can be certified including seed suppliers, farmers, food processors, retailers and restaurants. Requirements vary from country to country and generally involve a set of production standards for growing, storage, processing, packaging and shipping that include:

- avoidance of synthetic chemical inputs (e.g. fertilizers, pesticides, antibiotics, food additives, etc)
- use of farmland that has been free from chemicals for a number of years (often three years)
- keeping detailed written production and sales records
- maintaining strict physical separation of organic products from the non-certified products.
- Undergoing periodic on-site inspections.

2.3.1 Purpose of Certification

Certification addresses a growing worldwide demand for organic food and is intended to assure quality and prevent fraud in organic trade. It helps all the stakeholders in the production and distribution chain. Certification helps the organic producer to identify himself as a supplier of products approved for use in the certified operations. While for the consumers certification serves as product assurance. In other words, certification is essentially a marketing initiative aimed at regulating and facilitating the sale of organic products to consumers. Individual certification bodies have their own logo which serves as brand to consumers. However, certification standards and organic laws do not affect the existing national policies or legislation.

2.3.2 Certification Process

Broadly the certification process is divided into two parts;

Inspection - to verify, the production and handling are carried out in accordance with the standards against which certification will be carried out.

Certification - to confirm the production and handling is in consonance with the standards.

It is important for the farmer or farmer federation intending to go for certification to be acquainted with the following points,

Understanding standards

Study the organic standards, which cover detailed requirements for crop production, storage, transportation and marketing.

Compliance

The production methods and farm facilities to comply with the standards which may involve modifying the existing practices, sourcing materials complying the regulations etc.

Documentation

All the documents starting like tracking from the history to the current set-up like, three year field history, area under different crops, farm maps, source of seed or planting material, fertility management, pest /disease/ weed management, record keeping system, storage system, equipments etc. Documentation is very important in the organic certification process.

Planning

A production plan is developed and submitted from sowing to marketing like source of seed, location of different crops in the field, nutrient and pest management activities, harvesting methods, storage methods and locations etc.

Inspection

Annual on-farm inspections are made by the inspector of the certification agency which involves visit to the farm, examination of records and oral interview. The inspector checks the cropping plan and rotation, area under each crop, history of past three years of each field where organic products are grown, manuring and storage of manure, origin of seed material and planting material, weeds, pest and disease management procedures, harvest estimates, storage possibilities, livestock in the farm and bookkeeping. The soil and the product samples are collected by the inspector for lab analysis.

Record keeping

Written day-to-day farming and marketing records covering all activities to be made available for inspection, at any time of the year.

A conventional farm must adhere to organic standards for a period of three years which is known as 'transition'. If the farm is already growing without synthetic chemicals for many years, depending on the pesticide residue analysis of the soil, the farm can be certified without the transition period which is under the sole jurisdiction of the inspection and the certification agency. The crops under transition are certified as 'organic in-conversion'. Along with the routine inspections which are scheduled in advance, short notice or random/surprise inspections are also conducted by the inspection and certification agency.

2.3.2.1 Certification decision

The certification committee members will take the certification decision based on the available documentation. In cases where decision is positive, the decision will be notified within three months after the inspection report and missing documents if any, has been received.

2.3.2.2 Use of Certification logo and label

Certification logo either 'certified organic' or 'in-conversion' as approved by the certification committee, will be sent to the farmer or the farmer federation as a soft copy. The farmer then makes the label incorporating the logo and other relevant details and sends it to the certification office for approval. The label approval committee of certification office approves the label as per the standards and sends the approval decision along with certificate to the farmer and only then the farmer or producer can use the label.

2.3.2.3 Appeal

If the producer has valid reasons not to accept the certification decision, the concerned party can request for reconsideration of the decision. The case is discussed by the certification committee for reconsideration. If the producer still does not agree with the revised decision, he/she can appeal to the appeals committee which takes a final decision on the case.

2.4 Documentation of Farm Records and Traceability

Documentation of all the production processing and marketing activites with complete details to facilitate traceability at any point of time is an important component of inspection and certification. The details of documentation are discussed.

2.4.1 Internal Control System (ICS)

According to IFOAM, Internal Control System (ICS) is a documented quality assurance system that allows the external certification body to delegate the inspection of individual or group members (In case of a group of farmers (group certification) to a body identified from within the operators of the group). It aims to provide a clear transparency so that the external inspectors can easily understand and evaluate the functioning of the system and also to guard the integrity of the organic quality of the products. It also describes the responsibilities of the group and staff in the project. The responsibility for the implementation of the ICS lies with the concerned organization or farmer group, commonly referred as operator.

2.4.2 Developing Internal Control System (ICS)

It is very important that ICS is developed looking into the ground realities of the concerned organization. For organic certification, ICS is mandatory. All persons dealing with the products (growers, buyers and traders) are identified, registered, instructed on the requirements of organic certification and contracted to ensure compliance. The activities of the chain of people involved are monitored by regular visits and documentary control. Following are the procedural steps for developing ICS.

2.4.2.1 The operator and its policy

The description of the organization involved and its activities has to be provided in detail. The availability of manpower and experts who work within the current social, agricultural, and climatic conditions towards improving sustainability of the agricultural practices and quality of life for the farmers needs to be mentioned.

2.4.2.2 Description of production and processing

General Project Area

The details of the project area like the terrain, altitude, temperature variations, rainfall needs to be provided.

Agricultural practices and methods

The information of the farming practices of the region, methods used for nutrient management, pest management and other activities, availability of livestock for drought, milk and manure has to be furnished.

Buying, handling and exports

All buying transactions and records are registered to maximize integrity and transparency (refer forms in Appendix). Staff at buying, processing, warehouse, and export who are involved in the process and handling of the produce in hygienic conditions are to be provided.

Risk assessment

Possibilities of any contamination at the farm as well as at processing and storage units will be assessed. Appropriate measures that are taken to minimize the risk by estimating the yields and controlling the purchasing process at the farm level; and by eliminating chances of mix-up and contamination at the storage and export areas to be furnished.

Organization

Organization Flow chart has to be furnished. It should provide an overview of organizational units, hierarchies and the positions of the organic project staff are usually given.

2.4.2.3 Functioning of ICS

The following points explain how different parts of the ICS function.

2.4.2.4 Tasks and responsibilities

The tasks and responsibilities of the functionaries are furnished below.

2.4.2.4.1 Organic Approval Committee (OAC)

This committee will meet at least twice a year to approve (or reject) organic growers, Internal Inspectors, and organic produce. It will record all the decisions and activities and send a copy of its meeting records to the certifying agency. In addition, any time if there is a change in the producer list or any change in the procedure, the certifying agency will be notified. The members of the organic approval committee are elected by the general assembly. The members must be trained in organic agriculture and know the internal regulation.

2.4.2.4.2 Organic project staff

The organic project staff including the project leader, are mainly involved in inspection of the fields and farms and providing education to the farmers to make sure that everything goes according to organic production guidelines, set by the certifying agency. Following is an outline of duties that every member as Internal Inspector would have to undertake:

Internal Inspector

The Internal Inspector is responsible for the following tasks in the project.

- Drawing of village maps.
- Registration of the farmers or growers.
- Regular farm inspections, assessment of growers' questions and problems. Every farm is inspected at least twice a year and noted in the Farm Inspection form (refer Appendix).
- During the harvest season regular visits to the buying stations to ensure that procedures, as mentioned in the ICS, are followed.
- Giving organic agriculture training to the growers.

The Internal Inspector maintains a diary, in which the daily activities are noted, as well as the names and code number of the growers visited and the names of the buying stations visited. The Internal Inspector must not have any conflicts of interest that might hinder the work. He/she is not allowed to inspect his/ her own fields or the fields of his/ her immediate neighbors, friends or family. In case of any possible conflict of interest, this is reported to the Organic Approval Committee (OAC), and his/her tasks are taken over by another Internal Inspector.

Manager (Processing unit)

The Manager of the processing unit is responsible for ensuring that personnel at the processing unit work in accordance to the organic processing, storing and handling procedures.

Treasurer

The treasurer is responsible for:

- Buying of the organic produce from the growers,
- Writing out Cash Vouchers and payment to the growers,
- Filling in and filing the Buying Records (refer Appendix),
- Warning the Project Supervisor in cases where grower's delivery exceeds their crop forecast.

Warehouse and export manager

The manager of the warehouse is responsible for ensuring that personnel at the warehouse work according to the organic storing and handling procedures

2.4.2.4.3 Training

The main objective of training is to inform and train organic growers and project staff in the relevant aspects of organic farming and, make them aware of the contents and implications of the internal regulation for organic agriculture. Regular training and interaction with the experts to identify new solutions and innovative methods in organic agriculture is very much essential.

2.4.2.4.4 Overview of documentation and procedures

The different forms for documentation and procedures are provided in detail in the Appendix. These procedures should be with the respective organic project staff and available to all persons working in the project.

Registration of producers

The Internal Inspectors use the Registration or Application Form to register producers. This form contains the growers' name and other details and summary the farm, crop area and yield estimates. On this form, each grower is given a unique code number. Village Maps are made for the organic production area to allow the external inspectors to find their way independently through the area and get an overall picture.

After approving and signing the Registration Form the farmer and the respective organization (may be an NGO, Society or farmer group) signs the Contract (refer Appendix). This contract contains guidelines that the grower is obliged to follow, as well as commitments of the organization that is facilitating the project. The grower signs this contract when he/she has understood the requirements and agrees to follow them. A member of the Organic Approval Committee (OAC) countersigns the contract on behalf of the organization. The grower receives one copy of the contract that remains with the grower. To ensure the growers fully understand and agree with the contract they are signing, the contract to be translated and signed in the *Dzongkha* language.

Internal inspections

Producers are inspected by the Internal Inspectors at least twice a year. The findings of these internal inspections are noted on the Farm Inspection Form (refer Appendix). Above all, the form is used to provide evidence for the external certification body that each producer has been inspected. This form encourages the inspectors to have a serious reciprocal one to one interaction with the individual farmer. The Internal Inspector gives his/her observations on the condition of the farm and the practices of the grower and if any additional remarks. This form should be signed by the farmer to indicate that he/she has understood what is noted, that he/she agrees with the results and with the instructions for improvement. It is recommended that the Internal Inspector concentrates his/her field visits during the “critical stages” in the production period - around planting and harvesting.

Yield estimates

Yield estimates are made during the growers first registration and contracting period. Sometimes the growers remember their previous year’s yields. This information can be a reliable basis for an estimation of the succeeding season(s). In many cases, however, the yields vary between the years, or the growers don’t remember previous year’s yield. In such cases, yield estimates will have to be made by the Internal Inspector along with the grower shortly before the start of the harvesting time. The Internal Inspector notes down the estimates in the Buying Record and in the Farm Inspection Form (refer Appendix)

Buying procedures and documentation

Buying of the products from organic growers follows a strict procedure as described in Buying Procedures (refer Appendix) The documents are audited to ensure traceability of the crop produced in the different villages to the processing unit. The Buying Record records the purchases that are made from the growers and follows the same format. The form allows facilitating organizaton to monitor the growers’ deliveries against what they are expected to deliver. The treasurer fills in the form that the Project Leader and the Internal Inspector have access at all times. If a grower is found to be delivering much higher or lower than expected quantities, the Treasurer should notify the Project Leader, who should investigate the cause. Likewise the problems and irregularities of the grower in the project should be investigated by the Project Leader or Internal Inspector.

Storage and handling

At no time during the buying, further processing or handling there is any possibility that conventional products can infiltrate the project. Once bought, the organic product will be clearly identified and kept separate from any other non-organic produce (if any.) In Storage and Handling Procedures in the organic standards it is described how the organic product is kept separate from conventional products and how contamination is to be avoided.

Penalization

If a grower violates the organic standards by using artificial chemicals, then the grower will be excluded from the project by the OAC or Certifying agency for a certain period. The facilitating organization or Certifying agency will exclude any grower from organic project for the respective growing season, if a chemical drift contaminates his organic field. If a grower violates the organic standards, he/she exposes all of his/her fellow members to the risk of exclusion from the project by the facilitating organization or Certifying agency. If a violation is found during or after the processing, all the organic production of the offending grower from the particular processing period in which the violation took place or in the processing period in which the product was milled will be de-certified . De-certification takes place because the offender's produce is mixed with other members' produce. If any violation of the organic standards is found, it will be mentioned in the annual report of the OAC.

Organic Centre

The project administration is based in this office which should include accounting and database management. At the Organic centre, the following files are kept which relate to the ICS:

- The original Village Maps
- Original Application Forms,
- Original Farmers List,
- Originals of the Farmers Contracts,
- Originals of the Field Visit Reports,
- Originals of the Warehouse Contracts,
- Copies of the Cash Vouchers,
- Copies of the Buying Records,
- Originals of the Irregularity Delivery Forms,
- Books of accounts of the organic project,
- Minutes of the Organic Approval Committee,

Old files are stored at the Organic Centre with a clear indication of the year. Most of the forms, where possible, the files are copied onto the same form in the computer. This reduces the amounts of miscalculations, and the digital forms can be easily sent to Certifying agency.

2.5 Grower Group Certification

In Bhutan, majority of the producers are small and marginal with an average land holding of 1-2 ha. Most of the farmers are located in the remote mountainous areas away from the road head. The difficult terrain coupled with inaccessibility limits the farmers from selling their produce in the market. Such farmers cannot afford certification for getting a better price in the market. Hence, it is necessary to evolve the group certification process to overcome the economic difficulties of the farmers and to ensure compliance of their production as a group.

Grower Group Certification (GGC) refers to the certification of a group of producers who are in close proximity to one another, whose farms are uniform in most ways and who are organized under one management and marketing system. The group certification has been historically used for certification of co-operatives of growers of producers located in a geographical or social region, whose crops are marked collectively. Some of the important elements of the grower groups are:

i. The farmers or producers to be located in close geographical proximity to one another.
ii. The crops and the farming practices of the groups to be uniform and reflect a consistent process or methodology.
iii. The group to be managed under one central administration and that is uniform and consistent.
iv. Grower groups must establish and implement their own system of internal control, supervision and documentation of production practices, as well as other important aspects of each members operation, to insure compliance with organic certification standards.
v. Grower Groups to have a program of education to ensure that all members understand, the applicable organic standards and how they apply to their specific operation. Grower Groups must utilize

centralized processing, distribution and marketing facilities and system.

Group certification is an economical way of getting into the certification process where there are potential international markets which demands certification and is apt for small and marginal farmers of Bhutan.

2.6 Development of a legal framework for organic agriculture in Bhutan

In the present context of global warming and increasing cost of inputs in agriculture organic farming is seen as a viable alternative to the problems and by an increasing number of Governments. Organic agriculture helps to reduce the environmental impact of modern agriculture, improve traditional farming techniques, raise the farmers' income, and encourage the agri-food trade balance. It can also provide raw materials for higher value processed foods, increasing job opportunities and income diversification in rural areas. Clearly, this requires a multi-pronged approach, a multi-annual integrated action plan, which should include applied research, training and education, institutional reforms, in particular a national legislation in line with international requirements and applications, and marketing strategies. The main component comprises of,

Legal component

It is important to establish legal, institutional and scientific platform for researchers, producers, processors and traders which would facilitate the stakeholders to improve their revenues, the global economic situation of the country and contribute to environmental improvement. This will necessitate,

- Establishment of proper institutional framework for a coordinated and integrated development of organic farming in Bhutan that will include legal aspects, capacity building and institutional build-up.

- Accomplishment of adequate number of well trained technicians, scientists, decision makers and farmer leaders, with complete knowledge of all aspects of organic farming.
- Initiating a research program which is knowledge-based and market-

oriented which in short time could provide useful guidelines to farmers wishing to adopt organic farming techniques.

The specific objectives are as follows:

1. Developing a government institution/body for the promotion of a national organic programme.

   Elaboration of the national legal framework, so that it is in consonance with the international requirements which would facilitate to obtain international recognition. This would necessitate the analysis of national legislations and EU regulations which will support the acquisition of legislation, its comparative analysis, the knowledge and experiences in other countries, e.g. European Union and USA, which have already a long standing experience and a legal framework, that have become the international standards, and also more recently developed models from the region such as that of India, with which the Bhutan legislation needs to be aligned, in order to have products exportable to markets abroad.

2. Establishment of a certification system based on the national legislation and that can be internationally recognised in compliance with ISO 65 guidelines.

3. Capacity Building and training of personnel for certification and trainers for farmers

2.7 Developing an organization of a certification body

1. Studying the certification procedures for quality products within the existing international system of certification and accreditation as required by international trade system and by the EU regulations covering agro-food trade with other countries, including the organizational structure of the Certification bodies.

2. One week training for five officials of Ministry of Agriculture, Royal Government of Bhutan, at a selected certification body in Europe which will

allow to acquire first hand knowledge of the complexity of the certification procedures and of its organizational structure.

3. Developing the organization and procedures of a certification body, which could in due time be recognized by international standards.

International equivalence of organic standards is of key importance to decrease government administration and to prevent redundant certification. The application of the principle of equivalence would bring mutual benefits to both exporting and importing countries because it would ensure flexibility to exporters and conformity with requirements of importers

2.8 Participatory Guarantee System (PGS)

An ‘Organic Participatory Guarantee System’ (PGS) is a documented quality assurance system that provides a guarantee to consumers that all produce certified under the PGS label has been grown according to a certain set of organic standards.

A PGS has the same purpose as and similar structure to third party organic certification, the main difference is that much of the system is ‘self-governed’ by the farmers themselves, there is less paperwork, it costs less and the produce is normally grown for the local market rather than for export. Emphasis is placed on building supportive networks through which the farmers have access to education and training in organic farming, and are able to exchange knowledge and techniques with other farmers participating in the PGS programme.

At the core of the PGS is the ‘Local Group’, made up of a minimum of five farmers from the same village or from neighboring villages. The members of the Local Group are trained in organic farming by the ‘Regional Council’ and before joining the PGS must make a pledge that they understand and will adhere to the organic standards. The Local Group decides which farmers are to be certified for the year, carries out inspections of each farm and imposes sanctions on any farmer that violates the PGS rules. The Local Group submits all their records to the Regional Council, who adds the group’s information to a public database (normally a website) to ensure transparency in the certification process.

The main role of the Regional Council is to oversee and coordinate the PGS. The Regional Council is responsible for providing training to the farmers, ensuring that the PGS rules are being followed, and distributing certificates and identification numbers to the farmers. Where possible the Regional Council helps the Local Groups market their produce, either directly or indirectly by raising awareness of the PGS in the local media and amongst consumer groups.

The Regional Council does not have the power to certify or de-certify individual farmers – this is the responsibility of the Local Group. The Regional Council can, however, de-certify an entire group if it discovers any violation of the PGS rules. In this way, the individual farmers in a Local Group have a strong incentive to ensure that the other group members are conforming to the organic standard, otherwise they risk losing the certified status of the entire group.

Members of the public (i.e. local consumers) are encouraged to become members of the Regional Council and to participate in random inspections of their local PGS farms. In this way a direct link is created between the farmer and the consumer that helps to build trust in the system, which will help the farmers market their produce as well as provide consumers with a trusted source of organic food.

2.9 Fair Trade

Fair trade is an alternative approach for developing trading partnerships that aims for sustainable development of excluded or disadvantaged small producers in the developing countries. It seeks to achieve this by providing better trading conditions, by raising awareness and by campaigning (Krier, 2001). Fairly traded products are purchased under co-operative rather than competitive trading principles, ensuring a fair (higher than free-market) price and fair (better than free market) working conditions for producers and suppliers in developing countries.

There is a growing concern amongst consumers in Europe purchasing products with certain ethical issues like human rights, labour conditions, animal well being, environment etc. This is indirectly an appreciation to those companies who are socially responsible and practice ethical business.

During 1990s the dip in the global coffee prices had catastrophic effect on the life of millions of small farmers forcing many into the crippling debt and countless others to lose their land which was the only source of their livelihood. Consumers after realizing their responsibilities to improve the living conditions of producers an alternative trading organization (ATO) was set up. The main aim of this organization was to buy directly from the farmers at higher prices and market their produce through their own shops and catalogues. The increasing demand and to reach out the customers with a range of Fair Trade products, ATO's started involving commercial manufacturers so that the products are available in the super markets. The entire process necessitated the development of Fair Trade criteria, a registration process and certification procedure to ensure compliance to Fair Trade criteria and the use of the Fair Trade label.

The Fair trade activities are growing at a rapid rate. At present there are Fair Trade labeling organizations in 17 countries and the products have a good penetration in the high premium segment market of North America and Europe. Now Fair Trade also deals with artifacts, handicrafts, toys and utility items. For many of these products, the raw material comes from forests and, in certain cases; only Forest Stewardship Council (FSC) certified wood and Non Timber Forest Products (NTFPs) are permitted as raw material in Fair Trade products.

The Group Certification and Internal Control system adopted for organic farm certification, complements the requirements of Fair Trade certification mechanisms with due support of standards and rules complying the Fair Trade criteria. Fair Trade certification would play a very important role Bhutan as it comprises of large number of small and marginal farmers living in remote hilly terrains. Some of the specialty produces of the region like the yak products; meat, cheese, woollen and leather products which are produced by the nomads or yak herders can be organized into a cooperative and exported under Fair Trade label. Every year the premium charged on the sale of Fair Traded product is sent to the respective cooperative for utilizing it, in improving their livelihoods. Similarly other products like brown rice and traditional medicinal herbs can be exported which would help the small produces to a very large extent.

Labels of International Organic Certification Bodies

3. Market for Organic Produce: Trends and Opportunities

The growing awareness of consumers for organic foods is on the rise for the past several years. Against 2-3% growth in the conventional food industry, the organic food industry has been experiencing annual growth between 17-22% during the last decade. Global retail organic sales, valued at USD 25 billion in 2003, are currently worth USD 31 billion and growing at over 20% per annum. The same is estimated to increase to USD 102 billion by 2020. Organic agriculture is practiced in approximately 110 countries and its share of agricultural land and farm continues to grow.

3.1 Markets for Organic Food

The major market for organic food products are in the United States, the European Union (Germany, France, Italy, Belgium and the United Kingdom) and Japan.

In the US, the annual market size for natural and organic products is estimated to be around USD 16- 30 billion. The retail sale of organic food and beverages in 2005 was approximately USD 12.8 billion. The growth rate is estimated between 9-16% per annum by 2010. A part of the demand is met from imports. During 2002, the import of organic food into the US was about USD 1.5 billion.

Table 1: Organic Food Category Sales in the US

Food Category	Sales (%)
Dairy products (milk, yoghurt, cheese etc.)	13%
Vegetables and fruit	42%
Bread grains	09%
Prepared foods	13%
Beverages	15%
Meat	01%
Snack Foods	05%
Sauces/Condiments	02%

Source: Organic Trade Association, 2006

The European Union (EU) organic market grew rapidly during 1990's by a range of 20-40% per annum. Retail sales grew at a rate of 5% from USD 10.5 billion in

2002 to USD 12 billion in 2004. Germany is the second largest market for organic food and drink in the EU, which accounts for almost 30% of total organic sales valued at USD 3.7 billion in 2003, followed by UK, which achieved estimated retail sales of USD 1.6 billion. Italy and France organic markets, each valued at approximately USD 1.5 billion. The French and UK markets have grown on an average of more than 40% annually since 2001.

Table 2: Countries clustered by stage of organic market development

Mature market countries	Growth market countries	Emerging market countries
Austria	Finland	Czec Republic
Denmark	Italy	Greece
Germany	The Netherlands	Ireland
Switzerland	Sweden	Slovenia
United Kingdom	France	Spain
	Belgium	Norway
	United Kingdom	Portugal

Source: OMlaRD,2004

In Asia the important countries producing organic products are China, India, Ukraine, Indonesia and Israel (mainly dried and fresh fruits, vegetables and nuts). Japan being the largest consumer of organic products in Asia, the market is growing at 20% per annum. The Japanese organic market is characterized as one with high demand, strong purchasing power and low domestic supply of organic products. On the supply side, the value of Chinese exports grew from less than USD 1 million in 1990’s to about USD 142 million in 2003. By 2003, more than 1,000 Chinese companies and farms were certified organic.

3.2 Challenges and Opportunities

The demand for processed organic products as well as raw commodities is on the rise. Since the productions of different commodities are wide spread most of the food products are available in the organic form. In Europe, markets are growing for ready-to-eat meals, frozen foods, baby foods, beverages and snacks.

This has resulted in the demand for ingredients needed for organic food processing like, juices, fruit powders, dried fruit, meat, flavourings, essential oils, herbs, spices and nuts. In Japan, the demand is for organic fresh produce, frozen foods, juice, baked goods, baby food, sauces, chicken and ready-to-eat food.

In toto, the growth in the food market is quite rapid in the last decade. There is an increasing demand for vegetables, fruits, meat and milk world over. The urban living is creating a new market for semi-processed foods. Burgeoning cities and rising incomes have major implications on both demand and supply. Over the last decade the retail market for food has consolidated swiftly. The 30 largest supermarket chains account for about 30-35% of total food sales worldwide. These supermarkets require certain quality standards-they need products of guaranteed quality and quality at a right time and place. Stimulated by improved communication and transportation, global traders are penetrating even remote rural markets. Small and marginal farmers are confronted with the cheap imports which is a major hurdle. The opportunities for small farmers in the present scenario are,

a) Population growth fuels demand for cereal crops creating a growing market in terms of volume and value.
b) Many developing countries experience rising average incomes assuring a widening consumer base for agriculture products.
c) Export markets are expanding rapidly, opening new opportunities for niche and high quality products.

The general assumption is that large farms can only be in a position to take advantage of such opportunities. The small farmer's all over the world face considerable obstacles to participate in the global trade. They lack the capital to invest and also the market information. In addition, there are additional investments to be made to meet the stringent quality standards like organic certification or to ensure product traceability. These barriers can be overcome if the small farmers join together to form associations in which they can develop common strategies and follow a common interest. There are innumerable examples from different parts of the world wherein small farmers through producer associations have succeeded in producing for exports generate significantly higher incomes than their neighbors who still grow for the local market.

3.3 Linking small- farmers to market

Amidst limitations of capital investment and economy of scale, pragmatic strategies can be developed to improve the linkages for small-scale farmers with markets. Following are some of the approaches:

Increasing returns from production

It is very important to make farming a profitable enterprise by increasing the production, introducing high value or niche products like fruits, vegetables, medicinal and aromatic herbs, spices etc. Providing appropriate storage facilities to store the produce in the peak season and market them during lean season helps to fetch incremental income for the farmers.

Farmer Groups or associations

Farmer groups or associations are necessary to facilitate farmers to explore the export potentials and also to ensure access to inputs, production technology, certification and market information. It would also play an important role in the domestic markets.

Domestic markets

Generally the local demands are not thoroughly investigated. In Bhutan, market surveys might identify untapped potentials for certain products. It would also provide avenues to replace the imported food by producing them locally.

Traditional Knowledge

There is a rich traditional knowledge in Bhutan which can be encashed through innovative approaches. It will not only serve as an income generating activity but also would restore the heritage. For instance, traditional herbal remedies, incense making, weaving etc can help small farmers to get alternate source of income.

Local Environment

The local conditions should be considered before choosing a crop or enterprise.

Certain areas can serve as pristine environments for eco-tourism or agri-tourism.

Low cost technologies

For the small farmers low cost technologies are more important than high-tech capital intensive technologies. The technologies should adapt well to the local conditions.

Developing linkages with local processing and marketing

Starting a new enterprise requires capital and other resources. It would be ideal to take advantage of the existing processing and marketing channels operatrional in the region.

3.4 Structure of Farmers Association or Consortium

The consortium of farmers should be a registered body with its own bylaws. It should serve as an umbrella federation of different village level groups. The village level group comprises of farmers who are interested and adopting organic agriculture.

Village committees

Each village level group can consist of 10-30 farmers. They elect a committee consisting of a president, secretary and 2-3 model farmers.

Zonal committees

The presidents of the village committees in a zone or Dzongkhags form a zonal committee which coordinates and plans activities within the zone. The zonal presidents elect 3-4 members amongst the presidents of the Dzongkhags who manage the activities of the consortium as a whole. The zonal committee monitors the collection of the produce, payment to the farmers and quality at the farm level. The committee also defines the standards for cultivation and harvesting, admits new members, reviews progress and finalizes the developmental plans.

The structure of the consortia should be in accordance to the existing law of the Royal Government of Bhutan and also in line with the local social and cultural conditions of the villages.

Sustainable agriculture interventions use participatory approaches and emphasize farmer organizations or associations to facilitate collective responsibility. Building on the rich traditional knowledge and resources of Bhutan would help to optimize the capabilities of the farmers. Women's savings and credit groups are becoming popular in India, Bangladesh and Srilanka which provide a good basis for organizing disadvantaged groups and giving them a voice so enabling them to participate in development. Formulating strategies to develop the local markets is quite promising if the livelihoods of the local people are improved.

3.5 Value Addition through Food Preservation

Nature has taught the human beings how to preserve the food. The low temperature prevailing in the cold region helped him to prolong the keeping quality of perishable foods. In the hot regions the sunshine assisted him to dry the perishable foods like fruits and vegetables. In the coastal areas salting prevented the spoilage of certain foods. The natural fermentation converted the fruit juices into products like wine, ciders and vinegars which became the important products for human consumption. Thus, the low and high temperatures were the principle agents employed to preserve many of the foods. At present several technologies have been developed based on these principles which have been placed on sound scientific basis. As a result, food industry today has become the largest industry in the world. Food Preservation can be the first step in the chain of food processing activities in Bhutan to add value locally and enhance the incomes of small and marginal farmers. It would also help the rejuvenation of the thriving small scale rural industries.

Handling of the food is very important otherwise it leads to spoilage. The cause of spoilage could be due to one or more of the following reasons;

- Growth and activity of microorganisms
- Presence of insects, rodents and other animals
- Action of enzyme of the plant, microbes or animal food
- Chemical reactions
- Physical changes such as those caused by harvesting, handling, burning, drying, pressure, freezing etc.

3.6 Methods of Food Preservation

There are different methods of food preservation, the feasible methods are discussed.

Canning

It is a process of heating hermitically sealed foods to a temperature, which kills harmful microbes and inactivate the enzymes. The principle application of canning has been in fruits and vegetables.

Aseptic Processing and Packing

This system allows the use of highly efficient heat exchangers and the opportunity for high temperature short time and ultra high temperature process. Because of the shortened time-temperatures, aseptic processing may produce products with high retention of nutrition and excellent sensory qualities. This technology is used for fruit juices or juice drinks, fruit juice concentrate, fruit purees, puddings, milk and dairy products, flavoured drinks, tomato products, edible oils, wine etc.

Ohmic heating

Here electric current is passed through food material which then heats as a result of its inherent electrical resistance. The process involves the passage of low frequency alternating current (50-60 Hz) through the product. The electrical energy is transformed into thermal energy. The extent of heating depends on the uniformity of the electrical conduction throughout the product and its residence time in the heater. A typical use of ohmic heaters is in an aseptic processing system.

Drying and Dehydration

Fruits and vegetables contain a lot of moisture which permit action of microorganisms and drying them helps to remove moisture and facilitate preservation. Sun drying is extensively employed in Bhutan to dry a variety of crops. Dehydration is a process in which food is dried by artificially produced heat under controlled conditions of temperature, relative humidity and air flow. Dried and dehydrated food can be stored for at least one year.

Sun Drying of Chillies in Bhutan

Microwave processing

It refers to the use of electromagnetic waves of certain frequencies to generate heat in a material through two mechanisms- dielectric and ionic. Microwave heating for pasteurization and sterilization are preferred to conventional heating because this requires less time to come up to the desired process, temperature, particularly for solid and semisolid foods.

Fermentation

The decomposition of carbohydrates by microorganisms or enzymes is called fermentation. In preservation by fermentation, the microorganisms are encouraged to multiply and continue their metabolic activities in foods. Acetic, lactic and alcoholic are the three types of fermentation involved in food preservation. The keeping quality of vinegar, fermented pickle and alcoholic beverages depends upon the presence of acetic acid, lactic acid and alcohol respectively.

Preservation by high sugar and acid

It is an important method to make jams, jellies, marmalades and preserves as it is simple, economical and easy to adopt.

Freezing

Freezing is well known method of increasing the storage life of fresh fruits and vegetables. By freezing the microbial growth is prevented completely and action of food enzymes greatly retarded. The lower the storage temperature the slower will be the rate of chemical or enzymes reaction. Most of the foods freeze at temperature between 0-3^{o}C. Frozen products are of better quality than canned products, however for storage of frozen products uninterrupted supply of electricity is essential.

Non Thermal methods of Preservation

Non-thermal methods are under research and offer promising application in fruit and vegetable processing. The major advantage of these methods is in terms of retention of vitamins, essential nutrients and flavours besides being cost and energy efficient. High hydrostatic pressure, oscillating magnetic field, high intensity pulsed electric fields, irradiation are some of the promising non-thermal methods for food processing.

Hurdle technology (HT)

Hurdle technology is another paradigm shift in preserving food especially, perishable fruits and vegetables offering a viable alternative to canning and dehydration. The HT process is a combination of processing technique in which several technological approaches and unit operations such as freezing, refrigeration, dehydration, irradiation, high pressure processing, p^H and water activity controls are used in unison in a synergistic to bring about desired microbiological safety and sensory acceptability. Convenience, safety, microbiological stability and fresh like appearance are qualities of HT products.

Appropriate technologies should be developed for small scale processing units which should be available for farmer federations, cooperatives and small entrepreneurs. Local farmers and the institutions should be motivated to build most befitting decentralized preservation and processing infrastructure. Information and marketing services should be strengthened to stabilize prices of value added products and also to address the problems concerning transportation of perishable commodities.

4. Organic production

The different inputs for organic crop production viz., nutrient management, plant protection, seeds and planning for converting a farm to organic is discussed in detail.

4.1 Nutrient Management

Soil is the most important factor in organic agriculture and it is considered as a living organism as it is diverse, full of life and energies. It is habitat of plants, animals, microflora and fauna that are all interlinked. A healthy soil contains millions of organisms in a teaspoon volume. The macro and micro-organisms decompose organic material and build up humus, mix the organic matter with soil particles and thus help to build stable crumb structure, earthworms dig tunnels which encourage deep rooting of plants and aeration of soil. These micro-organisms also bring insoluble and bound forms of nutrients into soluble forms from mineral particles. It is important that the soil is harnessed properly to maintain the yield and quality of the produce in organic agriculture system.

Soil is the basis of all human life. Destruction of the soil has contributed to the fall of past civilizations yet the lessons of history are seldom acknowledged and usually unheeded (Howard, 1956). The only hope for a healthy world rests on re-establishing the harmony in the soil that has been disrupted by the modern methods of chemical farming and unplanned rapid industrial growth.

4.1.1 Plant nutrition

Any crop can grow on any soil with the help of Sun's energy, water and air, however the theory of plant nutrition popularly called as the 'NPK theory' is adopted for increasing the per hectare yield on the assumption that what is not available in the soil must be supplied from outside in the form of synthetic chemicals. The plants do not require these chemicals. Like all living beings, plants are made up of atoms derived from planet Earth. Plants are autotrophic and have the unique ability to extract their nutrients from two sources viz., atmosphere and soil. Bourguignon (2005) reported that thirty-four elements are necessary to plants and these are divided into two large groups viz., those derived from the atmosphere and those derived from the soil.

Table 3: Elements derived by plants from atmosphere and soil

Elements from the atmosphere	**Elements from the Soil**
These represent 92 to 98% of a plant's dry weight	They represent 2–8% of a plant's dry weight 12 Vital elements of which; 2 are non-constitutive – K and Cl
4 Constitutive elements C, O, H and N	10 are constitutive – P, B, Ca, Mg, S, Fe, Mn, Mo, Cu and Zn 18 other elements (functions of some are not fully understood)

Bourguignon, 2005

From the above table it is clear that the source of nutrition from the soil is only 5% of the dry matter of plants. It is the atmosphere which provides the main part of the food that plants need. It is therefore not necessary to use fertilizers because plants need very little from the soil. The atmosphere is the source of 95% of the dry weight of plants comprising only three elements, carbon (C), oxygen (O) and hydrogen (H).The bulk of nutrition of plants comes from the atmosphere. Of the 95% that plant takes from the atmosphere to build its dry weight, carbon constitutes 44%, oxygen 44% and hydrogen 6%.Photosynthesis allows the integration of carbon and oxygen from carbon dioxide within the structure of a sugar. Hydrogen, which contributes 6% of plant tissues, is derived from the breakdown of rainwater and hydrogen, which is absorbed in the tissue of the plant. Nitrogen is derived from the atmosphere, through microbes that can transform gaseous nitrogen into ammonia. The ammonia directly enters in leguminous plants in the form of amino acids or is converted into nitrates by the soil microbes and then absorbed by other plants.

Soil provides two types of elements: non-constitutive elements which the plants borrows and returns to the soil at the end of the period of cultivation; and constitutive elements which enter the vegetative organic molecular composition. The constitutive elements of the plants derived from the soil do not enter in the form of atoms but in the form of oxides and chelates. These transformations are affected by the soil microbes, which render these elements accessible to plants from the parent rock or humus. Thus all other soil elements can be absorbed by plants through microbial action. The oxidation of soil elements is often achieved by very specific micro flora. Fifteen oligo-elements can enter plants in the organic form. Similar studies were reported by Milton Whitney, Chief Bureau of Soils, USDA who concluded that 95% of the constituents of the dry vegetation is from the atmosphere and 5% is from the soil. The statistics clearly reveal that the plants do not have a purely mineral diet.

4.1.2 Soil Organic Matter

Soil is an important production factor for crops as plants qualitatively feed from the soil and quantitatively from the atmosphere. Maintaining the soil fertility is an important factor contributing to soil health. For the growth of the plants, it requires suitable conditions for root growth, appropriate supply of water and nutrients available for the uptake by roots. If soil conditions are not suitable the plant growth is inhibited. For example, waterlogging, acidity, compaction or shortage of nutrients can tremendously decrease the yield of some crops. Organic matter in the soil has influence on the nutrients released by decomposition, the nutrient holding capacity, water retention, soil structure and soil life.

When plant material is decomposed with the help of soil macro and microorganisms, the components are released again as nutrients or gases and are available for plant growth. In the process of decomposition, a part of the material gets decomposed to certain extent, which join together to build up dark brown or black ‘soil organic matter’. Not all material of plant origin will decompose at the same speed. The more nutritious the material is, faster will be the degradation by soil organisms. Such fast decaying materials are for example, green leaves, animal dung etc.

The speed of decomposition also depends on soil moisture content and temperature. Soil life is most active under warm and moist conditions, thus conducive for faster decomposition of organic material which facilitates the release of nutrients but less humus is formed. However, slower decomposition due to hardy material or temperate climatic conditions, results in higher humus accumulation in the soil. Soil organic matter helps to build a loose and soft soil structure with good infiltration capacity. This leads to better aeration, infiltration of rain or irrigation water and easier penetration of roots.

The visible parts of organic matter act like tiny sponges which can hold water up to five times their own weight. During dry periods, if the soil organic matter is high, more water will be available for the plants for a longer time. The non-visible parts of the organic matter act like glue, sticking the soil particles together thus forming stable crumb structure of the soil. Such aggregates improve the soil structure especially in clay and sandy soils. Soil organic matter provides a suitable environment for the beneficial organisms. The organic matter has a great capacity to retain nutrients and release them continuously. It thereby increases the capacity of the soil to supply the plants with nutrients and reduces nutrient losses by leaching. It is very important to improve the organic matter of soil and also to prevent its loss for the soil.

4.1.3 Inputs for Nutrient management

Nutrient management is one of the major input demanding strategies in organic agriculture. Different options are available for suitable use of resources for nutrient management.

i. Farm Yard Manure (FYM)

Farm yard manure refers to the decomposed mixture of dung and urine of farm animals with the litter and left over roughages given to animals. The nutrient composition of FYM depends on the kind of animal, feed consumed by the animal, age, condition and function of the animal, storage methods and nature of litter. Improper handling and storing of FYM lead to heavy nutrient losses through leaching and volatilization. Since FYM is widely used in Bhutan, attempts should be made to improve the quality of FYM by research and development.

ii. Animal manure

Tethering of livestock in farm lands or fallow lands is an ancient practice. The droppings of these animals provide valuable manure. Poultry manure is a good source of nutrients, particularly for vegetables and other crops.

iii. Compost

Composting is a process of transforming organic material of plant and animal origin under controlled conditions into a hygienic, humus rich, relatively stable product that conditions soils and nourish plants. It offers several advantages such as improved soil texture, fertility and productivity. A wide range of composting technology is available. The choice of composting methodology depends on substrates. Basically there are two methods of composting; traditional method and rapid composting method. The traditional methods are based on passive composting approach wherein, biodegradable materials are stacked in pits or heap to decompose. It takes about 8-10 months for the material to decompose. Rapid composting involved pulverization, addition of water, mechanical stirring, aeration and use of microbial inoculants.

Mechanical composting is another option for making compost. The process provides congenial conditions for aeration, moisture and temperature for the bacteria, fungi and other forms of life to flourish and perform their task in the stabilization and decomposition of wastes at a rapid rate.

Lignin and cellulose are two major compounds occur in waste, which forms lignocellulosic complex that is highly resistant to decomposition. Microbial inoculants particularly cellulose and lignin decomposers play a major role in breaking the complex and hastening decomposition process. The cellulolytic micro-organisms like *Aspergillus sp*., *Penicillium sp*., *Trichoderma viride*, *Trichurus spiralis* and *Chaetomium sp.* are very efficient in breaking the cellulose materials. Some of the commonly used lignolytic fungi are *Pleuretus sojar caju*, *Polyporus versicolor* and *Phanerochatae chrysosporium.* These micro-organisms are used at the rate of 300grams/tonne of substrate. The inoculum of these fungi can be easily prepared on saw dust and or sorghum grains. Under practical conditions these inoculum are mixed in equal proportions to make the consortia.

The decomposition of biomass and the quality of the composts depend on characteristics of crop residues, C:N ratio, age of the material, particle size, available nutrients and microbial load and environmental factors.

iv. Phosphate rich organic manure (PROM)

Phosphate rich organic manure is prepared by using indigenously available rock phosphate, cattle dung and farm waste etc. A range of diverse types of substrates viz., paddy/wheat straw, farm wastes, cattle dung, wastes from sugar or fruit juice industry, FYM, oil cake, green manure, distillery waste etc., are used for making PROM. These substrate are fortified with high grade rock phosphate (32% P_2O_5) with fine particle size 80% passing through 74 micron sieve followed by inoculation with *Bacillus megaterium*, *Aspergillus awamori* and *Streptomyces sp*., The resultant products gives high phosphorus content and also a good source of P in neutral to alkaline soils. Besides PROM, N enriched phospho-manures are also prepared.

v. EM technology for composting

The use of a consortium of selected microorganisms like lactic acid and photosynthetic bacteria, yeast and filamentous fungi is called Effective Microorganism (EM) technology. In the consortium mutually compatible microorganisms are maintained in liquid culture below p^H 3.5 and works as activator to bring down composting period by 4 weeks. The substrates used for EM technology are kitchen waste, municipal solid waste and agricultural wastes to get compost in 60-90 days dependingon temperature, moisture and type of biomass used.

vi. Vermicomposting

It is a technology of converting the biodegradable wastes into compost by using selected species of earthworms. This technology allows quick transformation of substrate or organic residues into mineral rich compost. The commonly used earthworms for composting are *Eisenia foetida, Eudrillus eugeniae, Perionyx excavatus, Perionyx sansibaricus, Lampito mauritii, Lumbricus rubellus.*

vii. Biodynamic composting

It is a quicker method of producing compost in 8-12 weeks using green and dry plant debris/leaves. The compost are prepared on the soil surface where green and dry plant materials are piled up in the alternative layers integrating with cow dung slurry. The compost heap is inoculated with a set of biodynamic preparations numbered from 502-507 prepared from yarrow, chamomile, oak bark, stinging nettle, dandelion and valerian. These preparations enhance the nutrient content but also hasten the decomposition process. The compost can be enriched as per the need by rock phosphate, slaked lime and wood ash.

viii. Biofertilizers

Biofertilizers refer to the preparations containing active strains of microorganisms in sufficient numbers capable to provide essential mineral nutrients to the plant by fixing atmospheric nitrogen or to solubilize or mobilize plant nutrients or otherwise stimulate plant growth through synthesis of growth promoting substances. Biofertilizers are apparently environmental and farmer friendly renewable sources. They are non-bulky, low cost agricultural inputs playing a vital role in improving the nutrient availability to the crop plants. Decentralized biofertilizer production units with low cost technologies can be developed in Bhutan by isolating the local strains of beneficial soil micro-organisms.

A diverse category of bio-inoculants such as nitrogen fixers, phosphate solubilizers and plant growth promoters are used in agriculture.

a. Nitrogen fixing biofertilizers

Rhizobium

Rhizobium is one of the most important and oldest known biofertilizer. It is a symbiotic bacterium which, colonize on the roots of the specific legumes to form root nodules having the capacity to fix atmospheric nitrogen. About 80,000 tonnes of nitrogen is estimated to be available in atmosphere above each one hectare of land. It has been widely and extensively used as a biofertilizer because of its proven ability to fix and contribute nitrogen for the benefit of the leguminous host plants. The rhizobium legume association can add upto 20-25 kg nitrogen per hectare and leave substantial amount of nitrogen for the succeeding crop.

Azotobacter* and *Azospirillum

These are non-symbiotic bacteria and are capable to contribute nitrogen to non-leguminous crops mainly cereals and millets. *Azotobacter* is a free living heterotrophic nitrogen fixing bacteria found in neutral alkaline soils. These cultures can be used for cereal crops like rice, wheat, barley, sorghum, maize, vegetable crops like tomato and potato. Also it is used in crops like mustard and cotton. Seeds and seedling treatment with azotobacter culture is a very simple process. Besides its ability to fix nitrogen from air, it also secretes growth promoting substances which help in better seed germination and expanded root system and facilitate the plant in nutrient uptake. Azotobacter secretes growth substances and produce antifungal antibiotics, which improves plant stand in inoculated field by inhibiting root pathogens.

Azospirillum is an aerophillic nitrogen fixer, is commonly found in association with the roots of cereals and grasses. High nitrogen fixation capacity, low energy requirement, abundant establishment in roots of cereals and tolerance to high soil temperature make it more suitable under tropical conditions. It can be use for crops like sorghum, pearl millet, minor millets, barley and forage legumes. They fix 20-40 kg N/ha. Azospirillum also secretes growth promoting substances like Indole acetic acid and Gibberellic acid.

Azolla

It is an aquatic fern widely found in temperate and tropical natural conditions as well as in lowland rice growing regions. *Azolla* fixes atmospheric nitrogen in symbiotic association with *Anabena* algae. This association uses energy from photosynthesis to fix atmospheric nitrogen upto 100-150 kg per hectare annually. It is widely used in paddy cultivation. *Azolla* can be used either as a green manure before transplanting or as a dual crop after transplanting of rice. The growth and efficiency of *Azolla* is generally high in hilly, humid and coastal regions than in high temperature regions.

Blue Green Algae (BGA)

Blue green algae or cyanobacteria, the photosynthetic nitrogen fixing organisms, are important biofertilizers for rice cultivation. Studies reveal that BGA applied at the rate of 10 kg per hectare after seven days of transplanting of rice contributes about 20-30 kg nitrogen per hectare per season. Besides fixing nitrogen these algae excrete vitamin B12, auxins and ascorbic acid which contribute to the growth of the plant. Application of algal biofertilizers is also useful for the reclamation of marginal soils such as saline-alkaline and calcareous soils.

b. Phosphate solubilizing microorganisms

Phosphorus is an important plant nutrient which is not readily available. Some heterotrophic bacteria have the ability to solubilize inorganic phosphorus from insoluble sources by secreting organic acids. The important phosphate solubilizing bacteria are *Pseudomonas spp. and Bacillus spp*. Several fungi species belonging to the genera *Penicillium* and *Aspergillus* are also involved in solubilization of phosphates in soil. These microorganisms can be used for all crops and can solubilize 20-30% of insoluble phosphate in the soil.

c. Vesicular Arbuscular mycorrhiza (VAM)

Mycorrhiza is the symbiotic association of certain fungi with roots of higher plants. Among the mycorrhiza, VAM a fungal biofertilizer is most promising. It colonises the roots and increases the growth and yield of crops over a broad ecological range from aquatic to desert environments. The VAM increases the plant phosphorus uptake and ability of other nutrient elements like zinc, copper, potassium, sulphur etc. and also improves the water retention of plants and enhances resistance against drought and diseases. Mycorrhiza is a broad spectrum biofertilizer which is suited for nursery, transplanted and plantation crops. VAM plays very important role in forest ecology for sustainable production.

ix. Plant Growth Promoting Rhizobacteria (PGPRs)

Soil is a natural growth media for living plants and microorganisms. The area of enhanced activity surrounding living roots that is composed of soil particles and active communities of soil-microorganisms is called rhizosphere. Rhizospere bacteria that favourably affect plant growth and yield of commercially important crops are referred as Plant Growth Promoting Rhizobacteria (PGPR). The beneficial effect of rhizosphere bacteria have most often been based on increased plant growth, faster seed germination, better seedling emergence, enhanced nodulation and nitrogen fixation in leguminous crops and suppression of plant diseases. PGPR's include bacteria belonging to the genera *Azotobacter*, *Azospirillum*, *Arthobacter*, *Bacillus*, *Enterobacter*, *Klebsiella*, *Pseudomonas*, *Xanthomonas*, *Bacillus subtilis* and *Serratia*.

Table 4: List of biofertlizers along with target crops

Biofertilizers	Type of microorganisms	Target crop	Mode of Action
Rhizobium	Bacteria	Leguminous crops (Pulses, oilseeds, fodder)	atmospheric nitrogen fixation
Acetobacter	Bacteria	Wheat, rice, vegetables	atmospheric nitrogen fixation
Azospirillium	Bacteria	Rice, sugarcane	atmospheric nitrogen fixation , release of growth promoters
Blue green algae (BGA)	Cyanobacteria	Rice	Nitrogen fixation
Azolla	Fern	Rice	Nitrogen fixation
Phosphate solubilising bacteria (PSBs)	Bacteria	All the crops	Solubilization of insoluble soil phosphates
Mycorrhiza	Fungi	All crops	Solubilization of insoluble soil phosphates

x. Green Manuring

The practice of growing crops or plants and ploughing in at flowering stage to improve the physical, chemical and biological properties of soil is called green manuring and the crops used for the purpose are called green manure crops. Green leaf manuring is a practice wherein the green leaves and tender green twigs collected from shrubs and trees grown on bunds, wastelands and nearby forest areas are incorporated into the soil. In certain situations, the green manure crops are grown along with the main crop e.g in the basis of tree crops like mango, and are incorporated. This method is called as 'Insitu green manuring' as it does not require any additional land for green manure production.

xi. Concentrated organic manures

Concentrated organic manures are the byproducts of animal or plant industry which are organic in nature and contain higher percentage of nutrients compared to bulky organic manures. The commonly available concentrated manures are oil cakes, meal group of manures etc.

Oil cakes

The solid portion left after the extraction of oil from oilseeds is dried and used as manure. Both the edible and non edible oil cakes can be used as manure. The edible oil cakes like groundnut cake while the non edible oil cakes like castor cake are well powdered and used as manures.

Meal group of manures

Examples for the meal group of manures are bone meal, hornmeal and hoof meal. The fish meal prepared from non-edible and unsold fish is also used as manure.The use of meal is restricted as per the organic standards.

x. Liquid organic manures

Plants absorb nutrients 20 times faster through the leaves when applied as foliar spray than through roots when applied in soil. Liquid manures are highly useful for immediate plant responses and when there are adverse soil conditions hindering soil application and plant uptake.

Vermiwash

This is the extract of vermicompost containing earthworms.

Liquid farm yard manure

Farm yard manure filled in bags is immersed in a barrel containing fresh water. These are covered and kept for few weeks with regular stirring for fermentation and enhancing the microbial activity.

Biogas slurry

The spent slurry from the biogas plant is a very rich source of plant nutrients and humus.

xi. Mineral Fertilizers

Mineral fertilizers are allowed in organic agriculture after getting permission from the respective certification agency. It is based on the ground natural rock and are used only as a supplement to organic manures. Their direct application is not permitted as they contain easily soluble nutrients which can disturb soil conditions and result in unbalanced plant nutrition. Some of the mineral fertilizers are, rock phosphate, lime, sulphur, gypsum etc.

4.1.4 Cultural practices for improving soil fertility

i. Contour farming

In sloppy areas, to prevent the loss of top soil along with water, cultivation is done only after proper terracing. Crops are planted along the contours. This practice improves the soil fertility.

ii. Mulching

Mulching of soil with crop residues not only reduces the loss of soil moisture during dry periods but reduces soil erosion during rainy seasons. The mulch decomposes and helps to improve soil fertility.

iii. Crop rotation

Repeated cultivation of the same crop in an area is not recommended since it results in mining of soil of the same nutrients over the years and reduces macro porosity which in turn reduces the infiltration rate and increases the overland flow of rain water. Crop rotation is beneficial for reducing runoff and erosion, improvement of soil physical conditions buildup of soil fertility and weed management.

iv. Multistoried cropping

The high density multi species cropping system utilizing sunshine at different strata of canopy is an efficient system in energy utilization and building soil fertility.

v. Biofencing

Biofencing is the practice of establishing and maintaining perennial herbs, shrubs and trees that are resistant to biotic and abiotic stresses along the field boundaries. The clippings of the fence can be used for mulching and composting. Also it helps to prevent the soil erosion from the farm.

vi. Bunding

The main objective of bunding is to reduce the slope length. It also helps to prevent the run off losses of organic matter during rainfall.

vii. Silt detention tank

A small tank is constructed at a lower elevation for trapping silt from the upper areas. The sediment collected is brought back and applied in the filed for sustaining soil health.

The nutrient management in organic agriculture is based on the rationale use of agro eco-system and native resources. This is achieved by crop rotation, green manuring, biofertilizers and reutilization of organic farm byproducts by adopting appropriate technologies.

4.2 Plant Protection

Plant protection plays a very important role in agriculture. Like human beings, plants are also affected by pests. A 'pest' is any organism that is responsible for significant losses both in production and profits in agriculture and the term may include insects, micro-organisms, weeds, rodents, etc. The incidence of the pest is an indication of poor health of the plant and soil. A healthy soil always produces a healthy plant. The root cause of the incidence of pests is the use of chemical fertilizers that makes the plant soft and succulent which attracts the pests. In the conventional synthetic chemical based farming system, toxic pesticides are used to manage the pests. These toxic chemicals have a great impact on the soil, water, food and the environment.

In organic farming, the synthetic toxic pesticides are not used instead, natural methods which are non-polluting are employed to manage the pests. A variety of plants and micro-organisms have an ability to manage pests efficiently. In addition, cultural and mechanical methods are also utilized. All insects are not pests. Less than one percent of insects are pests, while a large majority of insects are beneficial. There are many natural enemies of pests like, insects, spiders, birds and other organisms which prey and predate on them. These natural enemies which are very important get killed by the synthetic pesticides. In organic farming it is very important to understand the intricate prey-predator relationship of the food web.

The common characteristics of different approaches in plant protection in organic agriculture are,

1. Multi-portaged attack on the pest/disease.
2. Focus on improving plant health thereby increasing its resistance capacity.
3. Enriching soil with (and buffering) beneficial microbial activity.

There are different approaches of managing pests like cultural and mechanical methods, use of botanicals and biological for pest management.

4.2.1 Cultural Practices

In Bhutan, for many decades, farmers have been modulating crop growth through simple adjustments in the time of sowing, cultural operations, and by controlling plant population density for altering the microclimate to minimize risks. Some of the agricultural operations are based on the Buddhist rituals. Observation of these agricultural practices over a long period of time, the farmers could realize that it makes the environment unfavourable for the pests to thrive. Some of the cultural practices include crop rotation, trap crops, intercropping, and use of resistant varieties. Let us know how we can manage pests by adopting simple cultural methods.

Crop rotation

One of the limitations of pests is that they are specific to crops and would prefer that the particular crop is available throughout the year. The pest problems can be reduced to a large extent by carefully rotating a crop belonging to one family with another from a different group. In other words, it involves sequential planting of botanically unrelated crops. Rotating groundnut with maize will reduce white grub attacks. Rotating pigeon pea or chickpea with a non-leguminous crop is a good practice for managing fusarium wilt and nematode problems. Crop rotations are very effective on pests which are less mobile and whose feeding habits are specific to certain crops. Rotating crops also maintains soil nutrient balance as different crops have different requirements.

Trap Crops

It is seen that pests are strongly attracted to certain plants. When these plants are sown in the main field or along the borders, the pests gather on them and can be used to trap the pests. Raising trap crops as inter and/or border crops is an important cropping system approach. The trap crop must be distinctly attractive to the pest when compared to the main crop. It provides protection either by preventing the pest from reaching the main crop or by restricting them to a certain part of the field where they can be economically destroyed. Mustard along with cabbage is a trap crop for the control of the diamond back moth, aphids and the leaf webber. African marigold is a good trap crop for the American boll worm; besides it also attracts the adults of the leaf minor to lay eggs on its leaves. Maize plants can be a trap crop to attract fruit fly adults in vegetable cultivation where the fruit fly is a major problem.

Intercropping

Planting diverse crops suitable to the region along the main crop is referred as Intercropping. This helps to break the pattern of growing same crop year after year (mono-cropping) and limits infestation from pests. Natural enemies of insect pests tend to be more abundant in intercrops than in mono crops, as they find better distribution of nectar and pollen sources. Changing the method of planting in certain crops by adopting a ‘paired row system’ provides the possibility of introducing short duration intercrops without affecting the plant population of the main crop which can be either a medium or long duration crop like cotton or sugarcane. Diverse planting not only obstructs adults from egg-laying but also the release of volatile allelo-chemicals (special chemicals which help insects to identify plants) from particular crops. These effects do not provide suitable conditions for the development of a microclimate favouring the multiplication of a particular type of pest. For example, cabbage along with carrot or tomato, is an important intercrop combination to effectively manage diamond back moth. Growing short duration pulses like blackgram, cowpea, soybean and green gram as intercrops in cotton, ladyfinger increases the effectiveness of natural enemies besides providing some additional income to the farmers.

Mixed Cropping

It is a method wherein a mixture of seeds is sown together in the field. Every village has got its own choice of crops depending on the food habits of the region. In most of the hilly regions 8-10 different types of pulse seeds are mixed and then sown to have a mixed crop. Mixed cropping systems are not preferred by the insects but facilitate the natural enemies of the pests.

Use of tolerant and resistant varieties

Selection of resistant or tolerant varieties is a very important factor when examining the diversity and intensity of pests in a particular place. Plants have their own sophisticated mechanisms to protect form the attack of pests. Majority of the traditional varieties are resistant to many pests.

Manipulation of sowing dates

Changing the sowing/planting dates can help in the avoidance of egg laying period of certain pests and establishment of tolerant plants before the pest occurrence. It also facilitates the early maturation of the crop before the pest incidence.

Irrigation

Irrigation can also be used to control pests which are soil borne. If the field is infested with termites, flooding the field will help to manage the termites efficiently. Similarly many insects like cutworms, potato tuber moth, root grubs etc, cannot tolerate flooding and get killed. It also prevents many insects from egg laying.

4.2.2 Mechanical practices

These are the practices which involve killing or trapping of pests by mechanical means or the use of barriers to prevent pests from gaining access to plants. The traditional methods like 'catch and kill' for insect pests and 'cut and burn' for diseases are very popular and still being practiced by farmers on several crops. Various mechanical methods like the bamboo bow trap for the control of rats; the erection of owl perches in rice fields for rodent control; the provision of tin sheets around coconut trunks to prevent rats from damaging the nuts are widely adopted.

Traps

Insect traps are successfully used to capture the pests. Light traps attract night flying insects like moths, midges and some beetles. It consist of a source of light, such as electric bulb (200 watts), baffle plates and a collecting container. The most efficient light traps are fitted with mercury vapour lamps.

Sticky traps are useful for capturing insects which are active during both day and night. A sticky trap consists of a cylinder covered with a sticky material like vegetable oil. This is set up on a stick at crop level or at a suitable height. The insects get trapped and get killed. Yellow sticky traps are very effective in capturing aphids, thrips and whiteflies. The traps to a large extent are useful for monitoring of pest infestation which helps to take appropriate remedial action.

Spike thrust method

This method is very useful for boring insects in trees. These insects make a hole on the trunk and starts feeding inside the tree. Insects are killed by inserting a long needle or a wire into the hole. This is very effective method to control stem borers in tree crops.

Tree banding

To prevent insects and rats climbing to the tree tops sticky bands or polythene sheets are used around the trunk of the tree. It is a common practice in fruit trees to avoid mealy bugs and rats.

Trenching

Some insects like armyworms, red hairy caterpillars, nymphs of grasshoppers can be effectively checked by digging trenches around the field. The marching insects fall in this and can easily be killed.

Tree Paste

This is an effective method to prevent most of the insects which attack the trunk of the tree like termites, mealy bugs, borers etc., cow dung can be plastered on the tree. The dung plaster after drying turns into a very hard coating on the bark of the tree and prevents the insect infestations. Along with the dung clay can also be mixed which acts as a sticking agent and helps the plaster to stick well on the trunk of the tree.

4.2.3 Botanical Pesticides

The use of plant and plant products to manage pests are referred as botanical pesticides. It is estimated that about 2121 plant species possess pest control properties; 25 of these plant species posses the characteristics required for an ideal botanical insecticide. The extracts prepared from the above listed plants have insecticidal, antifeedant, repellant antifungal, antiviral and antibacterial properties. Following are the plants most widely used for the pest management.

Adathoda vesica

It is a commonly available plant which is grown as hedge. One kg of fresh leaves is finely pounded, mixed with six litres of water and allowed to soak for a day. The liquid is then filtered and a suitable sticker, such as local soap or soap nut, is added. Applications are best done in the evening time after sunset. The mode of action is antifeedant (prevents the feeding), insecticidal and acaricidal (kills the mites).

Acorus calamus

Acorus calamus is commonly referred as Sweet flag and use in traditional Bhutanese medicines. Rhizomes of this plant contain insecticidal properties. Pest control formulations are made using dried and powdered rhizomes. The dried slices of the rhizome can be kept with stored products to ward off storage pests.

Curcuma longa (Turmeric)

Turmeric powder is being used by farmers in different parts of the world to control tomato wilt. A solution of turmeric powder is used to treat the roots of seedlings in tomato nurseries before they are transplanted. The turmeric solution is also effective for the control of the semi loopers, mites, green leaf hoppers, aphids, etc and some diseases of plants. It is prepared by powdering 1 kg of dried turmeric into a fine powder which is then added to 3 to 4 litres of cow urine. One litre of the solution is diluted in 10 litres of water and sprayed on crops. The solution is properly mixed and 4 ml of soap solution is added in one litre of the spray solution to improve its stickiness.

Asafoetida

Asafoetida or 'hing' is used by farmers for the control of termites (*Odontotermes obesus*). About 40–50 gm of asafoetida is tied in a cotton cloth. Two to three such packs are placed in the irrigation channel at a distance of about 20–30 metres from each other during irrigation. The disagreeable odour repels termites and other insects. Asafoetida solution is also used by some farmers for the control of larvae of *Helicoverpa* or American boll worm. It can also be used as a foliar spray. About 100 to 150 gm of asafoetida (per litre of water) are boiled for 10 to 15 minutes. After the solution is cooled, it is sprayed with 40 to 50 litres of fresh water on crops.

***Allium cepa* (Onion)**

The use of onion along with common salt is effective for the control of storage pests. About 2–3 kg of common salt and 3–4 kg of onion are mixed for every 100 kg of chickpea (*Cicer arietinum*) seed in storage. Onion can also be used as a foliar spray.

Capsicum annuum

Use of dry chilli (*Capsicum annuum*) is one of the most popular practices for controlling insects that invade storage. For instance, for the control of storage pests in mung bean (*Vigna radiata*), place 4–5 dry chilies per kilo of seed. This is known to be quite an effective method. Chillies can also be used for foliar sprays. Bhutan has a good collection of hot chillies.

***Ricinus communis* (Castor)**

About 500 gm of shelled castor seed or 750 gm of unshelled seed are first crushed. The crushed seeds are heated in two litres of water for ten minutes. A little soap are added. The solution is filtered and then ten litres of water is added into it. The final solution is sprayed on to the plants.

Tobacco

It is a quick acting insecticide. The tobacco leaves are very effective on a variety of pests which are very difficult to control. One kilogram of tobacco leaves are boiled in 10 litres of water for 30 minutes. The solution thus obtained after boiling is diluted 20 times and sprayed on crops. Use of tobacco is not permitted under national and international organic standards.

Lantana camara

A very effective foliar spray can be prepared by utilizing the whole plant. In addition, water extract of its dried leaves and flowers are used to control many insects including aphids.

Coriander

About 200 gm of crushed seeds are boiled for ten minutes in one litre of water, filtered, and diluted at a rate of 1 : 2 with water. This acts as a good repellent against spider mites.

Marigold

The extract of marigold flowers has been known for its use against insect pests and nematodes. The flowers are crushed to a paste and diluted with water to make sprays. Growing of marigolds is recommended in kitchen gardens and around homes to repel mosquitoes.

4.2.3.1 Disease management

Organic farming practices have provided in the past, effective and sustainable means of disease control. To avoid disease occurrence, practices adopted included careful seed selection, crop rotation, and manipulation of sowing dates. The traditional practices today include different cultural control methods like altering plant and crop architecture, biological control, burning, adjusting crop density or depth or time of planting, fallowing, flooding, mulching, multiple cropping, mixed cropping, planting without tillage, using organic amendments, planting in raised beds, crop rotations, sanitations and tillage. In organic agriculture, many options are available from time immemorial for the management of the plant diseases by using the plants. Most of the plants that are used are available in every village and can be easily made into a formulation by the farmers without investing on expensive technologies.

Simple organic practices that are effective to manage disease are as follows.

1. A simple practice to manage some soil borne pathogens like P*ythium*, *Phytophthora*, etc., is the use of raised beds, fields and ridges.

2. Flooding is followed to control the problem of soil borne pathogens.

3. The problem of *Pythium* damping off in nurseries of brinjal and tomato is overcome by earthing up the soil.

4. Seed borne diseases in wheat like wheat bunt are managed by treating with salt water.

5. Appropriate planting/sowing time helps to overcome the problem of some foliar diseases.

6. Sterility mosaic of pigeon pea is managed by mixed cropping of jowar (*Sorghum bicolor*) with *Cajanus cajan* which inhibits movement of vector mites.

7. Cow's urine: Application of cow urine prevents bacterial wilt (*Pseudomonas*

solanacearum) in tomato, potato and chilies. Cow urine is left undisturbed for two weeks and allowed to ferment. This fermented urine is diluted with water ten times and sprayed on the plants.

8. Application of organic manures also helps to manage soil borne pathogens. Good quality manure contains an appropriate balance of all the microorganisms necessary to provide the soil with defenses against pathogens.

9. Airborne diseases are overcome by planting trees across the wind direction.

10. Asafoetida and turmeric: Asafoetida and turmeric have been traditionally used to prevent bacterial wilt in tomato and brinjal. The soil is drenched with a solution prepared by adding one gram of asafoetida and 5 gm of turmeric in ten litres of water.

4.2.4 Bio-pesticides

Microorganisms when used as bio-control agents are referred as bio-pesticides. Insects and microorganisms are associated in many different ways. These associations range from mutuality associations to those where the microorganisms causes fatal disease in the insect host. Infectious insect diseases, usually causing deleterious effects in the invaded host, occur frequently in insects. These microorganisms which cause disease are often viewed as insect pathogens which can be used as microbial insecticides in different ways. An incredibly large number and diversity of pathogen species of microorganisms infect insect pests. The bio-pesticides are grouped under bacteria, fungi and viruses.

4.2.4.1 Bacterial Bio-pesticides

Bacterial pathogens of insects can be divided into two broad categories, spore forming and non-spore forming bacteria. Although most of the species of bacteria isolated from diseased insects are non-spore forming bacteria, spore forming bacteria belonging to the genus *Bacillus* are the most important from the standpoint of biological control.

a. Non-spore forming bacteria

These bacteria generally have a low disease causing capability (pathogenicity) when they occur in the digestive tract of an insect, but may be highly pathogenic if they are able to enter haemocoel (blood) of insects. Thus the diseases caused by non-spore forming bacteria generally rely on a conditional factor to gain entrance into the haemocoel. The general term ‘stress’ encompasses many of these conditions. Stress results from unusually high temperatures, poor food quality, crowding, mechanical injury or other factors. Non-spore forming bacteria which are not active invaders may enter the haemocoel when the insect has been stressed or injured. Once these bacteria are inside the insect they multiply rapidly and cause the death of the insect. For instance, *Serratia marscens* is the non-spore forming bacteria which is effective against insects belonging to moths and butterflies (Lepidoptera) like *Helicoverpa armigera* and *Spodoptera litura*.

b. Spore-forming bacteria

Spore- forming bacteria as the name implies, produce environmentally resistant spores in addition to vegetative or reproductive cells. There are three primary genera; *Bacillus* and *Paenibacillus* are generally aerobic (require oxygen) and the genus *Clostridium* is anaerobic.

The genus *Bacillus* contains both species that produce toxins and species that do not produce toxins. *Bacillus thuringiensis* (*Bt*) is widely used as a microbial insecticide commercially produced. It is very effective on insect groups like moths and butterflies (*Bt kurstaki* and *Bt aizawai*), beetles (*Bt tenebrionis* and *Bt japonensis*) and flies (*Bt israeliensis*). The activity of *Bt* is due to the presence of a variety of toxins that they produce.

Bacillus thuringiensis acts as stomach poison. The infection occurs through ingestion and the bacterium develops in the intestinal tract of its host later passing on to the haemocoel and finally killing the insect. Normally in the field conditions, one kilogram of *Bt* is made into a thick paste by adding small quantity of water. It is mixed in 200-300 litres of water and sprayed in one acre.

The other spore forming bacteria which are commercially produced are *Paenibacillus popilliae* for control of Japanese beetles and *Bacillus sphaericus* for mosquito control.

4.2.4.2 Fungal Bio-pesticide

Fungi are another group of microorganisms which are widely used as bio-pesticide. The most important fungi which are commercially used are *Beauveria sp. , Metarrhizium sp*. and *Verticillium sp*.

Beauveria bassiana is a common fungus found in the soil. It attacks a wide range of both immature and adult insects like, whiteflies, aphids, grasshoppers, termites, weevils, etc. *Beauveria* produces spores that are resistant to environmental extremes. The spores infect directly through the outer surface of the insect skin. Under favourable temperature and moisture conditions, the spore adhering to the insect or host will germinate and secretes enzymes which attack and dissolve the cuticle (outer layer of the insect body). It then enters into the insect body and multiplies. In the insect body, it produces a toxin which weakens the immune system of the host. *Beauveria* is available commercially as a microbial insecticide because it can be easily mass produced by fermentation process.

Metarrhizium anisopliae is another fungi which is widely used in agriculture. It is highly active on white grubs, beetles, caterpillars, semiloopers, cutworms, aphids, mealybugs etc. It infects all stages of the insects like eggs, larve, pupae, nymphs and adults. The spores of these fungi enter the insect body and kill the insect. It can also be applied in the soil wherein 200 ml (liquid formulation) or 1 kilogram (powder formulation) can be mixed in 50-100 kgs of farm yard manure (FYM) or 2-3 month old cattle manure which is sufficient for one acre.

Verticillium lecani is available in the powder and liquid formulation. This fungus is very effective on insects which suck the plant sap (sucking type of insects) like scale insects, aphids, thrips, jassids etc on a variety of crops. It attacks all the stages of insect and the mode of action is similar to the above mentioned fungi. *Verticillium* is sprayed at the rate of 5 ml in one litre of water. Addition of sugar and soap solution to the spray before spraying on the standing crop improves the results.

4.2.4.3 Viral Bio-pesticide

Similar to bacteria and fungi, viruses are also utilized in managing the pests. The most important group of viruses used as a biopesticide are called as Nuclear Polyhedrosis Viruses (NPV). These viruses are known to infect over 500 species of insects. When the larvae of insects ingest these viruses, the larval bodies gets darkened, tissues disintegrate and finally it dies. Commercially NPV's of *Helicoverpa* and *Spodoptera* are available and used by the farmers.

4.2.4.4 Management of Diseases

The microorganisms that are used to manage the plant diseases are *Trichoderma*, *Pseudomonas* and *Bacillus.* These biocontrol agents can be applied to various plant parts like seed, root, foliage, and also for the soil.

Seed treatment

The seeds are treated with the biocontrol agents in a very simple way. Seeds are immersed in water for one minute and then spread on a polythene sheet. *Trichoderma viride* at the rate of 10grams/kg of pulses, oilseeds and cotton is mixed with the seeds and sown in the field. *Pseudomonas fluorescens* is also used by the farmers to manage diseases like,root and stem rots, damping off, downey and powdery mildews in different crops. Seed treatment of *Pseudomonas fluorescens* at the rate of 10grams/kg of seeds can protect the seedlings from different diseases.

Soil application

The biocontrol agents like *Trichoderma* is very effective when applied in the soil. About five kilogram of *Trichoderma* is mixed with 100 kilograms of farm yard manure or well rotten cattle manure. It is moistened with water for one week and then broadcasted in the soil after ploughing and before sowing of seeds.

Foliar application

The biopesticide can also be sprayed on the crop as a foliar spray by using theknapsack sprayer. One kilogram of biopesticide is mixed in 200- 250 litres of water and sprayed on the crop.

Seedling dip

The seedlings before planting can also be treated with bio-pesticide to protect them from the various plant diseases. About 10 gram of bio-pesticide is mixed in a litre of water and seedlings are dipped in the solution for 30 minutes. Such treated seedlings are then planted in the main field.

Soil drenching

In certain cases wherein the disease incidence is regular every year, the soil around the plant or the tree is poured with the bio-pesticide solution. This process is called as soil drenching. About 10 grams of bio-pesticide is mixed in a liter of water and applied around the tree. Depending on the size of the plant or tree the quantity of the solution is prepared in the same ratio.

Usage in the nursery bed

In crops like vegetables, flowers etc., wherein nursery is prepared first and then transplanted, the nursery gets infected with a variety of disease causing microorganisms. In such conditions, the nursery soil is mixed with the bio-pesticide and then the sowing is undertaken. By adopting this technique it provides protection to the young seedlings from any unforeseen diseases.

4.2.5 Biological control

Biological control is an important component in organic agriculture for plant protection. It is the use of natural enemies to reduce the damage caused by a pest population. Biological control differs from "natural control." Natural control is what occurs much of the time, natural enemies keeping populations of potential pests in check without intervention. Biological control, on the other hand, requires intervention, rather than simply letting nature take its course.

Natural enemies of insect pests, also known as biological control agents or biocontrol agents, include predators, parasitoids, and pathogens. Biological control of weeds includes insects and pathogens and the biological control agents of plant diseases are most often referred to as antagonists. Predators, such as lady bird beetles and lacewings, are mainly free-living species that consume a large number of prey (insects) during their lifetime. Parasitoids are species whose immature stage develops on or within a single insect host, ultimately killing the host. Many species of wasps and some flies are parasitoids.

4.2.5.1 Biological control Agents

The biocontrol agents are categorized into two groups

a) Predators
b) Parasitoids

Predators

Predators are larger insects or animals which capture and feed on other insects or animals. They are bigger in size with well developed sense organs and require more than one prey (insect or other organisms) for their survival. The insects are divided into 29 orders (groups) and out of them insects belonging to 16 orders comprise of predaceous members. Including the spiders and mites, there are more than 200,000 species of predators. Most of the crops attract a large number of predators. The use of synthetic pesticides is the major threat to these predators. When the number of predators decline, managing the pests become a major problem. It is estimated that in any given crop there are more than 300 to 500 species of predators. Spiders represent the largest and the most diverse group and used in biological control. Also mites are used as predators.

The general characteristics of predators are,

a) capture and feed more than one prey for their survival.
b) relatively large size compared to the prey.
c) predaceous on larvae and adults of pests.

d) more active than the prey.

Most of the insect predators which are reared in the laboratory are released at a rate ranging from 600 per acre (eg. Rodalia beetle for the control of pest cotton cushion scale) to 7 lakhs per acre (eg. *Chrysoperla* for the control of aphids).

Table 5: Examples of predators

Predators	Prey
Lady bird beetles	Aphids, scale insects and mealy bugs
Ground Beetles	Many soil dwelling insects
Rove beetles	Many soil dwelling insects
Tiger beetles	Various insects on the ground surface
Lace wings	Aphids
Hover flies	Aphids
Robber flies	Various insects
Wasps	Caterpillars of many insects
Spiders	Many flying adult insects
Predatory mites	Plant feeding mites
Toads	Various soil inhabiting insects
Lizards	Various soil inhabiting insects
Birds	Various soil inhabiting insects

Parasitoids

The insect parasitoids are those whose larve feed internally or externally on the body of another insect. The attacked insect is called as host and sustains the parasite larve throughout its development. At times insect parasitoids are slightly smaller than their hosts wherein a single parasitoid larve develops inside each individual host insect. However, when the parasitoid is very small in size, many parasitoid larve develop within the host. As we have seen earlier that the predators are always larger than the prey. Parasitoids require a single host to complete its development, whereas the predators feed on several prey during its lifetime. Insect parasitoids are very common in nature and most insects invariably have one or several species of parasites associated with them. The parasitoids are specific to the stage of the insect that they attack. Some attack only larva and are called as larval parasitoids, some attack on pupa which are called as pupal parasitoids and those attack on eggs are called as egg parasitoids.

The egg parasitoids like *Trichogramma spp., Telenomus sp., Tetrastichus sp.* damage the egg stage of the pest by preventing the larval stage to appear which causes the damage to the crops. *Trichogramma spp*. is the egg parasitoid produced in large amounts in the laboratory for the control of pests. It controls bollworms, paddy stem borer, sorghum stem borer, fruit borers etc. The general recommendation of parasitoids is about 3000 to 50,000 adults per acre.

The pupal parasitoids like *Tetrastichus israeli* controls pests like American boll worms, paddy leaf rollers, many caterpillars in their pupal stages.

Biological control is an important component in organic farming in managing pests. Their handling is safe not only to the farmers who are using them but also to the environment unlike synthetic pesticides. The most interesting fact is that the biocontrol agents are very specific to the pests, which reflects its success in controlling pests. On the other hand if organic agriculture is practiced, over a period of time, these natural enemies would be in the field always and can benefit the farmer to a very large extent.

4.3 Seeds

Seeds play a very important role in the success of agriculture. Certain estimates reveal that the cost of seeds accounts for atleast 30% of the cost of production. The cost of seeds is on the rise and farmers are becoming dependent on the organizations producing seeds. Sometimes the seeds are not available on time and the farmers miss the sowing season. Due to the demand for particular varieties of seeds at times the seeds are adulterated amidst stringent legislations. There is a need to reduce the cost of seeds and also develop high yielding varieties that are open pollinated which can be produced by the farmers or farmers federation with some basic training on seed production.

.

Advantages of high yielding varieties of seeds

The open pollinated varieties offer lot of benefits to the small farmers;

i. High yielding open pollinated varieties breed true to type and adapt well to low cost organic farming systems which rely on crop rotation, crop diversification and systematic varietals mix up of crops from different genetic make up.

ii. It insures seeds for the next season.

iii. It ensures the farmer against pest outbreak, crop losses, biotic and abiotic stresses because they are characterized by polygenic resistance to pest and diseases being genetically diverse (multi gene resistance).

iv. Helps in reducing the cost on expensive seeds.

v. Farmers have a choice to select the seeds of his interest looking into the market demand.

vi. Studies reveal that they contain more micro nutrients which combat malnutrition and micro nutrient deficiency in the diet of rural poor and are very much suited for home gardening (Guillet,2004).

vii. They hold a great market potential, making available to local vendors, a diversity of products, colors, shapes, taste, and nutrition hence stimulating customer interest resulting in higher income generation.

viii. The reduced cost on seeds has ripple effects like the cost of food gets reduced, hence the food becomes easily accessible to the poor population without any pressure on the national exchequer.

However, training needs to be provided on in-situ and ex-situ seed production, transfer of knowledge in seed self sufficiency, seed conservation, seed exchange and seed marketing. This would create a network of farmers or farmer groups which will engage in the preservation, multiplication, usage, sharing, exchanging and donating the seeds inline with the culture and heritage of Bhutan..

4.4 Converting Farm to Organic

The process of conversion from conventional to holistic agriculture is very important and depends on the attitude of the farmer and also the availability of scientific, technological, economic and institutional support. The conversion process has three components.

1. Increased efficiency – Conventional systems are altered to reduce consumption of costly and scare resources, e.g. by avoiding fertilizers, monitoring pests, optimal cropping system, and timing of operations.

2. Substitution – Resource dependent and environmentally impacting products and practices are replaced by those that are more environmentally benign, e.g. synthetic nitrogen fertilizers by organic resources, pesticides by biological control agents, moldboard plows by chisels or discs.

3. Redesign – Causes of problems are recognized, and thereby prevented, and solved internally by site and time specific design and management approaches instead of by the application of external inputs, e.g., the farm is made more ecologically and economically diverse and therefore also more resource self-reliant.

The conversion methods should be relatively easy to implement & which minimize financial risk.

Transition phase

Transition phase involves the activities of soil and the farm environment, which are variables therefore, any specific formulae or set of practices doesn’t exist which can be adopted for successful conversion. Specific farming strategies need to be designed for individual farms. Usually, conversion is understood as a period which incurs loss to the farm, whereas it is not so. A proper planning and management in time and space is the primary requirement.

Farm structure and soil fertility often determine the speed of transition. Whole farm conversion is advocated, as the effects of alternative strategies are easier to assess in the absence of conventional inputs and practices. The conversion process usually takes about 2 to 3 years in soils wherein crops are cultivated with intensive use of synthetic agro-chemicals, because the toxic residues associated with conventional methods of production may prevent certain biological process from reaching a new equilibrium. However in Bhutan, the use of agro-chemicals is restricted to few pockets which are accessible to the road heads. In the remote mountain areas the farming is traditionally organic and the soils have not been polluted yet.

4.4.1 Key Elements for Conversion

A detailed plan of action specific to the situation and needs is necessary. Such a plan should comprise the following key elements.

(i) Soil Improvement Measures
(ii) Manure production and handling methods
(iii) Development of a crop rotation strategy
(iv) Manure application
(v) Tillage alteration
(vi) Live stock rate
(vii) Weed, Insect and disease management
(viii) Mechanization possibilities
(ix) Housing and storage requirement
(x) Marketing opportunities.
(xi) Labour requirement estimates
(xii) Yield estimate rates
(xiii) Financial estimates and implications
(xiv) Timetable for conversion.

4.4.2 Strategy for Conversion

The following strategies can play a significant role in Bhutan to begin the conversion process.

i. Changing the mindset of farmers to opt organic farming as they are the non-violent approaches to agriculture adhering the Buddhist philosophy.
ii. Creating interest to learn more about simple techniques.
iii. Exposure visits to few organic farms and study the success stories.
iv. Getting the help of organizations or advisors involved in training in organic agriculture.
v. Participatory planning and accepting the plan.

vi. Developing skills to manage stress and drudgery.

vii. Planning and discussing the technical/financial plans- budget and time frame.

viii. Sharing the task with the family and the family labour and orienting them towards the task.

ix. Breaking down the plan into various simple task for implementation.

x. The extension support of the Department of Agriculture (DoA) will be essential tool for facilitating the conversion process. Equipping all extension agents in low cost sustainable farming technologies and providing appropriate solutions to the farmers on utilizing the local resources efficiently would be an important factor for conversion.

4.4.3 Action Plan for Conversion

After creating awareness and working out the basic strategy, it is important to design a plan of action considering the ground realities. It helps the farmer to plan in advance for meeting the requirements on time. In Bhutan more than 70% of the farmers are small, under such circumstances, it is better if the farmers taken up organic agriculture in a collective way. It is very economical for such a group to enter into the certification processes as the costs and resources are shared. The plan of action comprises of,

i. Preparing a topography map of the farm

ii. Deciding to convert the whole or part of the farm. If a part of the farm is chosen, a plan has to be formulated to create a buffer zone.

iii. Dividing the farm into various fields and numbering them.

iv. Developing a cropping calendar for three years.

v. Aggregating the crop production plan into farming systems.

vi. Introducing crop rotation, mixed cropping, companion cropping.

vii. Designing the basic infrastructure like buildings/structures, irrigation systems.

viii. Land leveling, bunding, terracing, contours, check dams, water harvesting

ix. Integration of animal husbandry with farming systems.

x. Production of inputs on farm like compost, bio-pesticides, plant tonics etc.

xi. Harvest and post harvesting techniques.

xii. Tools and equipments.

xiii. Storage, packaging, labeling and marketing.

xiv. Seeds, seedling and nursery management.

xv. Maintenance of records of production, processing and marketing (which can be taken care by NGO, society or Producer Company).

The conversion process becomes successful only when the farmer / organization produces all the required farm inputs by utilizing the on-farm resources. On the contrary, organic farming can be a non – economical venture when the inputs are bought and used on line with the practices similar to the conventional farming systems. Bhutan is bereft with abundant natural resources, varied climates, strategic geographic location which provides enormous potential to produce all inputs on-farm by utilizing the natural resources.

5. Agricultural Policy and Support Systems

The use of high yielding and hybrid varieties of crops and higher inputs of fertilizers and plant protection chemicals has resulted in a substantial increase in the production of food grains. But, it has now been realized globally that, the increase in production was achieved at the cost of soil health, environmental pollution, loss of indigenous crop diversity and poor health among rural people. The agricultural practices advocated during the 'intensive agriculture regime' commonly referred as 'green revolution' have contributed irreparable damage to soil fertility, structure and water holding capacity. Destruction of useful insects, micro organisms and predators has eliminated the natural check on insect pests. Pollution with toxic chemicals has not only endangered the health of the farmers and the workers who produce them, but also poisoned the food with high toxic residues.

In Bhutan, the synthetic fertilizers and pesticides have been used in agriculture for the last two decades. Since most of the farmers and their arable land are in remote mountainous terrains, these inputs have not reached them. The farmers who are residing near the towns with approach road are using more of fertilizers than pesticides. Till now there are no documented reports on the impact of these chemicals on health. However, it is being noted by many farmers that the use of fertilizers is creating a hard pan in the soil and imbalance in the soil nutrient status (Norbu and Floyd, 2001).

The experiences different countries reveal that the benefits of chemical farming are short lived and the negative effects are more damaging. To continue achieving satisfactory yields with these green revolution farming methods, higher quantities of chemical inputs were needed, making these technologies less and less affordable, especially for the majority of farmers who have only limited land and financial resources. A pragmatic strategy under prevailing conditions which is in collaboration with nature and nurturing it for optimized sustainable productivity needs to be developed. Organic farming offers one such option through which natural resources can be improved while simultaneously using them effectively for the benefit of mankind.

Organic farming has emerged as a viable alternative to conventional farming systems. It helps in maintaining soil health, strengthens the natural resource foundation and sustains production systems at the levels commensurate with the carrying capacity of the eco-system. However, it is important that the transition from conventional to organic farming takes place gradually and effectively so that the food production does not suffer from the likely impact of learning and adapting to a new farming system. Scientific management plan has to be drawn before switching to organic farming. It is a misunderstood concept that the stoppage of synthetic inputs like fertilizers and pesticides would result in yield decline. However, the scientific reports and research world over reveal that with good management practices in marginal and low input farming systems akin to Bhutan the yield improves rather than decline. To achieve these objectives national and regional efforts are required to facilitate careful adoption of organic farming by the farmers.

5.1 Approach

Promotion of organic farming should be farmer centered and the approach adopted must create conditions for the conservation and efficient use of locally available natural resources. In this direction, intervention from Royal Government of Bhutan and Ministry of Agriculture is required to instill confidence in the minds of the farmers. These interventions to aim and address the following issues:

- Sustainable livelihoods of small farmers through low cost organic agriculture
- Assuring farmer income during conversion and learning phase
- Providing initial support for organizing farmer federation or consortia.
- Promoting organic agriculture as a sustainable, safe and healthy method of increasing production independent of special price advantages
- Resolving often extreme distress in rural farming communities resulting from high input cost, low returns, increased debt etc..
- Developing land and crop management to compensate for more adverse and more variable weather conditions.

- Reliance on locally available, affordable and environment friendly inputs.
- Increased self reliance through inclusion of local seeds, manures and indigenous practices for plant protection.
- Encouraging mixed farming aimed at household food security while conserving biodiversity and local cultural values.
- Preparing farmers for competitive marketing through value addition, e.g. through quality, specialty products, partial processing, presentation.
- Creating consumer awareness on natural farming and safe food
- Harnessing export potential of organic and other specialty products.

5.1.1 Major Strategies

- Research and Development in low cost organic agriculture, technology development and transfer.
- Farmer empowerment, organizational structure and institutional support.
- Education and training
- Re -empowering women who were responsible for seed saving and maintaining future family harmony.
- Business structure, infrastructural support and market development.

5.1.2 Major actions

- Providing incentives initially to convert conventional farms into organic farms with time bound programmes.
- To enhance the income of the farmers by reducing the cost of production, reorganizing the market chain and attaining sustainability.
- To introduce participatory approaches in promotion of organic farming by involving all stakeholders at all decision making levels, facilitated by the Government.
- To integrate all land based activities like Agriculture, Horticulture, Animal Husbandry, Forestry and other land use activities in policy making and at implementation levels.
- To promote production of organic inputs on individual/commercial scale locally involving Self Help Groups (SHG's)/Non Government Organizations (NGOs)/Farmers Associations.

5.1.3 Specific activities

- Production of green manure seeds in sufficient quantities to be used by every farmer.
- Promotion of multi-purpose local tree species (food, fibre, fodder and timber) on farms.
- To create infrastructure to facilitate grading, processing, packing and marketing of organic produce locally with transparent pricing and benefit distribution.
- To document existing sustainable organic farming practices and to develop packages of practices by Research Organizations/ Government Departments/ NGOs.
- To popularize use of organic produce among consumers, large scale production by small producers of truthful organic produce certified by local agencies/ NGOs /Farmer Associations need to be encouraged.
- To create infrastructure for testing organic inputs and outputs (products) with effective and economic methods, test centers and sampling.
- To support private sector participation in marketing of organic produce.
- To support organic food processing industries and encourage stable farmer-buyer relationships.
- To introduce organic farming curricula in Schools, Colleges and Universities.
- To create new market opportunities in export markets through development of value added organic products.

5.2 Policy measures

Developing appropriate policy and a work plan is very important for the success of organic agriculture in Bhutan. A good beginning has been made by Department of Agriculture (DoA) through the formulation of Framework for Organic Farming in Bhutan. The policy shall comprise,

- Establishment of a National Level Board (Bhutan Organic Development Board) for coordinating all programmes related to organic farming in all the

Dzongkhags under the chairmanship of the Secretary, Agriculture to frame the national Policy on organic farming, monitoring and implementation of these policies, ensure co-ordination among various departments and organizations concerned with organic farming including management of budget allocation to different organic farming sectors and agencies. The working group shall be in line with the National Framework for Organic Farming in Bhutan.

National Level Board

1. Secretary, Agriculture	Chairman
2. Director General, MoA,	Member
3. Director Generals(DoF, DoL, CoRRB, BAFRA NSSC, NPPC, AMS)	Members
4. Director, Agriculture	Member
5. Joint Director, Agriculture	Member
6. Two farmer representatives	Members
7. Coordinator, National Organic Program	Member Secretary

- A multi-stakeholder, non-governmental technical body with well defined authority and function shall be constituted. This body with an expert on organic farming as its chairman and members shall be drawn from different sectors of society and NGOs. This body shall frame operational guidelines for promotion of organic farming and act as an advisory body to the National Level Board in framing technical guidelines and assist the Board in evaluation and approval of projects and monitoring of programmes.

- Credit support for organic farming activities at reasonable interest rates and with feasible security (guarantee) conditions.

- Introduction of organic farming and biodiversity syllabus in primary/ secondary/college/ university education.

5.3 Support Systems

In addition to a sound policy in organic agriculture, different support systems needs to be nurtured and built-in for the smooth functioning of the program. Some of the successful support systems are discussed below.

5.3.1 Bio-village

Bio-village is an important concept which seeks to promote an efficient and sustainable use of natural and biological resources leading to the continuous and steady growth of off-farm and on-farm production while protecting and improving the environmental capital stock of the village. The aim is to strengthen and upgrade rural food, energy and livelihood security, both ecologically and economically.

A great emphasis is placed upon appropriate, environmentally friendly and resource conserving eco-technologies that improve livelihoods and help encourage the upstart of local bio-friendly organizations. Bio-villages promote an integration of people's indigenous technical knowledge with advances in biological and communication technologies so collective social mobilization, microfinance, capacity building, multiple livelihood engineering, marketing skills, value addition, standardization of quality control, information management etc. are some of the essentials of the process.

Bio-village is of, for and by the farmers with a main objective of brining prosperity through low-cost agriculture and innovative management of community needs.

Features of Bio-village

Main features of the bio-village are,

i. Food, shelter and other basic needs of the community will be surveyed by a group determined by a village committee (VC).

ii. A strategy to meet the total needs of the village by the village committee (VC) will be prepared with involvement of Technology Facilitating Partners (TFP) which is a consortium of researchers, government agencies and NGOs.

iii. Focus of the farmer will be farming-system involving animal husbandry and crops (grain, fruits, fiber, medicinal and aromatic plants etc.) with maximum use of locally available natural resources.

iv. Resources needed for crop and animal production will be produced in the village.

v. Organic agriculture approaches for production and protection of crops and animals will be adopted by the farmers who would be provided timely training.

vi. The different sustainable agriculture approaches and their success will serve as demonstration fields worth visiting by farmers from other areas. The interested farmers of other villages after seeing the results and discussion with the farmers of the bio-village would become interested to adopt the same in their villages. The knowledge and technology transfer will have a ripple effect and without any assistance the spread would be quick and effective. Bio-village will have a positive impact in the socio-economic aspects of the farming community

5.3.2 Farmer Field Schools

Farmers are the best educators to the other farmers. The farmer to farmer extension helps to a great extent for information exchange and dissemination. Farmer field school is a concept wherein the farmers of the village or a group of nearby villages meet once a week at a particular place which can be at one of the farmers house or a community hall. The farmers share their practical experiences or new techniques like,

- Soil and water conservation techniques
- Production of organic inputs like compost by utilizing the village refuse
- Planning for planting of trees
- Kitchen gardens
- Family health care gardens with medicinal herbs
- Biogas or alternate energy sources
- Apiculture

- Seed production techniques

Interesting experiences of the farmers are shared which are practical, simple and economical. Since the farmers are sharing their experiences there is trust amongst the fellow farmers who would attempt them in their own fields. In India, the Maharastra Organic Farmers Federation (MOFF) has about 500 farmer field schools in the entire state of Maharastra. Farmers from the other states visit these farmer schools to have first hand information on the practical technologies and wish to learn from the farmers who are adopting the same.

5.4 Interventions to assist organic farming and development of the sector

Organic agriculture is in many ways an eminently preferable model for the development of agriculture in Bhutan. There are multiple benefits associated with organic agriculture like, natural resource conservation, social benefits by generating rural employment, enhancing nutritional security, reduced dependence on external inputs and also makes agriculture a profitable enterprise. To promote organic agriculture in Bhutan, various steps need to be taken at various levels such as,

5.4.1 Small farmers

Problems

i. Poor infrastructure (for production and logistics)
ii. Lack of proper organization and domestic marketing network
iii. Require marketing initiative (during conversion period and immediately after certification)

Strategies

i. To organize small farmers to act as an organization that produces and markets their own products for the domestic and export markets.
ii. Organizing training programs for the farmers not only in organic agriculture methods (production, harvest and post harvest techniques etc) but also in how to sell, promote, diversify their products and fulfill certification requirements like ICS.
iii. Provide exposure to the farmer groups in organizations dealing in production, processing and marketing.
iv. Farmer groups should have access to financial support for organic production, administration, group certification and marketing programs for their products.
v. Offer continuous organic market information to the farmer groups and connect with the prospective buyers.

vi. Promotion of organic products in national and export markets where farmers can participate like, national and international fairs, commercial missions to specific export countries.

5.4.2 Processing Industry

Problem

Processing of organic produce is at a nascent stage.

Strategies

i. Creating awareness in organic processing and value addition for the product. For instance, the apples of Bhutan during the season are exported and in the lean season are imported at a higher price. These apples can be processed in different forms as per the requirement of the consumer and can be marketed through out the year. Similarly many products can be processed which can add value locally, earn high income and form the basis of thriving small scale rural industries.

ii. Incentives to be provided for the entrepreneurs venturing into processing of organic produce.

5.4.3 Certification

Problem

i. Lack of national standards and harmonization with the international standards.

ii. No certification agency operating in Bhutan

Strategies

i. Developing national standards with a legal framework online with the international standards for organic agriculture.

ii. Creating a national certification body.

iii. The labeling of food produced through sustainable agriculture would be the first step in promoting such products.

5.4.4 Domestic Consumers

Problem

Lack of awareness of organic products benefiting health and environment.

Strategies

i. Public awareness campaigns to stimulate demand for organic foods
ii. Publicity and information to the consumers on the benefits of organic food e.g by radio broadcast and telecasts.
iii. Introducing organic agriculture into the curriculum of schools and colleges.
iv. However, there is a strong preference for the ethnic foods which are locally produced which is an area for market development.

5.4.5 Agricultural Research

The emphasis of agricultural research in Bhutan has been towards increasing the food production through intensive agricultural practices. The impacts of such a system of agriculture wherein chemical fertilizers and pesticides are used season after season, year after year are being noticed through out the world. Though the quantity of synthetic agrochemical usage is low in Bhutan, it is always a better option to direct the research towards attaining sustainable production along with preservation of natural resources.

Organic agriculture is gaining lot of importance all over the world because it is benefiting both the farmer and the environment. The global pressure on the non renewable resources and the energy crisis is paving a way in identifying sustainable and alternative ways of food production which has positive impact on soil, water, environment and biodiversity. The need of the hour is to reorient the research in the development of clean technologies that would facilitate,.

- Meeting family's food and nutritional needs.
- Reducing the cost of production in agriculture
- Production of inputs utilizing locally available resources.
- Bringing sustainability in production with low cost technologies
- Contributing to local/regional market requirements
- Achieving socio-economic improvement and food security

5.4.6 Human Resource Development (HRD) Policy for Knowledge based Agriculture

Globalization and free trade, and fast pace of technological advancements are ushering challenges and opportunities for agriculture and rural development. Agriculture in Bhutan as a part of the global agriculture should keep pace with fast and changing technologies that are oriented towards renewable natural resources, expanding and complicated information systems, new market strategies, new services and products etc. The widening gap between the technology generation and technology dissemination amongst the user groups is of great concern. It has been proved beyond doubt that the input in the form of scientific knowledge can only bring 100-200 percent increase in productivity of the soil and agriculture. Future agriculture will be increasingly science led with emphasis on ecology and energy conservation which would require modern economic management. Education holds the key for overall growth and development in agriculture sector. It is essential to equip the agriculture human resource with the knowledge development.

There is a need to have a well designed HRD policy to meet the emerging challenges in the organic agriculture sector- productivity enhancement, improvement in quality, sustainable intensification and diversification, community participation, establishing the forward and backward linkages and increase in employment generation.

The HRD policy needs to be framed on holistic approach and models besides obviating the deficiencies should include- career pathways for the learners in organic agricultural profession, establish statutory authorities for monitoring, maintenance and determination of standards in agricultural education; employment and training of agricultural teachers at various levels, an optimum ratio of para-professionals to professionals and capitalization of open education and new trends of information and communication technology.

"Give a man a fish and you feed him for a day"
"Teach a man to fish and you feed him for a lifetime"

Chinese proverb

References

Bourguignon, C., 2005. *Regenerating the soil*. Other India Press, Goa, India. 188p.

FAO. 2001.The place of Agriculture in Sustainable Development", March 2001.

GTZ Sustainet. 2006.Sustainable Agriculture:A pathway out of poverty for India's rural poor. Deutsche Gesellschaft fur Technische Zusammenarbeit, Eschborn.

Guillet D. 2004. A Manual for the production of seeds in the family garden. Published by Association Kokopelli, Ales, France. 439pp

Higa,T and G.N. Wididana 199l. Changes In the soil microflora Induced by effective microorganisms. p.153-162. In J.F. Parr, S.B. Hornick, and C.E. Whitman (*ed.*) Proceedings of the First International Conference on Kyusei Nature Farming. U.S. Department of Agriculture, Washington, D.C., USA.

Howard, A. 1956. *An Agricultural Testament*, Other India Press, Mapusa, Goa, Earthcare Books, Bombay and Third World Network, Malaysia. 262p.

IFOAM Brochure. 2007. Published by IFOAM Head Office, Bonn, Germany.

Krier, J.M.: 2001, Fair Trade in Europe 2001: Facts and Figures on the Fair Trade Sector in 18 European Countries. Research report for the European Fair trade Association.

Ministry of Agriculture (MoA) and World Food Programme (WFP), Bhutan. 2005. Vulnerability Analysis and Mapping. Published by Ministry of Agriculture, Royal Government of Bhutan.

Mollison, Bill and Holmgren, David. 1987. Permaculture One: A Perennial Agriculture for Human Settlements. 3rd Edition. Tagari Publishers, Tyalgum, New South Wales, Australia. 127 p.

Norbu Chencho and Floyd, Christopher.2001. Changing Soil Fertility Management in Bhutan: Effect on Practices, Nutrient Status and Sustainability. Presented in Annual Meetings of Soil Science Society of America, American Society of Agronomy and Crop Science Society of America, Charlotte, NC, USA. Oct 21-25.

RoGB. 2002. Community Based Natural Resource Management in Bhutan- A Framework. Department of Research and Development Services. Ministry of Agriculture, Royal Government of Bhutan, Thimphu.

Statistical Yearbook of Bhutan. 2004. National Statistical Bureau, March 2004.

Swaminathan, M.S. 2006. Sustainable Agriculture and Food Security in India. In: Towards a sustainable society - Perceptions. Edited by, Dewan, M.L. Published by Clarion Books, New Delhi,India. 256p.

Thimmaiah.A and Anjali.2004. Biodynamic Agriculture: Harmony in Chaos. In: Proceedings of national Symposium on organic farming in Horticulture for Sustainable Production, CISH, Lucknow. Pp 90-93.

Thimmaiah,A.2006. Current Status of Inputs for Organic Agriculture. Published by Food and Agriculture Organization (FAO) of United Nations (UN), India. 122pp.

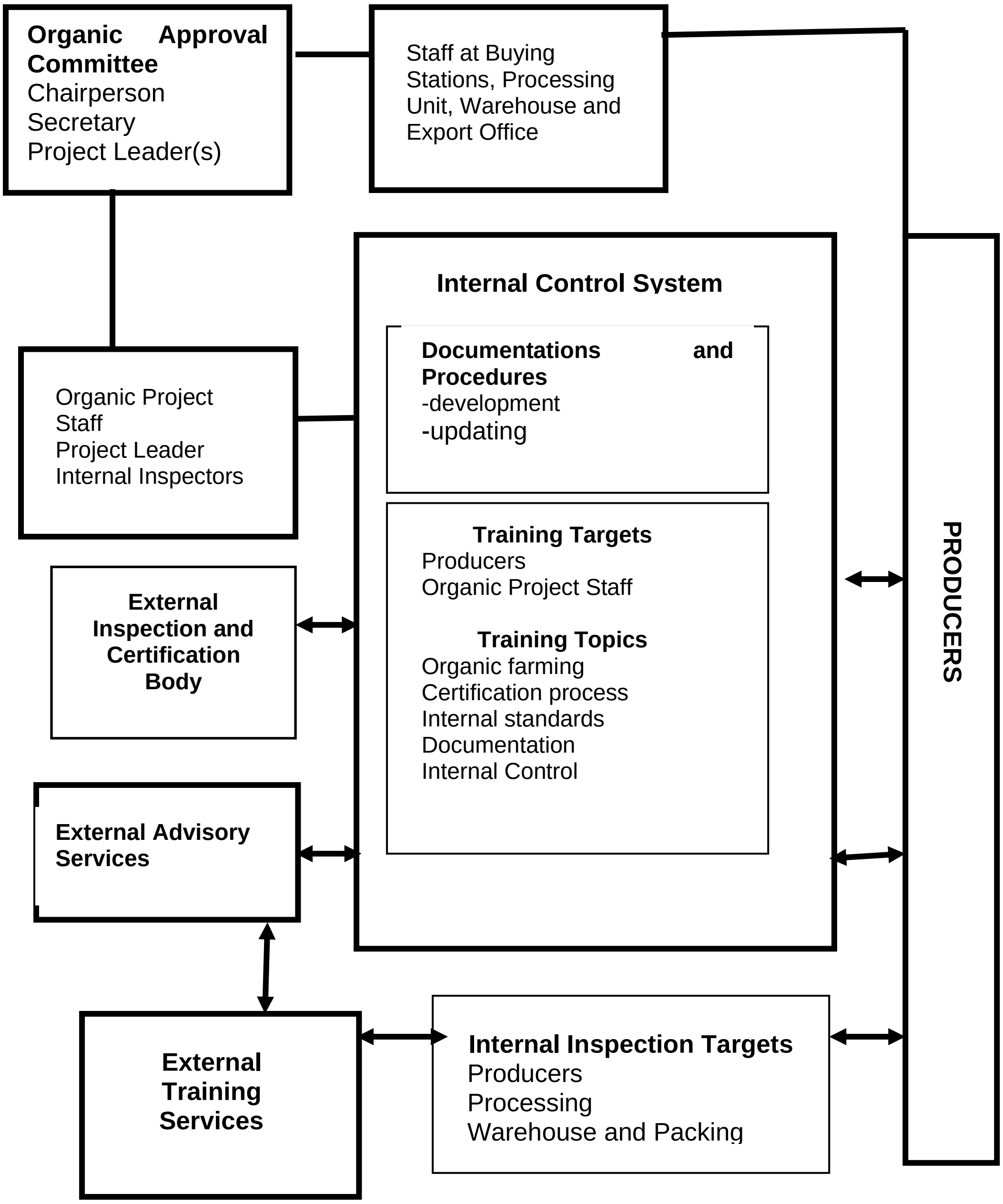
Websites:
www.worldbank.org

www.fao.org

APPENDIX

Appendix 1: ICS Formats

A) Organizational Chart



B) Application Form

Farmer Name	Farmer Code:
Farmer Address	
Buying station	Village name

Crop Details

Field code number (similar to field map)	Ha (or acres)	Date of planting Month/Year	Estimated yield in Kg's	Date of last use of Chemicals Month/Year		
				Fertilizer (kg)	Herbicide (Lts)	Pesticide (Lts)
Totals						

Notes on field situation in organic crop

	Organic holding in field with multiple owners, no clear borders. All owners are organic.
	Field is clearly separated from other fields by:
	Other: (describe)

Other fields

Crop or describe land use	Ha	Use of chemicals: Yes/No
Total ha		

I, the farmer, declare that this information is correct and that I have understood the conditions for the Organic Production. I have also received a copy of the farmer's organic contract. Date: Place Signature farmer:	I, the field Officer, confirm that the above mentioned information is correct. Internal Inspector Name: Signature:

General information

Enter farmer's full name, the village name, farmer's address, farmer's code number.

System of farmers code numbering

Each farmer receives a code number, as for example XY001,where letters are the village code and the tree digit number is the farmer in that village.

System of field numbering

Each registered field receives a running number (the first field registered is 1, the second 2 etc). Villages are independently numbered.

Information on Organic crop

Enter the number of fields, the size of the field in hectares/square meters, and total the area in hectares/square meters. Note the yield estimate in kg of export crop, based on the yields of preceding years. Note the date of the last application of agro-chemicals if the farmer has been using agro-chemicals in the past three years.

Notes on field situation

The form allows space for comments regarding the borders of the organic export crop fields. Check the applicable situation. Important note (see also Farmers contract): if a farmer tills a field where no clear boarders exist, all farmers of the respective field must be willing to convert to organic farming. If one or more farmers of such a field are not interested in joining the organic program, none of the sub-fields can be contracted.

Signing

The farmer signs and dates the form on the left side to confirm that the information given on the form is correct. The Field Officer (FO) signs on the right side of the form also to confirm that the information filled in the form are correct.

C) Growers Contract

Grower Name: Grower Code: Grower's address: Village:

1. I, the undersigned, accept to become a member of the (name of the organization) organic project, certified and controlled by (name of certification agency).

2. I promise to follow the Internal Control System (ICS) as well as the organic agricultural principles.

3. I will not use pesticides, herbicides or synthetic fertilizers on any crop within my organic export field(s) or in other crops.

4. I will avoid where possible the use of any chemical substance(s) on any other crop bordering my field(s).

5. I shall endeavor to maintain the following organic principles:
   - Use of clean planting/seeding material, when available;
   - Maintain and improve soil fertility by mulching and application of organic matter, compost, manure, green manure and/or crop residues;
   - Avoid environmental degradation: cutting down trees unnecessarily, burning of crop remains, or any other organic material; dumping of toxic material (such as batteries) or burning of plastics;
   - Prevent soil erosion, constructing contour borders where necessary;

6. I will commit myself to follow the organic management-training program as organized by (name of the organization)

7. If I observe any violation of the organic principles, I will report this to the internal Inspector or another responsible person of (organization)

8. I understand that any violation(s) of the organic principles by even a single grower will lead to the exclusion of this production or of the entire village.

9. I will allow inspections by persons authorized by (organization) and/or (certification agency).

(Organization) will provide the following support

1. Buy the organic export crop for a sustainable and transparent price including a possible organic premium (depending on market) when the export crop is of suitable quality.

2. Provide support services to the growers by way of Internal Inspectors(s) and/or consultant(s).

3. Co-ordinate the entire project including timely submission of the project for organic certification.

Location: Date:
Grower's name:
Grower's Signature:

For (organization)
Name:
Signature

Note: Organization here can be NGO, cooperative or farmers consortia.

Notes for Internal Inspector

After approving and signing the Farm Entrance Form, the grower and (organization) sign the Growers' contract. Make sure that the grower receives one copy of the contract, which remains with the grower.

Important notice: If a grower tills a field where no clear borders exist, all growers of the respective field must be willing to convert to organic farming. If one or more growers of such a field are not interested in joining the organic program, none of the sub-fields can be contracted.

D) Farm Inspection Form

Village Name | Village Code
Name of Farmer | Farmer's Code

Inspection Date		Date of last inspection	
Farmer Present		Time spent	
Fields Visited			
Course of visit			

CROPS
Comments, instructions, and suggestions

Rotation	Y	N	G	F	P	
Land Preparation			G	F	P	
Use of manure	Y	N				
Use of other fertilizers	Y	N				
Recognizes pests			G	F	P	
Sprays when needed	Y	N				
Weed Control			G	F	P	
General score			G	F	P	Estimated yield:

ANIMAL CONDITION
Comments, instructions, and suggestions

Cows	G	F	P	
Goats	G	F	P	
Treatment used	G	F	P	
Manure management	G	F	P	

STORAGE
Comments, instructions, and suggestions

Clean	G	F	P	
No Contaminants	Y	N		

Conclusions (check the appropriate box.)

Farmer is performing	G	F	P
Farmer has violated organic standards	Y	N	
Farmer must urgently improve	Y	+/-	N
Farmer has improved since last inspection	Y	N	

Comments and questions from the farmer

I, the farmer, agree that the information given in this report is correct and complete.

Date:	Signature:

I, the field Officer confirm that the information given in this report is correct and complete

Date:	Name:	Signature:

Y=Yes, N=No, G=Good, F= Fair, P=Poor

E) Buying Procedures

Purchasing of organic produce is done through (organization) which collects and records the produce from organic farmers and farmers in transition on the Buying Record form. Produce is kept separately for each farmer. The Treasurer confirms that the delivered amount of organic produce is plausible, by comparing the actual delivery with the crop estimate (noted in the Buying record by the Internal Inspector or Project Supervisor at latest one week before delivery). If there is any doubt about the produce, the produce is kept apart until the Project Supervisor has checked with the respective farmer and has indicated whether to allow the produce into the organic supply chain.

A Cash Voucher is completed. The vouchers will be stamped ‘organic’ or ‘in conversion’. The farmer receives a copy of the Cash Voucher. Organic Project Supervisor would keep other copy.

Information regarding purchasing conventional produce is kept separately.

Appendix 2

CODEX ALIMENTARIUS
Guidelines for the use of inputs in organic agriculture

PERMITTED SUBSTANCES FOR THE PRODUCTION OF ORGANIC FOODS

Precautions

1. Any substances used in an organic system for soil fertilization and conditioning, pest and disease control, for the health of livestock and quality of the animal products, or for preparation, preservation and storage of the food product should comply with the relevant national regulations.

2. Conditions for use of certain substances contained in the following lists may be specified by the certification body or authority, e.g. volume, frequency of application, specific purpose, etc.

3. Where substances are required for primary production they should be used with care and with the knowledge that even permitted substances may be subject to misuse and may alter the ecosystem of the soil or farm.

4. The following lists do not attempt to be all inclusive or exclusive, or a finite regulatory tool but rather provide advice to governments on internationally agreed inputs. A system of review criteria as detailed in Section 5 of these Guidelines for products to be considered by national governments should be the primary determinant for acceptability or rejection of substances.

Table1: Substances for use in soil fertilizing and Conditioning

Substances	Description; compositional requirements; conditions of use
Farmyard and poultry manure	Need recognized by certification body or authority if not sourced from organic production systems. "Factory" farming21 sources not permitted.
Slurry or urine	If not from organic sources, need recognized by inspection body. Preferably after controlled fermentation and/or appropriate dilution. 'Factory'farming sources not permitted.
Composted animal excrements, including poultry	Need recognized by the certification body or authority
Manure and composted farm yard manure	'Factory' farming sources not permitted.
Dried farmyard manure and dehydrated poultry manure	Need recognized by the certification body or authority. 'Factory' farming sources not permitted.
Guano	Need recognized by the certification body or authority.
Straw	Need recognized by the certification body or authority.
Compost and spent mushroom and Vermiculite substrate	Need recognized by the certification body or authority. The initial composition of the substrate must be limited to the products on this list
Sorted, composted or fermented home refuse	need recognized by the certification body or authority.
Compost from plant residues	
processed animal products from slaughter houses & fish industries	need recognized by the certification body or authority.
By-products of food & textile industries not treated with synthetic additives	need recognized by the certification body or authority.
Seaweeds and seaweed products	need recognized by the certification body or authority.
Sawdust, bark and wood waste	need recognized by the certification body or authority, wood not chemically treated after felling from wood not chemically treated after felling.
wood ash and wood charcoal	need recognized by the certification body or authority,
Natural phosphate rock	need recognized by the certification body or authority. Cadmium should not exceed 90mg/kg P205 .
Basic slag	need recognized by the certification body or authority.
Rock potash, mined potassium salts (e.g. kainite, sylvinite)	should have less than 60% chlorine.
Sulphate of potash (e.g. patenkali)	obtained by physical procedures but not enriched by chemical processes to increase its solubility need recognized by the certification body or authority.
Calcium carbonate of natural origin (e.g. chalk, marl, limestone, phosphate chalk)	
Magnesium rock	

Calcareous magnesium rock	
Epsom salt (magnesium-sulphate)	
Gypsum (calcium sulphate)	Only from natural sources/origin.
Stillage and stillage extract	Ammonium stillage excluded
Sodium chloride	only mined salt
Aluminium calcium phosphate	Cadmium should not exceed 90mg/kg
Trace elements (e.g. boron, copper, iron, manganese, molybdenum, zinc)	Need recognized by the certification body or authority.
Sulphur	-need recognized by the certification body or authority.
Stone meal	
-Clay (e.g. bentonite, perlite, zeolite)	
Naturally occurring biological organisms (e.g. worms)	
Vermiculite,	
Peat	excluding synthetic additives; permitted for seed, potting module composts. Other use as recognized by certification body or authority. Not permitted as a soil conditioner.
Humus from earthworms and insects	
Chloride of lime	need recognized by the certification body or authority.
Human excrements	need recognized by the certification body or authority. The source is separated from household and industrial wastes that pose a risk of chemical contamination. It is treated sufficiently to eliminate risks from pests, parasites, pathogenic microorganisms, and is not applied to crops intended for human consumption or to the edible parts of plants.
By-products of the sugar industry (e.g. Vinasse),	need recognized by the certification body or authority.
By-products from oil palm, coconut and cocoa (including empty fruit bunch, palm oil mill effluent (pome), cocoa peat and empty cocoa pods)	need recognized by the certification body or authority.
By-products of industries processing ingredients from organic agriculture	need recognized by the certification body or authority.
Calcium chloride solution	leaf treatment in case of proven calcium deficiency.
"Factory" farming refers to industrial management systems that are heavily reliant on veterinary and feed inputs not permitted in organic agriculture.	

Table 2: Substances for plant pest and disease control.

Substance	Description; compositional requirements; Conditions for use
I. Plant and Animal	
Preparations on basis of pyrethrins extracted from *Chrysanthemum cinerariaefolium*, Containing possibly a synergist	need recognized by the certification body or authority. Exclusion of Piperonyl butoxide after 2005 as a synergist.
Preparations of Rotenone from *Derris elliptica*, *Lonchocarpus*, *Thephrosia spp*.	need recognized by the certification body or authority.
Preparations from *Quassia amara*	need recognized by the certification body or authority.
Preparations from *Ryania speciosa*	need recognized by the certification body or authority.
Commercial preparations/ products of Neem (*Azadirachtin*) from *Azadirachta indica*	need recognized by the certification body or authority.
Propolis	need recognized by the certification body or authority.
Plant and animal oils,	
Seaweed, seaweed meal, seaweed extracts, sea salts and salty water	need recognized by the certification body or authority. Not chemically treated.
Gelatine	
Lecithin	Need recognized by the certification body or authority.
Casein	
Natural acids (e.g. vinegar)	Need recognized by the certification body or authority.
Fermented product from *Aspergillus spp.*	
Extract from mushroom (*Shiitake fungus*)	Need recognized by certification body or authority
Extract from *Chlorella spp*	
Chitin nematicides	Natural origin
Natural plant preparations, excluding tobacco	Need recognized by certification body or authority.
Tobacco tea (except pure nicotine)	Need recognized by certification body or authority.
Sabadilla	
Beeswax	
II. Mineral	
Copper in the form of copper hydroxide, copper oxychloride, (tribasic) copper sulphate, cuprous oxide, Bordeaux mixture and Burgundy mixture	Need, prescription and application rates recognized by certification body or authority. As a fungicide on condition that the substance be used in such a way as to minimize copper accumulation in the soil.
Sulphur	Need recognized by certification body or authority.
Mineral powders (stone meal, silicates)	
Diatomaceous earth	Need recognized by certification body or authority.
Silicates, clay (bentonite)	
Sodium silicate	
Sodium bicarbonate	

Potassium permanganate	Need recognized by certification body or authority.
Iron phosphates	As molluscicide.
Paraffin oil	Need recognized by certification body or authority.
III. Micro organisms used for biological pest controls	
Micro-organisms (bacteria, viruses, fungi) e.g. *Bacillus thuringiensis*, Granulosis virus, etc.	Need recognized by certification body or authority.
IV. Other	
Carbon dioxide and nitrogen gas	Need recognized by certification body or authority.
Potassium soap (soft soap)	
Ethyl alcohol	Need recognized by certification body or authority.
Homeopathic and Ayurvedic preparations	
Herbal and biodynamic preparations	
Sterilized insect males	Need recognized by certification body or authority.
Rodenticides	Products for pest control in livestock buildings and installations. Need recognized by certification body or authority.
V. Traps	
Pheromone preparations	
Preparations on the basis of metaldehyde containing a repellent to higher animal species and as far as applied in traps.	Need recognized by certification body or authority.
Mineral oils	Need recognized by the certification body or authority.
Mechanical control devices such as e.g., crop protection nets, spiral barriers, glue-coated plastic traps, sticky bands.	

Appendix 3

Basic Organic Agriculture Standards

Products for Use in Fertilizing and Soil Conditioning

In organic agriculture the maintenance of soil fertility may be achieved through the recycling of organic material whose nutrients are made available to crops through the action of soil micro-organisms and bacteria. Many of these inputs are restricted for use in organic production. In this appendix "restricted" means that the conditions and the procedure for use shall be set by the certification programme. Factors such as contamination, risk of nutritional imbalances and depletion of natural resources shall be taken into consideration.

Matter Produced on an Organic Farm Unit

- Farmyard & poultry manure, slurry, urine — Permitted
- Crop residues and green manure — Permitted
- Straw and other mulches — Permitted

Matter Produced Outside the Organic Farm Unit

- Blood meal, meat meal, bone meal and feather meal without Preservatives — Restricted
- Compost made from any carbon based residues (animal excrement including poultry) — Restricted
- Farmyard manure, slurry, urine — Restricted
- (preferably after control fermentation and / or appropriate dilution) "factory" farming sources not permitted.
- Fish and fish products without preservatives — Restricted
- Guano — Restricted
- Human excrement — Not allowed
- By-products from the food and textile industries of biodegradable material of microbial, plant or animal origin without any synthetic additives — Restricted

• Peat without synthetic additives (prohibited for soil conditioning)	Permitted
• Sawdust, wood shavings, wood provided it comes from untreated wood	Permitted
• Seaweed and seaweed products obtained by physical processes, extraction with water or aqueous acid and/or alkaline solution	Restricted
• Sewage sludge and urban composts from separated sources which are monitored for contamination	Restricted
• Straw	Restricted
• Vermicasts	Restricted
• Animal charcol	Restricted
• Compost and spent mushroom and vermiculate substances	Restricted
• Compost from organic household reference	Restricted
• Compost from plant residues	Permitted
• By products from oil palm, coconut and cocoa (including empty fruit bunch, palm oil mill effluent (pome), cocoa peat and empty cocoa pods)	Restricted
• By products of industries processing ingredients from organic agriculture	Restricted

"Factory" farming refers to industrial management systems that are heavily reliant on veterinary and feed inputs not permitted in organic agriculture.

Minerals

• Basic slag	Restricted
• Calcareous and magnesium rock	Restricted
• Calcified seaweed	Permitted
• Calcium chloride	Permitted
• Calcium carbonate of network origin (chalk, limestone, gypsum and phosphate chalk)	Permitted

• Mineral potassium with low chlorine content (e.g. sulphate of potash, kainite, sylvinite, patenkali)	Restricted
• Natural phosphates (e.g. Rock phosphates)	Restricted
• Pulverised rock	Restricted
• Sodium chloride	Permitted
• Trace elements (baron, In, Fe, Mn, molybolerum, Zn)	Restricted
• Woodash from untreated wood	Restricted
• Pottassium sulphate	Restricted
• Magnesium sulphate (Epson salt)	Permitted
• Gypsum (calcium sulphate)	Permitted
• Stillage and stillage extract	Permitted
• Aluminum calcium phosphate	Restricted
• Sulphur	Restricted
• Stone mill	Restricted
• Clay (bentonite, perlite, zeolite)	Permitted

Microbiological Prepararations

• Bacterial preparations (biofertilizers)	Permitted
• Biodynamic preparations	Permitted
• Plant preparations and botanical extracts	Permitted
• Vermiculate	Permitted
• Peat	Permitted

Products for Plant Pest and Disease Control

Certain products are allowed for use in organic agriculture for the control of pests and diseases in plant production. Many of these products are restricted for use in organic production. Such products should only be used when absolutely necessary and should bechosen taking the environmental impact into consideration.

In this appendix "restricted" means that the conditions and the procedure for use shall be set by the certification programme.

I. Substances from plant and animal origin

• *Azadirachta indica* [neem preparations (neem oil)]	Restricted
• Preparation of rotenone from *Derris elliptica, Lonchocarpus, Thephrosia spp.*	Restricted
• Gelatine	Permitted
• Propolis	Restricted
• Plant based extracts (e.g. neem, garlic, pongamia, etc.)	Permitted
• Preparation on basis of pyrethrins extracted from *Chrysanthemum cinerariaefolium*, containing possibly a synergist pyrethrum cinerafolium	Restricted
• Preparation from *Quassia amara*	Restricted
• Release of parasite predators of insect pests	Restricted
• Preparation from *Ryania sp.*	Restricted
• Tobacco tea	Not allowed
• Lecithin	Restricted
• Casein	Permitted
• Sea weeds, sea weed meal, sea weed extracts, sea salt and salty water	Restricted
• Extract from mushroom (Shiitake fungus)	Permitted
• Extract from *Chlorella sp.*	Permitted
• Fermented product from *Aspergillus*	Restricted
• Natural acids (vinegar)	Restricted

II. Minerals

• Chloride of lime/soda	Restricted
• Clay (e.g. bentonite, perlite, vermiculite, zeolite)	Permitted
• Copper salts / inorganic salts (Bordeaux mix, copper hydroxide, copper oxychloride) used as a fungicide, maximum 8 kg per ha per year depending upon the crop and under the supervision of inspection and certification agency	Restricted
• Mineral powders (stone meal, silicates)	Not allowed

• Diatomaceous earth	Restricted
• Light mineral oils	Restricted
• Permanganate of potash	Restricted
• Lime sulphur (calcium polysulphide)	Restricted
• Silicates (sodium silicate, quartz)	Restricted
• Sodium bicarbonate	Permitted
• Sulphur (as a fungicide, acaricide, repellent)	Restricted

III. Microorganisms / Biocontrol agents

• Viral preparations (e.g., Granulosis viruses, Nuclear polyhydrosis, viruses etc.).	Permitted
• Fungal preparations (e.g., Trichoderma species etc.)	Permitted
• Bacterial preparations (e.g., Bacillus species etc.)	Permitted
• Parasites, predators and sterilized insects.”	Permitted

IV. Others

• Carbon dioxide and nitrogen gas	Restricted
• Soft soap (potassium soap)	Permitted
• Ethyl alcohol	Not allowed
• Homeopathic and Ayurvedic preparations	Permitted
• Herbal and biodynamic preparations	Permitted

V. Traps

• Physical methods (e.g., chromatic traps, mechanical traps, light traps, sticky traps and pheromones)	Permitted
• Mulches, nets	Permitted