Agriculture

for

Food Security

Textbook for Class IX

Department of Curriculum and Professional Development
Ministry of Education
Thimphu

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We would like to sincerely acknowledge the retrieval and use of ideas and pictures from various sources. We reaffirm that this book is purely for educational purposes.

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Preface

Understanding the AgFS Curriculum Design

The AgFS Curriculum for classes IX to XII has been designed to fulfil thee aspiration of the Ministry of Education, Royal Government of Bhutan, in its attempt to improve the relevance of Secondary Education through curriculum diversification project of the 9th Five Year Plan. The curriculum design and development of AgFS was closely guided and monitored annually by the Curriculum Board of the MoE from 2008 to 2011 and approved for implementation by the 26th Curriculum Board meeting in 2012. Accordingly AgFSC was developed and implemented in schools gradually preparing teachers, consolidating suitable text materials developed for the learners from classes IX to XII and its implementation guides for teachers, professionally trained but with little subject knowledge.

The AgFS is designed as a vocational curriculum with strong academic standard. The technical concepts, values and attitudes, and skills of AgFS require students to apply their Scientific and Geography knowledge and skills learned to understand AgFS and strengthen its application in their life outside school. The AgFS curriculum provides opportunity to use their prior knowledge and to understand AgFS as an avenue of opportunity that can generates self-employment entrepreneurship, addressing the growing unemployment of the literate youth and other social issues of the Bhutanese society.

The AgFS textbooks are, therefore designed to provide all information that the learners of AgFS need know, understand and critically practice the 'package of practices for cultivated food crops, horticulture, and livestock' and generate innovations, rather than wasting time looking for information and 'reinventing the wheel'.

Aims of AgFSC:

The AgFS Curriculum aims to educate Bhutanese youth on the country's Agro-Ecological-Zones with favourable climatic conditions for growing food crops, vegetables, fruits, and rearing livestock that provides ample opportunities of self-employment and employment of others. It is a subject that can address unemployment of literate youth and many other social issues. The AgFS aspires to educate Bhutanese youth change their mind set towards agriculture and opt to take up AgFS in the services of our GNH nation, grow our own food, medicine, fibre and other needs to reduce Bhutan's imports, threatening the nation's food sovereignty and depletion of its small economy. This curriculum advocates

vocational pathways of Bhutanese youth to contribute to the nation's development and feeding Bhutan's small population.

Educational Experiences

The AgFS book of class IX begins with a brief introduction to the concept of 'Food and Nutrition Security', importance of nutrition for healthy life. This theme justifies the reasons opting for agriculture as a vocation for self-employment and employment of others. Chapter two introduces the basic concept of agriculture and its importance, linking to Agro-Ecological Zones of Bhutan that shaped unique Bhutanese society with agricultural production system, socio-economic, cultural and institutional environment.

The 'package of practices for cultivated vegetable' in chapter three provides general concepts and procedures of growing wide range of vegetables commonly grown in Bhutan. This chapter provides students with opportunities for self-employing enterprise and be productive in the society. The 'package of practices' of fruits in chapter three follows similar pattern and adds yet another avenue of opportunities to be in the services of this great nation and human kind in the outside world.

'Starting a Poultry Farm' in chapter five and 'Starting a Pig Farm' in chapter six, discusses on the importance of animals rearing, farming procedures and management, contributing to fulfil the needs of humankind with food, medicine and fibre and other needs. These themes further expands students to be enterprising in their life in the society. 'Forestry for Agriculture' in chapter seven, discusses the importance of one of the major sustainable natural resources of the Bhutanese farmers. It provides basic ideas of private, community and social forestry enterprise with which the farmers can generate additional income and sustainable natural resources for their farm.

'Establishing an Agriculture Entrepreneurship' is the last chapter of 'Agriculture for Food Security' textbook. This theme gives ideas on starting an agriculture business for self-employment and employment of others – an alternative pathways to academic studies

Implementation of AgFS

The AgFS subject is to be offered to the students who are interested in the subject and not necessary to the ones who are academically not inclined. However, preference may be given to students who wish to discontinue studies after the basic education – after X or XII.

AgFS, as a technical subject need to understand that what students learn in theory is expected to practice in the school as well or learn observing what others do in their fields. Therefore, AgFS is not expected to be taught like any other academic subject. Both the teachers and the students – teaching or learning AgFS, need to read independently, understand and discuss in the class or at the site on the concepts and procedural skills of AgFS, share experiences of Agriculture of all the themes analytically, critically and creatively experiment, adapting to suit the practices in the changing climate and environment. The ideas from the book are to be taken as a starting point for discussions and not as absolute knowledge and skills procedures. Future modern farmers need to be experimental to do anything that will work better.

It is necessary to plan and carryout practical work of AgFS in the school campus as well as plan and organise field trips to the place or farm nearby where vegetables, fruits, livestock and forestry activities, etc. are being carried out. A field trip is not a substitute of practical work of school but a complement to get exposure of what and how students can learn from others. On the basis of field trips students can be encouraged to write what activities and how such activities are being carried out, analyse and how students could do better, individually or in small group.

It is also envisaged that students will be provided with ample opportunities to visit RNR Research and Development Centres and interact with researchers. It is recommended that RNR staff of the 'gewog', dzongkhag and regional ARDC of Ministry of Agriculture and Forests are consulted for their technical expertise, seek support of their services and utilise, especially for practical work.

The AgFS textbook provides production and management recommendations for whole range of vegetables, fruits and livestock, teachers and students select the most relevant crop/livestock that is suitably grown/raised in the locality. This will also allow students to relate their studies with the farms around.

Mode of Assessment

The assessment of student's performance in AgFS theory and practical work is to be based on the principle of (a) 'assessment as learning', (b) 'assessment for learning' and (c) 'assessment of learning'. The tools design for different aspects of teaching and learning processes are to be used for objective assessment of student's performance.

Enabling conditions for AgFS curriculum implementation in schools

All Schools need to:

1. Advocate on the awareness of AgFS as a vocational/technical subject available for students from Classes IX to XII, which provides employment for the literate youth and enhance food security for the sovereignty of the GNH nation.
2. Encourage teachers to teach AgFS, reduce work load of teaching other academic subject (s) and school administrative work.
3. Offer AgFS subject to the students who are interested in the subject.
4. Establish institutional linkage with ARDC, Gewog RNR centres, School Agriculture Programme (SAP) unit of Department of School Education, Ministry of Education, and the SAP focal department of Department of Agriculture, MoAF, Dzongkhag Livestock Officer, and Dzongkhag Agriculture Officer for collaboration to implement AgFSC in schools.
5. Budget to implement AgFSC in schools.
6. Provide resources for AgFS curriculum implementation such as:
    a. *Land for AgFS for practical work* include space for gardening, space for constructing shed for livestock and horticulture, proper fence,
    b. *Agriculture Tools* for different agriculture activities such as:
        i. Spades, pick axes, crowbars, racks, weeding hoe, shovel, sickle, knives, water pipe, watering can, knapsack, wheel barrow, and any other tools required for AgFS students proportionately.
        ii. *Horticulture* – pruning and grafting tool sets.
7. Facilitate AgFS Class to use the services of Agriculture experts available in the locality through field trips and guest speakers.

Foreword

For the children of a predominantly agricultural land that our country is, there ought to be a natural link between their hands and the soil. Thankfully, this is largely the case especially in our more rural areas. In the more urban parts though, the human-nature bond is coming under increasing pressure owing to the onslaught of modernisation. The humanising influence of working with the hand is, therefore, getting weaker with the passage of time.

Our seats of learning have had a long tradition of school agriculture that has provided excellent opportunities for our students to work the land, raise garden, grow fruits and vegetables and generally tend the surroundings under the auspices of the Socially Useful and Productive Work programme and . With the initiation of a more structured School Agriculture Programme as a joint effort between the Ministry of Education and the Ministry of Agriculture & Forests, we have witnessed a visible improvement both in the process as well as the outcome of students' work.

The launch of the all-out educational reform initiative through the nurturing of Green School concept is expected to restore, among others, the vital link between human beings and the natural environment both as a science and as an art. We expect our students to experience the joy of sowing the seeds, see them germinate and emerge above the soil, follow the changes in shape and size, fruit and flower, mature and complete the cycle. We want our children and youth to feel the soil, understand the effect of sun and rain on plants as well as notice the impact of wind and drought.

A happy consequence of this engagement with the soil will be the production of much-needed food items, organic and nutritious, satisfying because self-produced, nurtured through love and care. The otherwise dreary-looking bare land dons multiple colours as seasons change and beautify the campus and elevate it as a seat of learning. The different sights, sounds and smells that a rich campus produces sharpen and sensitise our senses and awaken us to our full sensibilities.

These multiple benefits of keeping ourselves close to the life-affirming soil have inspired us to introduce School Agriculture as one of the optional subjects for classes nine and above from the 2013 academic session. We commend the excellent

work done by our colleagues in the Royal Education Council (REC) , Ministry of Education (MoE), and the Department of Agriculture (DoA) , Ministry of Agriculture and Forests (MoAF), and all other contributors for their inputs in the production of this document.

We trust that our students will find the contents as appealing and educative as our educators and instructors bring to our schools the joy of farming both as a hobby and as an occupation and help in building a healthy and food-secure Bhutan of Gross National Happiness.

Tashi Delek!

Dr. Pema Gyamtsho,
Minister,
Ministry of Agriculture and Forests.

Thakur S Powdyel,
Minister,
Ministry of Education.

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1 Introduction to Agriculture for Food and Nutrition Security

CHAPTER

'Agriculture for Food Security' as a subject beginning with this chapter on 'Food and Nutrition Security (FNS)' may have surprised many with questions of why it is so.

It is simply for the reason that 'food' is a necessity for all. History reveals that ancient people roamed the earth hunting for food and shelter. Later they settled down as they began to learn how to cultivate the land and rear animals for food and shelter.

Bhutanese history indicates that our forefathers lived in small communities at different altitudes of different regions – some rearing animals, some growing food crops and medicinal herbs. They lived a hard life but were self-sufficient. With the turn of this century, Bhutanese youth have started repeating history – roaming the earth looking for jobs leaving behind aged family members on their arable land. Jobs for our Bhutanese youth can be created in our own community to support human life with food, shelter and medicine by enhancing the country's largest employment sector 'Agriculture' – more than 60 % of Bhutanese population as per NSB, 2018.

It is also for this very reason there are numerous agro-industries and agriculture activities in all societies and they do well because these types of industries will stop only on the day we all stop eating or the need for food ends. 'Food and Nutrition' is the key to the development of agro-industries, especially in the 21st century world of health consciousness. Bhutanese agriculture industries need to take cue from the food and nutrition requirement of the society and expand entrepreneurship in agro-industries in providing nutritious and safe food to its citizens.

This chapter aims at revising the student's knowledge on the concepts of food, nutrition, food for healthy life style, benefit, assessment of malnutrition, and the

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concepts of food and nutrition security that the Bhutanese literate youth needs to strive to attain for Bhutanese society. The Bhutanese Agriculture industry of the 21st century and beyond needs to secure 'food sovereignty' at least for Bhutanese populance. It is a sacred responsibility of every Bhutanese as a citizen of this GNH society, strive for the nation's 'food sovereignty'. It is important for all to know what is meant by FNS and what kinds of work the FNS entails.

1.1 Food and Nutrition Security

The Food and Nutrition Security Policy of the Kingdom of Bhutan, 2014, emphasizes to ensure that *"all people living in Bhutan at all times have physical, economic and social access to safe and adequate nutritious food for a healthy and active life contributing to realization of Gross National Happiness.*"

The FNS which is possible only through agriculture or farming, is an important theme for a country like ours. According to the Food and Agriculture Organization (FAO, 2000), Food Security is achieved when it is ensured that "all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life". In this context, food is defined as any substance that people eat and drink to maintain life and growth. Safe and clean water is therefore a part of food commodities. Nutrition Security is defined as "adequate nutritional status in terms of protein, energy, vitamins, and minerals for all household members at all times". The nutrition focus emphasizes on caring practices, health services and healthy environments to the definition and concept of FNS. The FNS combines food and nutrition security and has several dimensions such as Availability, Accessibility, Use and Utilization of food and Stability.

Availability refers to the physical existence of food, be it from own production or purchased from the markets. At the national level, food availability is a combination of domestic food production and commercial food imports from other countries. Access means when all households and all individuals within those households have sufficient resources to obtain food. Household resources mean capital or money, labour and knowledge or skills. Use of food refers to the socio-economic aspect of household food security. If sufficient and nutritious food is both available and accessible the household has to make decisions concerning what food is to be purchased, prepared and consumed and how the food is allocated within the

household. In households where distribution is unequal, even if the overall access is sufficient, some individuals may suffer from food deficiency. The same is true if the composition of the consumed food is unbalanced. Stability or sustainability refers to the temporal (time) dimension of nutrition security. It means the timeframe over which food security is being considered. It is categorized as *chronic food insecurity*, which means the inability to meet food needs on a continuing basis, or *transitory food insecurity* when the inability to meet food needs is of a temporary nature.

Recollect the Biology lessons on 'food and nutrition' that you have learned, before you strive to secure it for our nation. The knowledge on 'food and nutrition' is expected to help you identify and grow crops, vegetables, fruits or raise livestock that a healthy Bhutanese society would require in this modern world.

Constituents of food and nutrients

Foods are everything that we eat or drink every day. Food that we eat helps us to maintain good health, growth, and protection from diseases and provides energy for daily work. Food contains both organic (fats, carbohydrates, protein, vitamins and water) and inorganic (minerals) substance called nutrients.

Nutrients are substances that provide nourishment essential for the maintenance of life and growth. Based on the quantity required by the body, nutrients are classified as macronutrients and micronutrients. *Macronutrients* are required in large amounts whereas *micronutrients* are needed only in little amount but are very essential for the functioning of the body and our survival.

Some nutrients such as vitamins, minerals and certain class of amino acids and fatty acids are termed essential because our body cannot make within and must obtain them from food. Apart from nutrients there are also some substance called dietary fibre or roughage in the food that do not have nutritional value but required by our body to help in digestion and absorption of water.

Finally, *nutrition* is the process involved in taking in and utilization of food substances by which growth, repair and maintenance of the body are accomplished. It involves ingestion, digestion, absorption and assimilation. Nutrition can be defined as food or nourishment needed to keep an organism growing, healthy

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and viable. It also refers to the process of providing or receiving food or other life-supporting substances. The study of nutrition covers the types of food needed to keep an organism thriving and the means by which the organism derives nourishment by the digestive process. Food is an integral part of human survival and selecting food wisely is the key to good health and longevity.

Healthy diets help children grow, develop, and perform well in school and in life. A healthy diet allows adults to work productively and feel their best. Good food choices also can help to prevent chronic diseases, such as heart disease, certain cancers, diabetes, and stroke that are leading causes of death and disability. A proper diet can also reduce major risk factors for chronic diseases, such as obesity, high blood pressure and high blood cholesterol. Healthy diet normally refers to a *balanced diet*. Are you aware that:

1. Low fruit and vegetable intake ranks in top 10 risk factors for global mortality" causing 19% of gastrointestinal cancer, 31% of heart disease and 11% of stroke?
2. Increase fruits and vegetables consumption can save 2.7 million lives annually (UNICEF, 2006)?
3. Iron deficiency causing anaemia has raised the death toll to 81% children under 5 years, 55% pregnant women and 27% men?
4. The cause of anaemia in Bhutan is mainly due to poor consumption of protein energy and diets deficient in key nutrients particularly vitamin A and Iron?
5. The National Nutrition Resolution passed in 67th National assembly provides the rights to each citizen to prevent from malnutrition and every effort from the government to provide policy supports?"

Well, it is important to be aware but more so, knowing what follows next could help us resolve our problems. Continue learning more on food and nutrition.

1.3. Classification of foods based on their main functions

Food is defined as material consisting essentially of protein, carbohydrate and fat used in the body of an organism to sustain growth, repair vital processes and to provide energy. Food can be categorized into three groups based on their functions as follows:

a) Energy giving food

Energy giving foods provides energy to maintain the vital functions of the body such as respiration, heartbeat, brain function, muscle tone, maintaining temperature and metabolic activities. Fats and carbohydrate containing foods are the richest source of energy giving foods.

b) Growth promoting foods

Protein containing foods are termed as growth promoting foods. Proteins are essential for normal growth, repair and maintenance of the body. For this reason these foods are required in larger quantities for growing individuals. Proteins are available from both animal and plant sources.

c) Protective foods

Foods that contain high quantities of minerals and vitamins are termed as protective foods. Vitamins and minerals help our body to protect against diseases. For instance, deficiency of vitamin A causes infections and poor eyesight. Deficiency of iron causes iron deficiency anaemia and poor brain functions leading to reduced cognitive ability.

Food Guide Pyramid is a guide of required daily food intake based on nutritive values into food groups, and an advise that a certain serving of each groups to be eaten daily. The Bhutanese food guide pyramid contains six groups of foods depending on the quantity needed by the body. We need to include all the groups in our everyday diet to get all the nutrients needed by the body. That is because, no single food group contain, all the nutrients needed by our body. For example, fruits and vegetables are rich in vitamin C and other vitamins but not vitamin B12. Whereas meat and egg are good source of Vitamin B 12 but are poor source of vitamin C.

The Bhutanese Food Guide Pyramid has *rice, bread, cereals* and *grains* as the base of the pyramid showing foods from the grain and cereal group (*Figure 1.1*). About 50 – 60% of the energy requirement should come from this food group and these means eating 6–11 servings from this food groups every day. Enjoy meals that have whole grains such as rice, breads, and starchy tubers such as potatoes, yam and tapioca.

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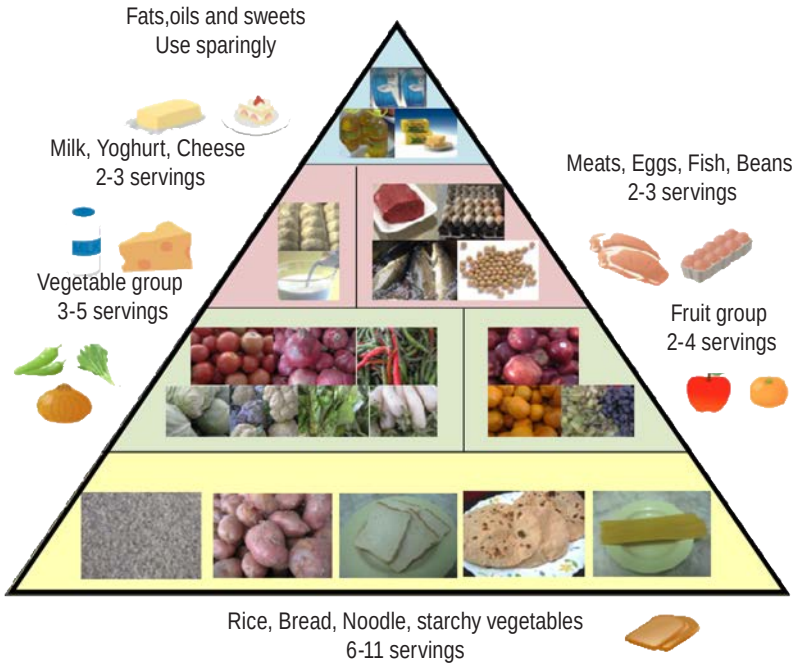

Figure 1.1 Bhutanese Food Guide

These foods contain large amounts of carbohydrates, which provide sustained energy release as well as fibre. One serving = one slice of bread, about 28 grams of cereals, one cup of cooked rice.

Vegetables: It is recommended that at least 3 – 5 servings of vegetables to be eaten every day. Vegetables are high in vitamins, minerals and fibre and low in fat. One serving = approximately 40 grams of cooked/raw vegetables, or three heaped tablespoons of cooked/raw vegetables, or 125 mL of fresh vegetable juice. In total an individual is recommended to eat at least 200 grams of vegetables every day.

Fruits: In the food guide pyramid fruit is placed alongside the vegetables and is recommended at least 4 servings every day. Fruits and vegetables are the richest source of vitamins and minerals that helps our body to fight against infection and improves our cognitive development. Therefore, we should eat them every day. One serving size = 40 grams of fruits, a medium sized apple, banana and orange. If the fruit is small one serving size may be 2 fruits, or 125 m of fresh fruit juice. In total an individual is recommended to eat at least 200 grams of fruits or a litre of fresh fruit juice every day.

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Meat, egg, fish and alternatives (pulses and legumes): All kinds of meats from animals, poultry and fish are put in this group. They are the richest source of protein. Protein is needed for growth and maintenance of our body. A growing child, and a pregnant mother requires more protein than others. Protein is also available from other sources such as pulses and legumes – dry beans, soya beans and dhal. Meat and meat products also contain lots of fats therefore the daily serving of this food group is 2 – 3 serving daily. One serving = one egg, 30 grams of peanut butter, 80 grams of cooked meat without fat.

Dairy products: This group include milk, buttermilk, cheese and yogurt. They contain high amount of mineral calcium that helps to make our bone strong. 2 – 3 servings are recommended daily. Dairy products are often high in fat (butter). One serving = 250 mL of milk, 50 g of cheese .

Fats, oils, sugar and salt: This food group except for salt provide high calories with low other nutritional value and should be used sparingly if at all. Most of the food that we eat contain fats, sugar and salt already either in their natural form or added for taste. Therefore, we should add only sparingly while preparing our foods. Eating too much of foods from this group will lead to obesity and related diseases such as diabetes and hypertension.

Dietary fibre: Fibres are the indigestible part of the diet that comes mainly from plant and some from meat. It consists of bran, cellulose and other substances that our body cannot digest. The daily requirement of dietary fibre is not less than 20 grams. Our daily requirement of dietary fibres comes from whole grain cereals, the husk of cereals and in vegetable and fruit. The dietary fibres provide bulk to the diet and helps to satisfy appetite, stimulate peristalsis (muscular activity) of the alimentary canal, attracts water increasing the bulk and softness of stool, prevent constipation and prevent gastrointestinal disorder.

A *Balance diet* is a diet that provides appropriate amounts of all nutrients in the correct proportion to meet the daily requirement of the body cells and is achieved by eating a variety of foods. Eating a wide variety of foods and drinks from all the food groups can be considered as balanced diet. If any nutrients is in excess, or is deficit, health may be adversely affected. For example eating too much of fat containing or calorie rich food will lead to obesity and an iron deficit food leads to anaemia.

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Certain groups of individuals may require diet different from the recommendation provided by the food guide pyramid. For example, pregnant women have higher energy requirements to support the growing baby and milk production. Menstruating girls and women need higher iron levels in their diet than non-menstruating women to compensate blood loss. Babies and adolescents have high fat requirement than adults because they have higher growth and metabolic rates.

The balanced diet must be planned at your own calorie level, and serving size is key. One can get the most nutrients for the calories by choosing food with a high-nutrient density. Nutrient-dense foods provide substantial amounts of vitamins and minerals and relatively low calories, such as fresh fruit and vegetables, lean meat and fish, and whole grains and beans. Low nutrient-dense foods have few vitamins but lots of calories such as candy bars, aerated drinks soda and onion rings.

One has to make responsible eating choices within the context of your preferences and lifestyle. *What are your goals? Which food groups do you like to eat? Which food groups are missing? Do you eat too much sugar, salt and fried food? Which foods are the contributors and what foods can you eat instead?* The control rests within you to design the best eating plan for you. Eating healthy takes planning and practice. Having a basic nutrition knowledge helps in proper planning of your diet.

Macronutrients/Carbohydrates: They are found in a wide variety of foods, e.g. sugar, jam, cereals, bread, rice, potatoes, honey, fruits, and vegetables. They are classified as simple and complex carbohydrate. Whole grain cereals are examples of complex carbohydrate and they are good for our body. Carbohydrates are:

- provision for rapidly available energy and heat – 1 grams of carbohydrate on oxidation give approximately 4 kilocalories of energy.
- provision as a store of energy. When carbohydrate is eaten in excess of the body's need, it is converted to fat and deposited as adipose fat (under the skin).
- provision for avoiding breakdown of amino acids for energy.
- The only source of energy for brain cells and heart muscles in the form of glucose
- dietary fibre.

Fats: They are divided into saturated and unsaturated fatty acids. *Saturated fats* come from animal fats such as milk fats, butter, cheese, and pork and beef fats. *Unsaturated fats* mostly come from plant source, e.g. sunflower oil, olive oil, nuts,

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oily seeds. Some unsaturated fatty acids are essential in the diet because they cannot be synthesized in our body but is essential for growth and development. Fats:

- are concentrated source of energy – 1 gram of fat on oxidation gives approximately 9 kilocalories of energy.
- support certain body organs, e.g. the kidney, heart and eyeballs by pad of fats.
- transport fat-soluble vitamins.
- are stored energy as adipose tissue.
- cover and protect the nerve cells.
- protect or insulations – as a subcutaneous layer it reduces heat loss.
- make food tasty.

Protein: It is the nitrogen containing compound. Some contain minerals such as iron, copper, zinc, iodine, sulphur and phosphate. Dietary protein is the main source of nitrogen that is needed in our body. Protein is broken down after digestion into its smaller constituents called amino acids. They are divided into two categories, *essential* and *non-essential* amino acids. Essential amino acids cannot be synthesized by the body and therefore need to be included in the diet whereas non-essential amino acids can be synthesized within the body. A protein that contains all the essential and non-essential amino acids is termed as complete protein, e.g. meat, fish, milk, egg and soya beans. Protein are required for:

- growth and repair of body cell and tissues
- synthesising plasma protein, antibodies (immunoglobulin) and some hormones
- providing energy – 1 grams of protein on oxidation provides approximately 4 kilocalories of energy. Protein provides energy only when carbohydrates and fats are unavailable for oxidation.

Micronutrient: It consists of vitamins and minerals. We will discuss vitamin first. Vitamins are chemical compounds required in very small quantities, which are essential for normal functioning and health of the body. If it is deficit in our diet they produce specific deficiency symptom. They are found widely distributed in the food and are divided into fat-soluble and water-soluble. Fat soluble vitamins are A, D, E and K.

Vitamin A: It is found in egg yolk, liver, fish oil, butter, milk and cheese. From the plant source it is found in the form of carotene in dark green leafy vegetables like sag, broccoli, tomatoes, carrot and pumpkins. Vitamin A is required for the

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formation of light sensitive pigment in the cells of the retina in our eyes, growth and formation of cells, growth promotion of bones and immunity and defence against infectious diseases. Its deficiency can lead to night blindness due to defective pigment formation of the eyes, dry eyes, growth retardation and infections of ear, eyes and respiratory tracts.

Vitamin D: It is found in animal fat, egg, fish liver oil, butter and milk. Human can synthesis vitamin D by the action of ultra violet light on a form of cholesterol in the skin. Vitamin D promotes regulation of calcium and phosphate by increasing their absorption from the intestine and their retention by the kidneys. Therefore, it helps in hardening of the bones and teeth. Its deficiency causes rickets in children and osteomalacia and osteoporosis (softening of the bones) in adults.

Vitamin E: This group of vitamins are found in egg yolk, whole cereals, milk and butter. This vitamin works as an antioxidant meaning it protects the cells and tissues from being destroyed by oxidative reactions. Therefore, it makes your skin and other membrane looks smooth and beautiful. Along with other substances such as vitamin C and A it acts as an antioxidant. There are no known deficiency diseases, however when people do not eat enough fruits and vegetables and there is less amount of animal source food in the diet, it can produce deficiency symptoms such as dry skin and infections.

Vitamin K: The sources of vitamin K are fish, liver, leafy green vegetables and fruits. Vitamin K promotes blood clotting. Its deficiency leads to prevention of normal blood clotting and can be a risk because a person can bleed to death if the blood does not stop after getting hurt

Water-soluble vitamins: Water-soluble vitamin consists of vitamin C and B complex groups of vitamin. We will first discuss vitamin C

Vitamin C: It is found in fresh fruits especially citrus fruits such as lemon, mangoes, gooseberry and apricot. They are also found in fresh vegetables. It is easily destroyed by heat and light; therefore, one has to mindful while cooking vegetables. Vitamin C promotes healing of wound and acts as antioxidant. Its deficiency causes *scurvy* – soft and spongy gums leading to bleeding, loose teeth, and wound around the mouth, inside the mucosa membrane of the mouth and tongue and delays in healing wounds and fractures

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Vitamin B complex: This is a group of vitamins consisting of thiamine (B_1), riboflavin (B_2), folic acid, niacin, pyridoxine (B_6) pantothenic acid and cyanocobalamin (B_{12}). Most of these vitamins are present in animal source food such as eggs, liver, and meat. They are also present in dark green leafy vegetables, asparagus, broccoli, mushrooms, nuts, fresh beans and peas. Fruits are also good sources of B complex vitamin except for B_{12}. It is found only in animal source foods.

The B complex vitamin is required for metabolism of macronutrients, cell functions, and formation and maturation of red cells. Its deficiency causes:

- *Beriberi* – deficiency of thiamine leads to loss of muscle and cause weakness while walking,
- *Angular stomatitis* – deficiency of riboflavin cause wound around the mouth and tongue,
- *Pellagra* – deficiency of niacin leads to a disease called pellagra that is characterized by dryness of the skin, diarrhoea, forgetfulness and mental disturbance,
- *Anaemia* – deficiency of folic acid and B_{12} leads to large immature cell formation of RBC leading to anaemia.

Minerals: They are inorganic compounds and are necessary within the body for all body processes. Although in small quantity, are very essential for normal functioning of the body. There are many important minerals needed by our body, the main ones are discussed here and they are calcium, phosphorous, magnesium, sodium, potassium, iron and iodine.

Calcium: It is present in milk, cheese, eggs, liver, kidney, fish, and green leafy vegetables. About 99% of the calcium is found in bones and the remaining 1% is in the blood and other tissues. Calcium is required in *hardening of bones* – essential structural component of the bones, *coagulation of blood* and *mechanism of muscle contraction*. Its deficiency leads to rickets in children and *osteomalacia* and *osteoporosis* (softening of the bones) in adult, *muscle spasms,* and *numbness* and *tingling* in the hands, feet and face.

Phosphorous: Calcium and phosphorous have the same source, therefore if your diet has adequate calcium, phosphorous is also met through that diet. About 85% of the phosphorous is in the bones and teeth. Apart from hardening of bone and teeth along with calcium and vitamin D phosphate is an essential part of energy storage in the cells in the form of ATP (adenosine triphosphate).

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Magnesium: Major dietary source of magnesium are green leafy vegetables, wheat bran and whole grains, nuts and legumes. About 60% is found in the bones and teeth. Magnesium is required for hardening of bones and teeth, normal function of nerve and muscle, maintain rate and rhythm of heartbeat. It also participates in energy metabolism of macronutrients. Its deficiency leads to muscle weakness, restlessness, and anxiety, abnormal heart rates among others

Sodium: It is found naturally in a variety of foods – fish, meat, egg and milk, it is also found in processed food such as bread, chips and also from table salt. The normal intake of salt is 5 – 20 grams and the daily requirement is 1.6 grams. The excess salt is excreted through urine and sweat. Main function of sodium is contraction of muscle, transmission of nerve impulse along with potassium and chloride and maintenance of electrolyte balance in the body.

Potassium: It is widely distributed in all foods especially fruits and vegetables. It shares the function with sodium.

Iron: From the animal source iron is present in liver, kidney, beef, and poultry products such as chicken and egg. From the plant source dark green leafy vegetables, whole grain cereals, and fruits are the richest source of iron and vitamin C. vitamin C is important because it helps in absorption of iron. The body absorbs animal source irons more than plant source.

Iron is necessary for the formation of haemoglobin in the red blood cell. Haemoglobin in turns helps in carrying oxygen and nutrients to the brain and other vital organs. The physical work and mental capacity of a person depends on the amount of blood supply to the brain. Therefore, good status of iron in the body is very important for better learning outcomes in school children. Its *deficiency* leads to *anaemia* and consequently less ability to perform physical activity and reduce intellectual performance. Other symptoms include weakness, dizziness or fainting, difficulty breathing and paleness of skin and conjunctiva.

Iodine: It is present in salt-water fish and in vegetables grown in iodine cantaining soil. In Bhutan iodine is deficit in the soil and therefore not present in the vegetables. We get our iodine from the fortified (physical addition of iodine) salt. The daily requirement of iodine is 150 micro-gram. Iodine is necessary for formation of thyroid hormone. The thyroid hormone is essential for metabolism and heat generation in the body, regulation of metabolism of macronutrients, normal growth and development. *Deficiency* of iodine leads to reduced production

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of thyroid hormones and have *reduced basal metabolic* rate and hence the person always feels cold, dry skin and brittle hair, constipation, weight gain, reduced hear rate and depression, slowness, mental drowsiness (inability to understand lessons) and laziness.

Table 1.1 Recommended requirements of protein, fats, carbohydrates and minerals for a healthy human body.

Protein: 0.8 grams per kg body weight per day	Potassium: 2-5 gm/day
Fats and Oils: 20 grams per day	Magnesium: 200-300 mg/day
Carbohydrates: 400 grams per day	Iron: 28 mg/day for men
Fibre: 10-12 grams per days	Iron: 30 mg/day for women
Vitamins: trace amounts	Iodine: 150-200 mg/day
Minerals	Copper: 2.2 mg/day
Calcium: 400 mg/day	Zinc: 15-20 mg/day

Table 1.2 Nutrient contents in some of the common Agriculture crops (per 100 gm)

Crop	Protein (g)	Fat (g)	Carbohydrate (g)	Energy (kcal)
Cabbage	1.8	0.1	4.6	27
Cauliflower	1.7	0.1	8.8	43
Chilli	2.4	0.6	3.0	39
Carrot	0.9	0.2	10.6	48
Tomato	1.9	0.2	3.6	20
Bean	1.7	0.1	4.0	26
Pea	7.2	0.1	15.9	93
Radish	0.8	0.2	4.4	23
Potato	1.6	0.1	22.6	97
Spinach	2	0.7	0.9	26
Onion	1.2	0.1	11.1	50
Maize	11.1	3.6	66.2	342
Rice	6	0.8	82	361

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Table 1.3 Nutrient contents in some of the common fruits

Foods	Energy (kcal)	Calcium (mg)	Iron (mg)	Carotene (ug)	Vit.A (mg)
Apple	58	50	1.20	9	600
Apricot	53	20	2.20	2160	6
Banana	116	17	0.90	78	7
Cherry	64	24	1.30	0	7
Grape	58	20	0.50	3	1
Guava	51	10	1.40	0	212
Lemon	57	70	2.30	0	39
Litchi	61	10	0.70	0	31
Mango	74	14	1.30	2743	16
Orange	48	26	0.32	1104	30
Papaya	32	17	0.50	666	57
Peach	50	15	2.40	0	6
Pear	52	8	0.50	28	0
Pineapple	46	20	1.20	18	39
Plum	52	10	0.60	166	5
Strawberry	44	30	1.80	18	52

Table 1.4 Nutrient contents in some of the common Livestock food products

Foods	Protein (g)	Energy (Kcal)	Calcium (mg)	Iron (mg)	Vit. A (mg)
Fish	18.1	95	150	1.5	0
Beef	22.6	114	10	0.8	18
Mutton	18.5	194	150	2.5	9
Pork	18.7	114	30	2.2	2
Egg	13.3	173	60	2.1	360
Milk	3.2	67	120	0.2	174
Cheese	24.1	3.48	790	2.1	273
Butter	0	729	0	0	3200
Curd	3.1	60	149	0.2	102
Whey	0.8	15	30	0.5	0

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1.4. Health benefits of vegetables and fruits

Vegetables and fruits together contain all the nutrients our body need. They contain some amount of macronutrients (carbohydrates, fairly good amount of protein, some fats, fibres, and water) and they are the richest source of vitamins and minerals. They are the major contributor of dietary fibre in our diet. Apart from providing energy and dietary fibre, recent scientific studies have consistently shown that a diet rich in vegetables and fruits can reduce the risk of chronic diseases such as stroke, chronic heart diseases, hypertension, diabetes mellitus, some form of cancer, osteoporosis, and age-related eye disease.

Young children and adolescent need lots of energy for their growth and development. They also need equally increased amount of vitamins and minerals. Eating the recommended amount of fresh vegetables and fruits every day will ensure adequacy of vitamins and minerals. As mentioned above the recommended amount of vegetables is 200 grams and fruits 200 grams daily.

Sorting and storage of food: Foods should be sorted and stored separately to maintain hygiene and to prevent food from spoilage. If you are storing food in the refrigerator cooked and uncooked food should be stored separately. After buying vegetables and fruits from the market it should be washed thoroughly, wrapped properly in plastic bags or containers before storing. If it is dry foods, such as grains, cereals, and pulses they should be cleaned by picking stones and debris, and stored in airtight containers. Bulbs and tuber vegetables should be stored on racks with sand below. As far as possible, vegetables and fruits should be eaten fresh and the best sources is when you grow them in your own vegetable garden.

Preservation of nutrients during cooking: Cooking has both advantage and disadvantage in terms of nutrient gain and loss. Most often cooking releases nutrients from food by making the food soft and digestible. Cooking also kills harmful bacteria and prevents us from infection. However, cooking can cause loss of some nutrients because they are unstable in heat such as vitamin C, thiamine and iodine. Therefore, one must adopt proper preparation techniques to prepare food to achieve the maximum nutrient quality while retaining the taste and making the food safe for consumption.

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Some tips for healthy preparation of foods

1. Wash fruits and vegetables before cutting them.
2. Cook the vegetable with required water. Do not throw the excess water after boiling as it drains out the nutrients contents of vegetables.
3. Steaming – healthiest.
4. Frying – it is not always healthy option but one should avoid deep-frying of foods especially vegetables as it burns the food. When oil is heated beyond the smoking point it also changes the chemical compound in the fat making it toxic to the body.
5. It is always advisable to eat whole vegetables and fruits as the nutrient content is more towards the outside and also they provide roughage (fibre) to our diet.
6. Boiling – boiling vegetables is a good option but boiling for too long and over cooking it will also lose most of vitamin C and B groups. Therefore, do not leave vegetable boiling for too long.
7. Salt should be added towards the end of cooking to prevent the loss of iodine.
8. Stir frying – healthier alternative - nutrients still lost and fats still altered chemically.
9. Microwaving – Cooking using micro -oven retains the nutrients of foods.
10. Roasting – roasting is a good option to process food as there is no or limited use of oil.
11. Adding oil to vegetables will make the vegetable tasty and help in absorption of fat-soluble vitamins from the vegetables. However, oil should be used sparingly or just enough for that amount of vegetable. Use of good oils that contain more of unsaturated fatty acids is advisable for cooking. Saturated fatty acids tend to cause cardiovascular diseases. Oil used for deep-frying should not be re-used as the fats might have undergone chemical changes which are harmful to the body.

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1.5. Importance of physical activities for good health

Regular physical activity reduces the risk of many adverse health outcomes. The American Heart Association recommends at least 150-minutes of moderate activity each week or at least 30 minutes for 5 days a week. Moderate activity may include running 2 km distances, doing gardening such a digging your field with a hoe, playing basketball etc. There are various benefits of physical activities and some are listed below.

1. Boost mental wellness – regular physical activity can relieve tension, anxiety, depression and anger. After physical activity you will notice the "feel good sensation" and it will improve your general wellbeing.
2. Improve physical wellness – physical activity makes your heart beat fast and increases blood flow in your muscles, and improves circulation. Physical inactivity is a major risk of heart diseases in both adults and children equally. Studies have shown that adults who watch television for more than 4 hours every day had a 46% increase risk of any death and 80% increased risk of death from cardiovascular diseases.
3. Prolongs optimal health – with physical inactivity the body slowly loses its strength, stamina and ability to function well. People who are physically active and at a healthy body weight live longer than those who are not active and are obese. In addition, physical activity will help to manage your weight, prevent bone loss, and delays or prevent chronic diseases.

Malnutrition is a broad term commonly used to describe under nutrition but technically it also refers to over nutrition. People are malnourished if their diet does not provide adequate calories and protein for growth and maintenance or they are unable to fully utilize the food they eat due to illness resulting in under nutrition. They are also malnourished if they consume too many calories and fewer vitamins and mineral containing foods resulting in over nutrition.

There are various methods to identify the nutritional status among children and adults. First we discuss the measurement among children

1. Anthropometry – anthropometry means measurement of body. The measurement includes height and weight, age and sex. Sex is included because boys and girls grow differently from birth to until they are 20 years old. The anthropometric indicators are Height-for-Age (HA), Weight-for-Height (WH)

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and Weight-for-Age (WA).

- ***Height-for-Age*** indicator measures the adequacy of height of that child at the given age. A low HA indicate stunting (shortness for his age).
- ***Weight-for-Height*** indicator measures the weight of a child at the given height. A low WH indicates wasting (thinness)
- ***Weight-for-Age*** measures body weight of the child at that given age. A low WA indicates underweight (not adequate weight for his age).

2. Mid-Upper-Arm-Circumference (MUAC) – as the name indicates it is the measurement of the circumference of the mid upper arm using a MUAC tape. It is used to detect nutritional status accurately among children 6 – 59 months.
3. Body Mass Index (BMI) – body mass index is the ratio of body weight in kilograms and height in Metre Square. It is indicated by the formula given below:

$$\text{Body Mass Index} = \frac{\text{Body weight (kg)}}{\text{Height}^2\ (\text{m}^2)}$$

Standards

- Underweight — BMI less than 18.5
- Normal range — 18.5 to 24.9
- Overweight — 25 to 29.9
- Obese — 30 or above

BMI is applicable for both children and adults, however for children less than 21 years they are sex specific. Meaning the interpretation should be done based on sex of individual if you are less than 21 years old. After 21 years the same chart can be used to interpret the BMI of both men and women. Example of BMI – Dorji is 23 years old. He is 44 kg and 156 cm tall. Calculate his BMI, Using the formula BMI = 44/(1.56)2 = 44/2.43 = 18.1. Interpretation – Dorji is underweight.

There are also other methods of assessing nutritional status. Clinical indicator – Examination of external physical signs of nutrient deficiency by a doctor to see anaemia, which is indicated by paleness of the conjunctiva and palm of your hands, changes in the eyes to see signs of vitamin A deficiency.

It is hoped that by now you have been able to find link between the 'food and nutrition' topic to the agriculture industry – growing of food, vegetables and fruits.

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Agriculture activities do not stop here. It is utmost important that we connect what we require food, shelter, clothes and medicine to what we can learn to make ourselves more productive in life. You can learn more in the next chapter under horticulture.

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Student Activity

The activity for the students are suggestive and have a choice between one and two or different students can carry out both. Similar activities can be organised by the teacher if desired.

Practical Activity 1

1. Group students based on the community that they come from.
2. Ask them to list the food items that they take for breakfast, lunch and dinner,
3. Write food values against the food items.
4. Determine nutritional value of the food items of the community.
5. Write an advocacy article for display or prepare an action plan as to how the community can be persuaded to:
   a) grow fruits and vegetables for sale or
   b) consume fruits and vegetables for healthier diet.

Practical Activity 2

1. Divide the class into 3 groups
2. Instruct them to design instrument to collect information on type of food items, different groups of people usually take for breakfast, lunch, dinner and snacks besides meals.
3. Conduct survey of food intake by teachers, staff, student girls and boys; and compile results.
4. Determine nutrition value (carbohydrates, proteins, fats and minerals) derived from cereals, vegetables, fruits and animal products against what is required by the body of the respondents.
5. Write an article for display on the school notice board or read aloud in the morning assembly.

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2 CHAPTER

Introduction to Bhutanese Agriculture

Agriculture? What occurs to you the moment you hear or read the word 'Agriculture'? Well, everyone perceives and associates agriculture with something to do with soil or dirt, and a task involving drudgery; all the images of those agricultural tools like spades, ploughs, hoes, and so on come flooding our mind. Let us give a deeper thought- where does the food that fills our stomach and contribute to our regular growth and development come from? The obvious answer is agriculture or from farming. The role and importance of food then comes into play. Thus, the primary role of agriculture is to produce food for self-consumption as well as for sale to generate income.

This chapter, therefore, aims at providing the basic concepts of Agriculture and its importance to Bhutanese society. Agriculture is explained in simple terms and its role and significance in ensuring food security is emphasized. Agriculture is greatly influenced by the altitude, temperature and rainfall of a place. These parameters form the basis of agro-ecological zonation of the country. Farming systems or crops grown in a region thus are dictated by the agro-ecological zones. This chapter also dwells on the inseparable linkages between the three systems: forest, crop and livestock in Bhutan. Forest and livestock provide valuable nutrients for crop production, while crops and their residue feed domestic animals. Understanding Bhutanese agriculture and different systems of farming in various agro-ecozones of the country is essential in improving the productivity and efficiency of our farming.

2.1. What is Agriculture?

Agriculture is the science and practice of producing plants, other crops, and animals for food, other human needs, or economic gain (Ben G. Bareja 2010). It is also technically defined as the art and science of producing crops and livestock from the natural resources of the earth for economic purposes. In practical sense,

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it involves raising crops or livestock for food, fibre or fur; or the industry which includes marketing, processing and trade in these products. Agriculture is an activity which human being cannot shy away if we need to be alive. Agriculture can be equated as food, clothing and shelter, the primary needs of humans.

Another indispensable branch of Agriculture is Horticulture. The word 'Horticulture' is modelled after agriculture, and is derived from the Latin words *hortus* means "garden" and *Cultura* means "cultivation". Therefore, the term horticulture means growing of garden crops or simply the cultivation of garden crops. Horticulture is a branch of agriculture that deals with the art, science, technology, and business of plant cultivation. It includes the cultivation of fruits, vegetables, nuts, ornamental plants, medicinal and aromatic plants, herbs, spices, sprouts, mushrooms, condiments, seeds and beverages. It includes plant conservation, landscape restoration, landscape and garden design, construction and maintenances, and arboriculture.

Horticulture involves nine areas of study, which can be grouped into two broad sections – edibles and ornamentals, and are listed as follows.

a. Pomology: deals with the production and marketing of pome fruits (e.g. apple, pear, etc.)
b. Olericulture: includes the production and marketing of vegetables
c. Viticulture: refers to the production and marketing of grapes
d. Oenology: includes all aspects of wine and wine making.
e. Arboriculture: is the study of, and the selection, planting, care, and removal of individual trees, shrubs, vines, and other perennial woody plants.
f. Turf management: includes the production and maintenance of turf grass for sports, leisure use or amenity use
g. Floriculture: includes the production and marketing of flower crops
h. Landscape horticulture: includes the production, marketing and maintenance of landscape or ornamental plants
i. Postharvest physiology and technology: deals with maintaining the quality and preventing the spoilage of plants and animals produce practices and processes involving values addition of agriculture produce.

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2.2. Importance of Agriculture

The predominance of agrarian based economy, close association of farming and culture, weaker economic base, shrinking natural resources, and dependence on import for fulfilling the domestic food requirement emphasises the need to sustain farming to foster self-reliance which is an important national priority. As the educated population increases, it is going to add up to the unemployment issues. To promote self-reliance, prepare youth as productive citizen, and to avoid glut in the labour market, basic education needs to cater to the market demands by providing options for the agriculture sciences as a basic requirement.

Bhutan's economy is predominantly agrarian-based with about 58% of the population dependent on small-scale mountain agriculture and livestock rearing for their livelihood. The forest represents precious pool of natural resources for the people. The use of forest resource is an essential component of the livelihood system and is intricately woven into the Bhutanese culture.

Agriculture is critical to Bhutanese economy. In 2010, it accounted for about 16.8% of the total GDP of the country (NSB, 2011) making RNR sector the second largest contributor to national GDP. Agriculture sector also provides employment to 58% of population. Bhutan has maintained 70.46% forest cover, rich biodiversity and plentiful water resources. Mountainous terrain restricts arable agriculture only to 2.93%, meadow land 4.10%, shrub land 10.81%, snow cover 7.44%, and bare areas 3.20% of the total geographical area (LCMP, 2011). Nationwide, about 41% of farm households own less than 0.4 hectare of arable land. Around 47% of farm households (HH) own 0.4 to 2 hectares (MoA, 2009). The arable land of the country is further reduced by the infrastructure development and socio-economic development activities. Low productivity and small land holdings coupled with land fragmentation inflicts poverty in Bhutan, and as such, land is considered as main indicator of poverty.

2.3. Agro-Ecological Zones (AEZ) of Bhutan

Agriculture requires soil, water, air and light and therefore, agriculture is being carried out throughout the world, determining different cultures of the world. Similarly, people of different parts of Bhutan have different agricultural activities being carried out. *What, in your opinion, drives different activities in different parts of the country? What would be the probable merits and demerits of such scattered*

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and isolated farming practices in different parts of the country?

Let us recall our geography knowledge of Bhutan in terms of latitude and longitude, position/location on the globe, landscape, altitude – metre above sea level, the type of climate and seasons in a year. With refreshed knowledge of Bhutan's geography, it is easy to understand why people living in different parts of Bhutan are engaged in different agricultural activities.

Bhutan can be divided into six main *agro-ecological zones* (AEZs), primarily based on altitude, annual rainfall and air temperature (Table 2.1). These AEZs are further influenced by the mountainous terrain and valleys (Figure 2.1). These diverse agro-ecological conditions and topographic features have direct bearing on the farming systems practiced in each one of them.

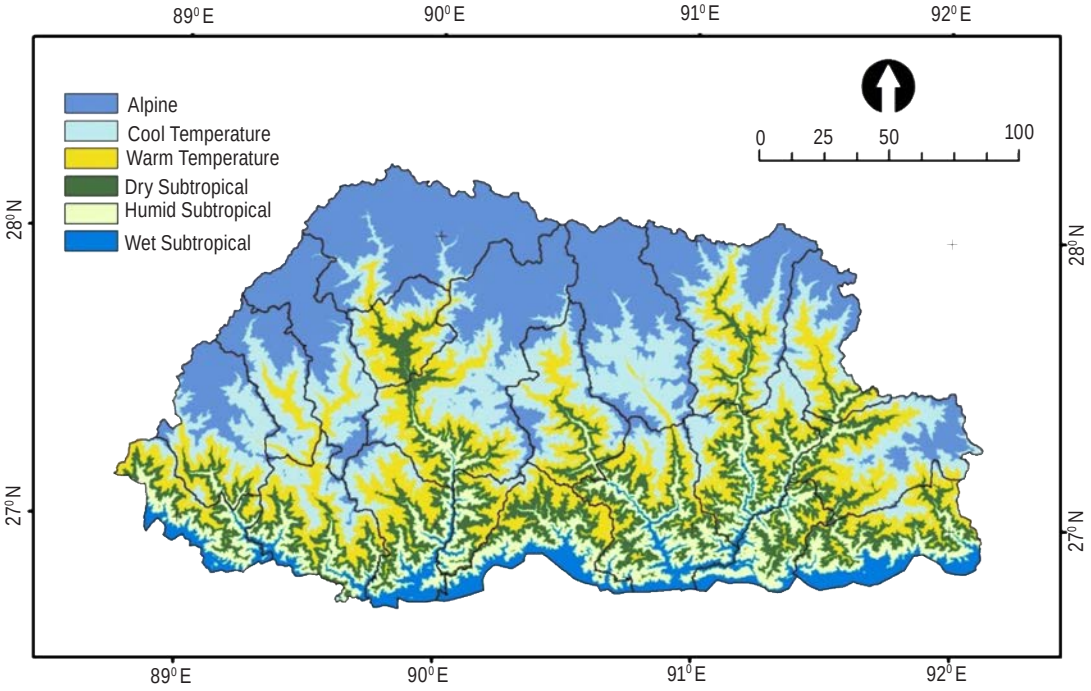

Figure 2.1 Distribution of the main agro-ecological zones of Bhutan.

A simple classification of Crop, Livestock and Non-Wood Forest Product (NWFP) across these main AEZs provides a clear differentiation and understanding of the diversity of agricultural production systems (Table 2.2).

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Table 2.1 Main agro-ecological zones of Bhutan(Source: Gyamtsho, 1996).

Agro-ecological Zone	Altitude Range (m.a.s.l)	Annual Rainfall (mm)	Average annual Air Temperature		
			Max °C	Min °C	Mean °C
1. Alpine	3600-4600	<650	12.0	-0.9	5.5
2. Cool Temperate	2600-3600	650-850	22.3	0.1	9.9
3. Warm Temperate	1800-2600	650-850	26.3	0.1	12.5
4. Dry Subtropical	1200-1800	850-1200	28.7	3.1	17.2
5. Humid Subtropical	600-1200	1200-2500	33.0	4.6	19.5
6. Wet Subtropical	150-600	2500-5500	34.6	11.6	23.6

The interaction of crop-livestock-forest resources and topography in different social systems leads to further niche production systems even within the same AEZ. For instance, in the humid zone, while the farming system in Tsirang is an irrigated rice-based system, farmers in Pemagatshel and Zhemgang depend on maize-based cropping systems. Similarly, in the dry zone a difference can be seen between Mongar and Wangdue – irrigated rice-based systems dominate in Wangdue and Mongar is predominantly rain fed maize-based. The difference in production systems is also closely associated with the livelihood system, agro-ecological setting and the state of development that the country has been able to provide.

The diversity of production systems of each AEZ of major crops, livestock and Non Wood Forest Product are shown in Table 2.2.

Table 2.2 Major crops, livestock and NWFP in different agro-ecological zones in Bhutan.

AEZs	**Crops**	**Livestock**	**NWFPs**
Alpine	None	Yak, sheep	Cordyceps, Nardostachys, Jatamansi, Rhododendron, Anthopogon
Cool Temperate	Potato, Barley, Mustard, Wheat	Cattle, Yak, Sheep	Cordyceps, Nardostachys Jatamansi, Rhododendron, Anthopogon

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Warm Temperate	Wheat, Maize, Barley, Buckwheat, Mustard, Apple, Pear, Peach, Plum, Potato and Vegetables.	Nublang, Mithun, Jersey, Jersey-cross, Pigs, Poultry	Mushroom, Orchids, Asparagus, Dyes.
Dry Subtropical	Rice, M aize, Wheat, Mustard, Millets, Orange, Banana, Guava, Vegetable	Nublang, Mithun, Jersey-cross, Pigs, Poultry.	Rattan and Cane, Ferns, Mushroom, Staranise (Illicium spp.) used as spice.
Humid Subtropical	Rice, Wheat, Maize, Mustard, Millets, Ginger, Areca nut, Orange, Large Cardamom, Guava	Cattle, Goat, Pigs, Poultry, Buffalo and Fishery.	Rattan and Cane, Ferns, Mushroom, Chirata
Wet Subtropical	Rice, Wheat, Maize, Mustard, Millets, Ginger, Areca nut, Orange	Cattle, Goat, Pigs, Poultry, Buffalo	Ferns, Bamboo shoot, Mushroom, Nettle grass, Pipla, Chirata

In the *alpine* and *cool-temperate zone* (3600 masl), semi-nomadic communities practise a pastoral production system with yak rearing as the main source of livelihood, lately they also rear small herds of sheep. They grow crops like high altitude barley, potato, buckwheat, mustard and few short season vegetables during the summer season in their backyard in areas above 3000 m.

Figure 2.2 Nomadic tribe of Laya

During winter when they migrate to warmer valleys, it is common to see yak herders in their traditional attire visiting houses to barter their cheese, butter, meat and wool with rice, chilli, and beans.

In the *cool temperate areas*, livestock rearing is still dominant with more cropping than in alpine zone. Farmers rear both cattle and yaks besides other livestock

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types like sheep and mules. Cattle graze the pastures in summer and yaks in winter. Higher proportions of people engage in farming and grow buckwheat, barley, wheat and potato in dry land (Figure 2.3).

Figure 2.3 Buckwheat field in Bumthang valley

Farmers of this zone maintain large tracks of natural pastures where they paddock their livestock.

The *warm temperate zone* is comparatively more fertile than other zones. Fertile soil and mild climate favours cultivation of different crops like paddy in irrigated terraced areas, mustard, chilli and wheat as second crops.

Figure 2.4 irrigated terraced rice field

Potato and barley are major crops in dry land fields. This zone also represents the major temperate fruit growing area (apple, pear, peach, plum and walnut). Livestock is another important component of the farming systems, particularly as a source of draught power and manure.

Figure 2.5 Potato field in dry upland areas

Predominated by maize cultivation, the *drysub-tropical zone* provides an upland farming environment where mostly rain fed crops are grown and irrigation water is the most limiting resource to farming.

Crops like millets (finger millet and fox-tail millet) and beans (phaseolus beans, kidney bean, soya beans) are the most popular ones. Potato is fast spreading as a cash crop. Lemongrass is found in abundance as undergrowth of chirpine and

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is extensively harvested, distilled and sold. With low productivity of land people still practices slash and burn agriculture with shorter fallow periods of 2-3 years despite government stopping it. Cattle, mules and pigs are other important sources of income.

The zone with altitudinal range of 150 to 1200masl receives annual rainfall of 1200-5500mm is classified as humid and wet sub-tropical zone. With abundance of water, irrigated rice production in terraces is the dominant cropping practice. Growing pulses on rice bunds, mustard and wheat after rice are common practices. This zone also represents the major production belt of citrus and large cardamom. In the low foothills, areca nut and ginger are extensively grown and generate substantial income. Local breeds of cattle, goat and poultry constitute livestock which helps in household income and farmyard manure(FYM).

The AEZs of the country provides abundant opportunities to the people of Bhutan to be engaged in diversified agriculture activities throughout the year such as rearing different livestock and growing varieties of crops – fruits and vegetables all the year round that can feed the small Bhutanese population easily. The AEZs are natural but the conditions of AEZs can also be altered with technology to enhance agriculture production. It is hoped that in due course of time, Bhutanese will learn to exploit the potential of AEZs for growing our own food – gaining the food security essential for the sovereignty of the GNH society.

2.4. *Agriculture in Bhutan*

The topography of the country and state of development influence by the AEZs, the Bhutanese agriculture is still largely based on the traditional subsistence oriented mixed farming systems that integrate cropping, livestock rearing, and use of forest products. It has evolved over a long period of time characterised by diversity of ecological conditions and a high degree of self-reliance. The unique mountain agriculture system characterised by diversity, variability over time and heterogeneity over space has led to the evolution of diverse farming systems specific to different localities. The integration between forest, crop and livestock system is built on the principle of input-output relationship. The diagram below is a representation of Bhutanese farming system.

In the centre of the web, the farm household manipulates the level of resources appropriated from one system to the other to optimise the benefit. The factors that

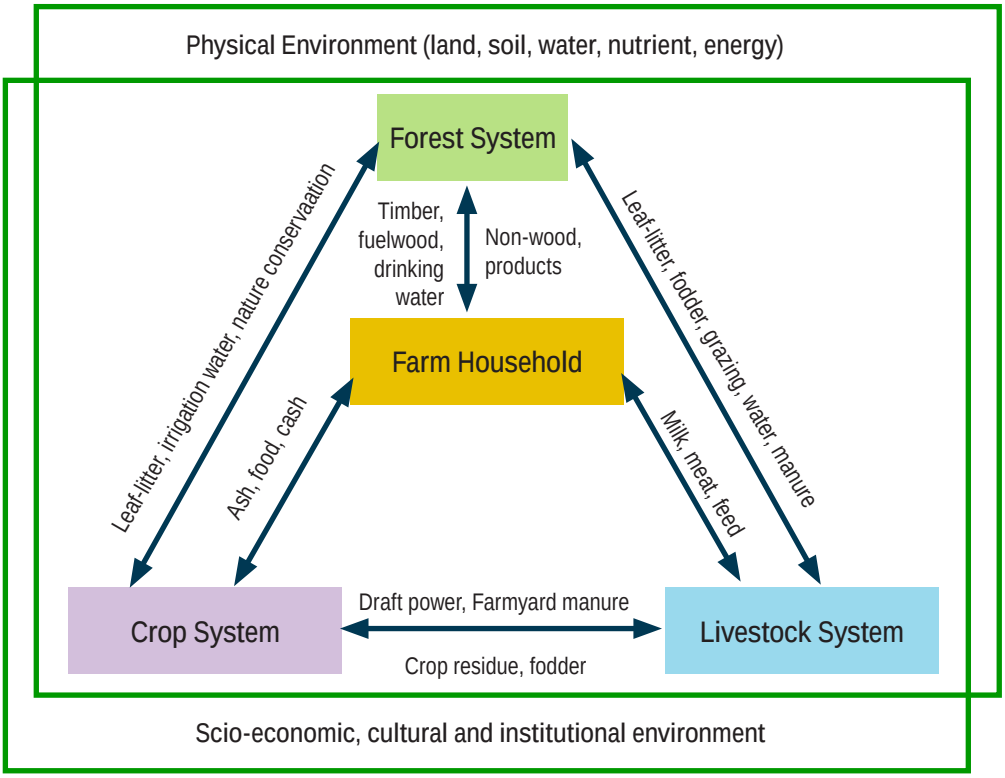

Figure 2.6 Key interactions in integrated farming systems in Bhutan

influence the resource flow are physical environment and socio-economic, cultural and institutional environment. Operating in a closely integrated production system, Bhutanese agriculture is largely organic with no or low use of inorganic fertiliser and pesticides.

Although the overall share of agriculture contribution to GDP has been declining from 26% in 2001 to 16.8% in 2010 (NSB, 2009), agriculture remains to be one of the most important sectors of the Bhutanese economy.

The Bhutanese farmer subsists by growing crops ranging from rice, wheat, maize, buckwheat, potatoes and barley depending on the climatic conditions. Livestock rearing is integral part of the farming life, as it supports food, draught power and nutrient recycling.

Figure 2.7 Maize filed on upland slope

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Figure 2.8 Rice field on upland slope

Rice based systems dominate irrigated terraced land up to an altitude of 2500 metres above sea level, while maize and potato based systems are commonly practiced on upland slopes. At altitudes between 2500-3000 metre above sea level, buckwheat, wheat, and barley are the traditional crops. Rice and maize are the main cereals grown in all zones except the western cool temperate zone where wheat, buckwheat, barley, mustard and potato predominate.

Figure 2.9 Mustard field in upland area

Wetland crops in winter include wheat, mustard and potatoes. Mustard is also grown under dry land conditions which occupy the largest cropped area. The only new basic food crop is the potato being cultivated in the temperate zone mainly for export purposes. Current production levels account for only 50% of rice self-sufficiency, 65% of wheat self-sufficiency and 59% of oil seeds self-sufficiency (DoA, 2008). The deficit is met through imports.

The gap between domestic production and national requirement is widening as consumption rates increase due to increasing preference for agricultural commodities not produced in the country like palm oil, sunflower oil and changing food habits.

It is a natural process in any developing country but not good for the Bhutanese economy, especially with growing unemployment of literate youth. This situation can be altered into Bhutan's favour with appropriate education for enhancing employment opportunities in the Bhutanese Agriculture sector. With the improved communication facilities in the country, there is already an increasing tendency to cultivate cash crops like apples in the temperate zone; and oranges, areca nut and cardamom in the subtropical zone in the south. Other cash crops that are exported include ginger, chillies and various kinds of vegetables.

The farm production is supplemented by keeping different kinds of domestic animals such as cattle for draught and milking purpose, chicken for eggs and pigs for meat etc. Among the livestock, 24% of the households rear Mithun[1] and Mithun-cross cattle both for dairy and draught power (Figure 2.10). Jersey and Brown Swiss cattle introduced through the Swiss Cooperation during 1960s are popular dairy cattle.

Figure 2.10 Methuen bulls kept for ploughing

Poultry as a source of egg has become very popular as egg is considered to be a culturally valued item for gifts – around 16% of rural households raise poultry. At higher altitudes, yaks and sheep are the principal source of livelihood (Figure 2.11). Yak herders still practice a migratory pastoral system where the family moves along with their yak herds before the winters in September to warmer area. For instance herders from Merak and Sakten in Trashigang, eastern Bhutan migrate to Radhi, Phongme and Khaling in winters. While the yaks graze on natural pastures in warm areas, herders move around the villages to barter the cheese, butter, and meat with grains and chilli.

Figure 2.11 Yak, a principal source of livelihood

Livestock products like cheese and butter are part of the Bhutanese diet with key dishes like "ema-datshi" and drink like "suja". Egg is another commodity which can be remunerating as imported eggs are highly regulated due to avian-flu outbreaks in neighbouring countries. Most of the commodities are locally sold without proper processing and packaging.

[1]The Mithun (Bosfrontalis) is a bovine species indigenous to the south-eastern parts of the Himalayas and the adjacent mountain ranges in north-east India. This bovine species, which is very little known elsewhere, is believed to have originated from the Gaur (Bosgauris). Mithun is the pride animal called as 'Cattle of Hilly Region' of north-eastern hilly region of India and tropical rain forest of China.

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2.5. Linkage between AEZ

The fact that these six AEZs specialise in particular production systems which is exclusive from the others, results in inter-dependence between these zones. While there is an apparent up-stream and down-stream linkage between communities, their basic linkage is related to livelihood systems (Table 2.3).

Table 2.3 Dominant farming systems, representative communities, major products and their linkages in the main agro-ecological zones of Bhutan.

AEZs	Dominant farming systems	Representative community	Major Products Flow of Products
Alpine	Pastoral farming systems	Gasa(Layap and Lunaps), Trashigang (Brokpas)	Yak cheese, Butter, wool and meat
Cool Temperate	Agro-pastoral farming systems	Shephu, Gantgey, Bumthaps	Buckwheat, cane mat and baskets, cheese, butter and sheep wool
Warm Temperate	Farming systems dominated by food crops and temperate horticulture crops	Thimphu, Paro	Red and white rice, apple chilli
Dry Sub-tropical	Farming systems dominated by food crops and slah and burn cultivation	Wangdue, Punakha, Zhemgang, Mongar, Trashigang	Rice, vegetables. maize and potato, woven clothes
Humid Sub-tropical	Farming systems dominated by orchards and subtropical horticulture crops	Tsirang, Dagana	CItrus, ginger. rice and maize
Wet Sub-tropical	Farming systems dominated by rainfed agriculture	Samtse, Sarpang, Samdrupjongkhar	Areca nut, ginger, mustard and rice

The people in the alpine zone are handicapped with the harsh climate and solely depend on yak rearing and produce excess of dairy products during summer. In winters when herders migrate to warmers areas with their yak herds, they carry along butter and cheese to barter with grains, ther food items and clothes. Yak herders move down as far as the dry sub-tropical zone and trade their goods. This age old trade network is vital to maintain the social system in the different

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zones. When the alpine dwellers move down in winters, they also bring rare high altitude herbs widely used in traditional medicines and incense. Similarly, there is also a close inter-dependence between communities of temperate and sub-tropical zones. The dependence is based broadly on crop products like red rice, potatoes, and apples from temperate zone and maize, citrus and vegetables from the sub-tropical zone.

The seasonal variations in these different AEZ also force people to move during harsh winters from high altitude areas to warmer valleys and foothills. As the temperature rises during March-April they migrate back to their villages. This practice of seasonal migration resulted in most of the families having summer and winter homes. The migration to south during winter is also forced as pasture are barren and covered with snow, taking their animals to south gives them access to grazing areas. There are even situations where western farmers of Paro, Thimphu and Ha districts own grazing land in Chukha. This movement of population between different AEZ has helped in maintaining close social networks between different communities.

The interdependence of people living in the different AEZs has brought sustenance to the life of different communities, understanding of different culture of the people living in different AEZs and brought unity in diversity to the people of this country and harmonious living with nature for centuries. The Bhutanese agriculture with 21st century technology can be the only solution to the Bhutanese sovereignty with its food security for the next generation. It is important that the hard working nature, contentment with basic necessity and living in harmony with nature of Bhutanese is revived for Bhutan's sustenance in the 21st century and beyond. Every Bhutanese need to embrace this philosophy that has help us to survive in the past and live being proud of Bhutanese instead of living as servants of others for easy money. Take up 'agriculture' to be productive citizens of this NGH nation and be contented of what you can do for yourself and the GNH society.

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Student Activity

1. Divide students into six groups from AEZ. Choice may be given to be in the group if they come from any particular AEZs.
2. Read the paragraph which they have been allotted AEZ /they are coming from (Village/Dzongkhags) to:
   a) share the experiences of their main occupation (of the AEZ group).
   b) Share as how they sustain their livelihood.
   c) List the crops that can be grown in their AEZ.
   d) Share as how they can support with each other at different AEZs.
   e) Share what they may be able to do to help GNH in attaining food security.
3. Groups will present their work to the class, followed by comments from the class and the teacher.
4. Provide suggestions and comments for improvement for final submission.
5. Assess their group work as per the assessment criteria.

3 Growing of Vegetables I

CHAPTER

Vegetables are an important source nutrient for us. We grow a diversity of vegetables in the country. This chapter discusses on the concepts of vegetables, types of common vegetables and their importance, the general procedures and practices of growing vegetables, preparation of compost – nutrition required, planning and raising nursery, transplantation, managing and caring of vegetables, especially against the diseases and pests. It is then followed by cultivation practices of some common vegetables such as cabbages, cauliflower, beans, peas, broccoli, sag and potatoes. The concepts and procedures on the art of growing vegetables and associated practical sessions are expected to change the attitude of students towards agriculture, induce love for growing vegetables so that this can help students take up agriculture as their future endeavour and ultimately contribute to food and nutrition security at the household as well as at the national level.

3.1 Vegetables and their importance

Vegetables are a complex group of a wide variety of crops. Vegetables, by definition, are those plants that have edible roots, tubers, stems, leaves, flowers and fruits. Most vegetables are annuals or biennials, completing their life-cycle in one or two years. Many vegetables can be grown under a wide range of conditions, while some have more specific requirements for soil, water and temperature. Thus in one place several species can be grown only during certain times of the year. Vegetable production involves a good knowledge and skills on production technologies.

Vegetables constitute an important component in our diet. They are the most important sources of minerals and vitamins. These elements are essential for the proper functioning of different organs of the body and hence their deficiency in the diet can result in adverse effect on human body. For instance, inability to see normally is caused by deficiency of vitamin A, development of weak bones results from lack of calcium and deficiency of iron in the diet also causes a condition known as anaemia. Pulses and lentils are generally rich in protein.

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3.2 Types of Vegetables

It is estimated that there are at least 10,000 plant species used as vegetables worldwide, although only about less than 50 are of great commercial value. Vegetables can be classified into two groups: according to cultural practices of production and according to botanical classification. Most vegetables can be successfully grown using similar cultural practices. By grouping the vegetables using cultural practices, it is possible to arrange the vegetables and further assist in crop rotation. The table below depicts classification of vegetables to help growers plan their work in growing vegetables and for business purposes.in various groups based on its botany, edible parts used, temperature, etc.

Table 3.1 Grouping of vegetables based on edible parts used

Group	Important characteristics	Crops
Edible roots and tubers	Fleshy roots are used. They are rich in carbohydrates besides vitamins like A and minerals	Potato, radish, carrots, turnip and beets
Bulbs	Bulbs and leaf stalk, contain sulphur based volatile oils	Onion, garlic, leek, shallots
Stems and shoots		Asparagus, bunching onion, pumpkin shoots.
Edible leaves	Leaves, rich sources of iron	Veg: Leaf beet (palak), spinach, mustard green, Cabbage, Chinese cabbage, tender shoots of pumpkins Salads: Lettuce, coriander, celery, parsley, mint, dill
Flowers	They are rich in sulphur, iron and vitamins and are considered to be cold tolerant.	Cauliflower, broccoli, artichoke

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Fruits	Fruits as vegetables are rich sources of vitamin A, B and C and minerals like iron and potassium	Tomato, egg plant , chilli,
Seeds	Pods as green or seed when ripe are good source of proteins.	Peas, beans, soybeans

3.3 Procedures for growing vegetables

a) Planning the Garden

Vegetables need water, air, nutrients and sunlight. It is therefore very important to plan as per the AEZs, as it is crucial and the first step in establishing a successful vegetable garden. Planning involves selection of site to ensure accessibility, selecting the plot that receives maximum sunlight, providing irrigation, drainage and fencing, location of compost heap, choice of vegetable seeds and procurement and planning a rough sketch of where each plant should be planted.

b) Selection of site

Most vegetable crops are annuals and biennials with few perennials. Being annual or perennial and perishable in nature, these crops deem intensive care and management. While planning, it is very important to be selective about the site to be developed a garden. Annual and perennials equally need regular attention to hoeing, weeding, watering and removal of damaged plant or parts. The site chosen should be within easy reach of required facilities for irrigation, tools and manure etc. The land with fertile soil, rich in organic matters and good drainage should be selected. Fencing is important. Ideally aim to establish permanent live fences of any favourable plants . Next best is to devise fencing with locally available resources.

c) Choosing site and procedures of making compost – organic fertiliser for vegetables

Soil nutrient is required for any vegetable crops for healthy growth. It can be easily produced with little efforts. It is discussed here, since some of the materials for compost will be available in the garden for preparing nursery beds.

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Composting is a technique of converting the wastes into humus- to improve the fertility and productivity of soil. It's very simple and suitable for small holder farmers. During the process of composting biodegradable wastes like crop residues, weeds, leaf litter, twigs and animal wastes etc. are decomposed into manure which is called as compost. The compost is rich in beneficial soil microorganisms, provides nutrients to the crops and improves the structure and texture of the soil. Compost provides many benefits as a soil amendment and as a source of organic matter by improving soil biological, chemical, and physical characteristics viz.

- Increases microbial activity, compost rich with all kinds of microorganisms and soil fauna that help convert soil nutrients into a form that can be readily absorbed by your plants.
- Enhances plant disease suppression with increased plant health and rich microbial population, the microorganisms, enzymes, vitamins and natural antibiotics that are present in compost actually help prevent many soil pathogens from harming your plants
- Increases soil fertility with the most complete range of balanced nutrients over many months unlike chemical fertiliser that provides fast but short term effect.
- Improves soil structure in clayey soils to be fluffy and friable
- Improves water retention in sandy soils with increased organic matter Adding compost moderates pH and soil fertility problems

There are different techniques to make compost that can be easily be practiced by the farmers or gardeners who do not have farm yard manures or those who do not have mixed farm practices. Some farmers in Bhutan collect leaf litters from the forest, spread over the field or garden before tilling/ploughing or digging the soil and then plough or dig the garden. The leaf litters serve as organic manures as well as retaining the soil moisture. Two simple ways are suggested.

i. Composting can be done in different ways such as heap, bins and pit etc. a pit dug in the ground/tank of an appropriate size depending on the manure required for the garden, place stones and gravels at the bottom of the pith for aeration and avoid logging, fill it up with leaf litters collected from nearby forest, grass cut from the school campus, weeded grass from the garden while preparing nursery beds, etc. add cow-dung slurry in between the layer of leaf litter or grass filling the compost pith, cover the pith with gunny bags or plastic sheet and leave the compost for maturing.

Can we stress on heap compost and do away of pit compositing?

(a) Basal layer for aeration

(b) First layer of waste material

(c) Preparation of cow dung slurry

(d) Heap building with dry/fresh material

Figure 3.1 Procedures of making compost

ii. Another simple way of composting is by heap compost in a compost shed or under a canopy of a tree. Select a site for compost pile, build foundation with tree branches over flat stones to ensure air circulation, stake a layer of leaf litters, followed by some green leaves or twigs, prepare cow-dung slurry and spread over the layer, add more leaf litters and green leaves and twigs, cow-dung slurry followed by more

Figure 3.2 Compost heap with Thatched roof

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layers of leaf litters. The heap needs to be covered by gunny bags or plastic sheet to retain moisture and warmth. The compost heap needs to be of manageable size. A shed may be built over the compost heap if it is in open air. The picture of constructing heap compost from training manual of MoAF is provided for your guidance.

The finished heap compost will look like the picture on the right. Turning the compost will facilitate maturing of compost. The first turning may be done after about three weeks and continue every after two weeks. The matured compost will be brown in colour and may be ready for use after two to three months depending on the climatic condition of the place.

d) Choosing the crops:

To reap the most out of the garden, wise choice of the vegetables to be grown has to be made. The choice is determined by the availability of space, seeds, crops, climatic conditions of the AEZ and the time. All vegetables do not grow successfully in different climatic conditions throughout the year. Select those vegetable crops that grow well in the given climatic conditions of the AEZ and in protected cultivation.

Successive sowing ensures a steady supply of fresh vegetables by extending the harvest over a longer period. Stagger the planting by frequent sowing, preferable at two-week intervals or as appropriate depending on the climate and facilities. Choose crop that adapts to multiple cropping. Multiple cropping is growing of two or more crops simultaneously in the same space thereby making maximum possible use of the available space and nutrients. It also helps to keep away pest and diseases and improves soil fertility. Beans are compatible with most vegetables; tomatoes with radishes, onion with lettuce, tomato or beets etc. The thumb rule is to combine roots with fruits or vice versa; bulbs with fruits or leafy vegetables; Cole crops with roots etc.

Figure 3.3 Raised bed

e) Nursery raising

The first step in successful vegetable production is to raise healthy vigorous seedlings. Young plants whether grown from seed or vegetative propagation, require a lot of care

particularly during the early stages of growth. A nursery is an area where plants are cared for during the early stages of growth, providing optimum conditions for germination and subsequent growth until they are strong enough to be planted out in their permanent place.

A nursery can be a simple raised bed in an open field (Figure 2.1), raised bed with poly tunnel (Figure 2.2)or green house with controlled environment. The crops like tomato, chilli, cabbage, cauliflower, broccoli eggplant ,and some leafy vegetables are first sown in nursery and then transplanted.

Management of nursery for raising healthy seedlings and transplanting them to the field are most important operations in vegetable production. Although raising seedlings in a nursery has advantages, some vegetables cannot transplant , particularly root crops, these crops must be sown directly in the field for optimum results.

Figure 3.4 Poly tunnel

The following are the advantages of sowing seeds in nursery:

- Avoids the problem of emergence in difficult soils.
- Weed control becomes simple and easier.
- Can achieve about 100% survival of plant population.
- Earlier planting and harvest because of shorter cropping cycle.
- Reduced field management costs.
- Uniform crop.
- Higher yield.
- Convenient in management of tender seedlings.
- Possibility of timely and careful plant protection measures.
- Most favourable growth medium is provided.
- Economic use of land and seed.

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Points to be considered while selecting the site and location of a nursery.

- The soil should be rich in organic matters and well drained.
- Select a small piece of land left fallow in the previous years if possible.
- The nursery should be nearer to the water source for irrigation.
- The plot should be near the residence to facilitate frequent monitoring/ inspection.
- It should be located in sunny area.
- An area previously not grown with the same crop or member of the same family is preferable.

3.4 Nursery bed preparation

1. Plough the field two to three times as a part of preparation of field for nursery or for plantation.
2. Remove all the stubbles, gravels, break the clods and make the soil as friable as possible for easy emergence of seedlings.
3. Sufficient amount of well decomposed compost or farmyard manure should be mixed thoroughly with the soil. The Farm Yard Manure (FYM) /chemical fertiliser application may be calculated as follows.

Apply 15-20 kg/10 m^2 of FYM/compost. The chemical fertilizers like Urea, Single Superphosphate (SSP), Muriate of Postash (MoP), Calcium Ammonium Nitrate (CAN) should be applied accordingly. For the application of the correct dose a simple calculation is required. Example: If you are asked to apply 60:75:35 kg NPK fertiliser per hectare, then the source needs to be identified and calculated accordingly. Urea contains 46% N, SSP contains 16% P and MoP contains 60%K.

Therefore, to calculate the above amount.

$$\text{Urea required} = \frac{\text{recommended rate}}{\%\ \text{nutrient content}} \times 100$$

$$\text{Urea required} = \frac{60}{46} \times 100 = 130\ \text{kg/ha}$$

$$\text{Therefore for 10 m}^2\ \text{area} = \frac{130}{10,000} \times 10 = 0.130\ \text{kg or 130 gm}$$

Similarly calculate for the remaining two fertilizers P and K from SSP and MoP. Total amount of fertilisers needed will be: Urea = 130 g/10 m^2; SSP= 460 g/10m^2; and MoP =60 g/10 m^2 as basal (during planting). Top dress 50 kgN/ha after 4-6

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weeks; which is Urea =110 g/10 m^2 top dressing (growing period).

Beds are raised or basin prepared after the soil is brought to a fine tilth. The beds should be 1m wide, 15-20 cm high and of convenient length depending on the size and terrain of the plot. Line sowing is always preferable to broadcasting in both nurseries and direct sown plots to facilitate weeding, hoeing and plant protection operations. It will have more uniform plant population and ease management.

Decide how many lines you wish to sow. Mark out the rows using small sticks or hand hoe, at the recommended row to row spacing of 5cm and sow the seeds thinly. Never start row right at the edge of the bed as they will not grow well. Always come in half a row width from the edge.

Sow the seeds at the recommended depth based on the size of the seeds. The general thumb rule is that seeds has to be sown at a depth double their size, meaning, bigger the seed deeper it has to be sown. If seeds are sown too deep, then nutrients reserves will be exhausted before the plant emerges. If seeds are sown too shallow, then they are likely to dry out or eaten by birds. Most appropriate depth to sow seed is 3 times deeper of its size.

Cover the seeds with fine soil and water them lightly. Mulch the bed with twiggy branches or jute bags to protect from birds, control weeds and retain soil moisture. Make sure to remove the mulches when the plants emerge. Some seeds with hard seed coat like chili can be soaked in water before sowing for rapid germination.

Table 3.2 Crop Calendar for some of the common vegetables

Vegetable	Altitude	J	F	M	A	M	J	J	A	S	O	N	D
Cabbage	High		x	x	x	x	x	x	x				
	Medium		x	x	x	x	x	x	x	x			
	Low								x	x	x	x	x
Cauliflower	High		x	x	x	x	x	x	x				
	Medium		x	x	x	x	x	x	x	x			
	Low								x	x	x	x	x
Broccoli	High		x	x	x	x	x	x	x				
	Medium			x	x	x	x	x	x	x			
	Low								x	x	x	x	x

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Tomato	High			x	x	x	x	x	x				
	Medium		x	x	x	x	x						
	Low								x	x	x	x	
Egg Plant	High		x	x	x	x	x	x					
	Medium		x	x	x	x	x	x					
	Low							x	x	x	x	x	
Chilli	High			x	x	x	x	x	x	x			
	Medium		x	x	x	x	x	x					
	Low	x	x							x	x	x	x
Beans	High			x	x	x	x						
	Medium			x	x	x	x						
	Low	x	x								x	x	x
Mustard Green	High			x	x	x	x	x	x	x			
	Medium		x	x	x	x	x	x	x				
	Low									x	x	x	x
Lettuce	High			x	x	x	x	x	x	x			
	Medium				x	x	x	x	x	x	x		
	Low										x	x	x
Onion	High		x	x	x	x	x	x	x	x	x		
	Medium		x	x	x	x	x	x	x	x	x		
	Low	x	x									x	x
Carrot	High			x	x	x	x	x	x	x			
	Medium		x	x	x	x	x	x	x				
	Low									x	x	x	x
Radish	High			x	x	x	x	x	x	x	x		
	Medium		x	x	x	x	x	x	x	x	x	x	x
	Low	x	x								x	x	x

The harvesting time depends on the sowing time. The shaded area in the above table is the cropping duration.

An exception to the above cropping calendar is that the seedlings raised in poly-tunnels can be sown as early as mid-December in the higher altitude. However, this is a very labour intensive work, demanding lots of extra-care and skills.

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Seed rate: The quantity of seed to be used depends upon its purity, viability, the time of planting, condition of soil, the size and vigour of the plants. Seeds known to possess low viability should be sown more thickly than those having high percentage of germination. Similarly, hybrid seeds with assured germination can be sown thinly compared to open pollinated varieties. However, the seed rate depends upon the distance between rows and plants in the field.

Table 3.3 Seed rates required for different crop

Vegetable crops	Seed rate (gm)/10m^2
Onion	4-5
Garlic (clove)	350
Cabbage	1-2
Cauliflower	0.5
Pea	90-100
Bean	80-100
Carrot	8-10
Radish	7.5-10
Sag	6-10
Tomato	1
Chilli	1-2

3.5 Care and management of nursery bed

a) Watering

Watering of the nursery bed should be done regularly preferably in the evening for the first week of sowing the seeds and irrigate frequently for rest of the growing period. Before germination, watering is done with a fine spray to avoid flushing away of seeds. The beds should neither be under-watered nor over-watered.

b) Mulching

Mulching of nursery beds with organic matter like straws or chopped grasses such as young artemisia leaves is a crucial step as this helps in retaining moisture, prevent the soil from developing hard cramp, weed control and thus help in the easy emergence of seedlings.

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c) Weeding and hoeing

All the unwanted weeds should be removed before the competition occurs. Timely weeding in nursery is very important to get healthy seedlings. If there are some weeds in the seed bed, remove them manually. Remove the weeds in between the rows by working out with a hoe.

d) Thinning of seedlings

It should be done to achieve healthy seedlings. Thinning involves removal of weak, unhealthy, diseased, insect pests damaged and dense plants from the nursery beds keeping distance of about 0.5 to 1.0 cm from plant to plant. The thinning ensures balance distribution of light, air to each and every plant. It also helps in watching the diseased and insect pest attacked plants while moving around the nursery. Taking measures for controlling them time to time is essential.

e) Hardening

It is done, so that, the seedlings become hardy to bear the shock of transplanting. Seedlings are exposed for a week or more to low temperature and water is withheld or irrigation frequency is reduced. The exposure to low temperature can be only followed in green houses. Seedlings raised in poly-tunnels can be easily hardened by simply removing the entire polythene sheet cover a week or two earlier to transplanting.

Figure 3.5 Hardening seedlings

3.6 Field preparation for transplantation

It is an important operation in order to make the soil well pulverised, so that seeds can germinate without any strain and rooting can take place well. For which you need to:

- Irrigate the field a week before tilling in order to loosen the soil clods.
- Field preparation can be done by digging or ploughing by animal drawn plough or Tractor or power tiller. At least two cross ploughing can be done before sowing the seeds.
- Incorporate manure/compost/FYM for enriching the soil.
- Remove weeds, stones and stubble of previous crops.

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Prepare a recommended *bed of 1m width* and this should be chosen such that the central part can be easily accessed from both sides of the bed. The length of the bed will depend on the terrain of the available land. In rainy season the beds should be raised little higher from the ground surface to prevent water stagnation and for dry season, prepare low beds to enhance moisture retention.

Spacing refers to distance between plant rows and between plants within a row. If there are more plants per unit area the competition for nutrients, moisture, sunlight, etc. will increase. Therefore the total yield will be increased . Plant population per unit area should be such that all plants get equal opportunity to utilise the resources for their optimum growth and development

Table 3.4 Spacing for some of the common vegetable crops

Vegetable crops	Spacing (cm) Row x Row and Plant x Plant
Onion, Garlic	15 x 10
Pea, Beans, Radish	30 x 5-10
Lettuce	45 x 30
Chilli, Cauliflower, Broccoli	45 x 45
Potato	60 x 15
Tomato, Cabbage	60 x 45
Egg plant	60 x 60
Pumpkin	150 x 250

Table 3.5 Suitable age for transplanting seedlings of some of the vegetable crops

Vegetable Crops	Age in weeks
Brinjal	3-4
Cabbage	4-6
Cauliflower	3-4
Onion	6-8
Tomato	3-4
Broccoli	3-4
Lettuce	4-5

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Transplanting is shifting of seedling from seedbed to production field where it will have more space to grow. The seedlings are transplanted in lines for easy cultural operations. By transplanting the seedlings, uniform crop stand is obtained.

Seedlings should be transplanted at the right stage. The stage of transplanting of seedlings is an important factor which determines the outcome of the crop.

Tips for transplantation

- Seedling should be hardened off before transplanting from the nursery bed.
- Try to select a cloudy day or evening hours for transplanting.
- Water the seedlings before uprooting them.
- The intact soil on the roots should not be removed. The seedlings or plants must be dug up not pulled out.
- Dig a hole big enough to fit the roots without bending them.
- Fill the hole with soil and firm the soil around the plant.
- Transplanted plants must be irrigated immediately. Dead seedlings must be replaced immediately as and when observed; within a week after the transplanting.
- It is recommended to label the field with name of the crop and other details.

3.7 Care and management after transplantation

Water is one of the most important factors for maximisation of yields. Depletion of soil moisture results in reduction of yield. Plants grow well when they have adequate supply of moisture in the soil. Plants need water to:

- Absorb nutrients from the soil.
- Replace losses due to transpiration.
- Maintain turgor pressure which supports the plant.
- For photosynthesis.

Procedures of watering

- Water the plants under cooler conditions, preferably in the evening.
- Water is absorbed by plants from the soil, not directly through the leaves, so always aim to get the water into the soil to reach root zones.
- Always use watering can.

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- Always water the plants before water stress symptoms becomes apparent.
- To achieve deep watering, water once, then leave the water to soak in, and repeat the watering.
- Do not flood a plot as it may wash away the surface soil particles

Method to check the soil moisture

Assessment of optimum need of water for the root zone is a must. The soil moisture content can be checked by taking a handful of mud just below 2// of the top soil and squeeze to form a ball.

- If it forms stable ball, then it has sufficient moisture.
- If the water drops in squeezing, then it has excess water.
- If it does not form a ball it requires additional water.

Moisture sensitive stages of vegetable crops

Vegetables need a fairly constant supply of soil moisture throughout the growing stages. Normally water stress in early stages delays maturity and reduces yields. Water shortage during the growing season, bolting, flowering, setting and maturity affects quality yields.

Table 3.6 Critical stages of moisture requirement

Vegetables	Critical stages
Asparagus	Fern growth
Beans	Flowering and pod formation
Broccoli	Head formation and fruit enlargement
Cauliflower	Frequent irrigation from planting to harvest
Egg plant	Flowering and fruit enlargement
Lettuce	Head development
Onion	Bulbing and enlargement
Potato	Tuber initiation to tuber maturity
Tomato	Flowering, fruit setting and enlargement
Chilli	Flowering and fruit development

At this moisture sensitive stages, it is very important to provide the crops with optimum water, otherwise the yield and quality will reduce drastically.

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a) Mulching

Mulches are covering materials applied on the soil surface. They are mainly used to reduce or increase the soil temperature. High soil temperature affects seed germination, vegetative growth, flowering, fruit set and yield. The materials can be either organic (e.g. straw, leaves) or manmade (e.g. Plastic). Both nursery beds and transplanted beds are recommended for mulching. However, for the nursery beds, it has to be removed at the time of germination to avoid abnormal growth of seedlings. Mulching materials must be locally available and cheap. There is a huge range of potential materials, including straw, leaves, weeds, sawdust, compost, wood chipping etc. Mulching:

- Suppresses weeds.
- Conserves moisture/improve infiltration.
- Increases the soil temperature.
- Improves soil structure and fertility.
- Adds organic matter in due course.
- Reduces run off and soil erosion.
- Saves young germinating and tender plants from direct sun light.
- Stimulates soil organisms.
- Protects the soil from forming the crust.
- Protects soil from direct sun light and harsh rain.

b) Weed management

Weeds are unwanted plants which compete with crops for nutrients, water, space and light and they make operations like harvesting more difficult and act as potential alternate hosts for pests and diseases. Weeds are found everywhere from crop lands to wastelands. Most of them are harmful to crops. However, for the successful production of vegetable crops, weed management is of utmost importance. Weeds can be controlled by:

- Regular hoeing.
- Intercropping.
- Mulching.
- Weeding.
- Crop rotation and relay cropping.

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c) Pruning and training

Pruning away some unwanted branches with the tangled mass of vegetation allows light and air penetration inside the canopy. Training involves providing the plants with supportive structures or stakes to the weaker or climber plants. Training of the plants is done in the initial stages of the crop or when the plants are still young. Advantages of pruning and training are:

- Increase the yield per unit area.
- Earlier maturity is ensured primarily.
- Quality gets improved.
- Labour cost of picking or harvesting is reduced.
- Hoeing, spraying dusting and irrigation operations can be performed conveniently.
- More exposure to sunlight and air.
- Reduce the incidence of pests and diseases

d) Earthing-up

It is one of the important operations needed to be done in most vegetables. The soils in between rows and plants are loosened and shifted to near around the plant. The main aim of earthing-up is to make the plant base strong/stable to avoid lodging of the plants even if there happens to be strong winds. Earthing up is mainly practised for roots and tuber crops.

e) Harvesting

It is the final agriculture operation. In order to achieve high quality and a good price in the market it is of utmost importance that harvesting is done at right condition. The grower should be vigilant of the crop's maturity as well as market demand period once the crop is ready for harvesting. Much care should be taken in handling the produce during harvesting. Farmers have their own way of assessing harvest maturity, which varies widely from crop to crop, but basically they take into account the colour, size and shape, hardness- softness, smell, taste and resonance of the produce when tapped.

f) Right time for harvesting

Growers generally know when to harvest, so that the produce can be dispatched

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as fresh to the market, properly packed and free from damages. However, a few thumb rules are:

- Use only clean field containers.
- Use containers that are free from rough edges, nails, etc.
- Keep harvested produce off bare soil and direct sunlight..
- Avoid over packing.
- Rough handling of the produce and containers will damage the produce.
- The recommended time for harvesting is generally during the coolest partof the day- early morning or late afternoon.
- Do not pack the produce in wet condition (dew or rain).
- Harvested produce should be protected from direct sunlight.
- Harvest vegetables at right stage.
- Some crops e.g. tomato can be harvested at different stages depending on the intended use or distance from the market.
- Sequential harvesting is always the best rather than harvesting all at once.

Advantages of harvesting vegetables at right stages

- It helps grower to fetch better price in the market.
- Yield is more.
- Good quality and flavour.
- Less damage by insect, pests and diseases.

Table 3.7 Period and stages of vegetable harvesting:

Name of vegetable	Period (day)	Stage of harvesting
Cole crops		
Cabbage	100-120	Developed, firm compact heads
Cauliflower	100-130	Curds are compact
Fruit vegetables		
Chillies	60-90	Green and matured for consumption
		Green or ripe fruits for pickle making
		Full ripe fruits for drying and powder making

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Tomato	120-150	Mature green stage for distant market
		Pink stage or turning pink stage for local market
		Ripe fruit for home consumption
		Full ripe stage for immediate use in canning and pickling
Brinjal	70-80	Tender fruit with stalks
Legume vegetables		
Beans	50-60	Tender stage of pods
Peas	100-130	When pods are well filled up with tender seeds
Root vegetables		
Carrot	60-70	Fully developed
Radish	60-80	Tender and fully developed roots
Tuber vegetables		
Potato	90-120	Fully developed
Bulb vegetables		
Onion	130-150	Fully matured bulbs
Garlic	130-150	Fully matured bulbs
Leafy vegetables		
Lettuce	70-80	Tender, developed leaves
Asparagus	250-300	Tender spears are cut just below the surface of the soil
Spinach	25-30	Tender, succulent

3.8 Common pests of vegetables

The incidences of pests can lead to considerable loss of crops if the control measures are not taken on time. Some of the common pests of vegetable crops are cut worm, caterpillar, cabbage moth, bean pod moth and aphids.

a) Cut worm

Cutworm is common and widely distributed. They are known as cut worm because they cut the plant and fell to the ground, either the whole or part of it, particularly at night. They are confined to the top few centimetres of surface soil. Seedlings of

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tomato, cabbage and maize are affected; it may also attack root crops like carrot, turnip and potatoes. It feeds on plant stems, cutting through young stems close to the ground.

Figure 3.6 Cut worm (Agrotissegetum)

Sometimes they drag some or whole part of the cut plant into the soil and this is a sure index of the place of hiding. If left uncontrolled they may fell many young plants in matter of few days. As a stem matures and stem become hard it cannot fell the plant. It can be controlled by

- Deep ploughing – will expose larvae to the soil surface for predators.
- Flooding the field for several days before planting may be feasible for some crops grown on paddy terraces can reduces the problem.
- Weed destruction- Weeds are often preferred sites for ovipositor and food for the first instar larvae. So keeping the land weed for several weeks before planting will reduce the number of larvae in the soil.
- Closer plant spacing- this method is practiced by the farmers growing chillies. They transplant chillies at a closer distance to compensate for the loss of any seedlings. It really does not matter much because the final spacing would remain adequate.

Hand picking of full grown larva is a practical method for small holdings farmers. However, constant vigilance during the early mornings is required to spot any fresh damage so as to locate the cut worm.

b) Large white butterfly

Vegetable crops such as cabbage, cauliflower and mustard of Brassicas family are attacked. The larvae feed in groups. They initially feed on the underside of the leaf surface. This results in complete defoliation of leaves.

Figure 3.7 Large white butterfly (Peris Brassicas)

Control: The adult butterfly can be

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seen easily in the field, while laying eggs. The eggs are easily visible and can be handpicked and destroyed. During the early stages when larvae feed in groups, they can be collected and destroyed.

c) Cabbage moth

Cabbage moth as it is named also attack cabbage, cauliflower and a range of other crops. The caterpillars are very variable in colour but are green when young, later becoming pale brown. The larvae bore in to the heart of cabbage eventually rendering it unfit for market. Although few in number as compared to large white butterfly, the resulting damage is more severe in this case than the other.

Figure 3.8 Cabbage moth and Larva of cabbage moth

Control: Control should be carried out early and before the larvae have a chance to burrow into the heart of the cabbage.

d) Bean pod moth(Maruatestulalis)

The full grown caterpillar is greenish with rows of black spots along the back and is about 15mm long. Pupation takes place in the pod. The adult moth has brown fore wings with white spots, whilst the hind wings are slivery grey with brown tips. Leaves, flowers and pods are fed on by the caterpillars, but more serious damage is done in the pods where the seeds are destroyed.

Figure 3.9 Bean pod moth (Marucatestulalis)

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e) Blight:

Blightis a fungal disease that attacks leaves, stems, fruits and roots of vegetables and destroy vegetables. Its *symptoms* can be detected easily. Lesions (affected parts/ wounds) are circular and water-soaked initially and become greyish brown as the disease advances. Infected leaves are usually "half-moon shaped". Leaves wilt and die. Dark lesion girdles the base of the stem and may expand on the stem restricting the upward movement of nutrients and water from roots. Stem girdling results in sudden wilting of the plant. Symptom on fruits is characterised by "small, water-soaked, dull green spot" that rapidly spreads to the whole length of the pod under favourable conditions. Infected fruit shrivel but remain attached to the plant. Root rots and hence restricts the movement of water and nutrients to other parts of plant.

Control:

- Select a site that has not been used for cultivation of same crop.
- Avoid water-logged fields.
- Follow crop rotation with non-solanaceous crops such as cabbage, cauliflowers, broccoli, etc.
- Use healthy seeds and seedlings.
- Raise and transplant seedlings on a raised bed at least 30 cm high and 1 m wide to ensure that moisture does not collect at the base of the plants.
- Drain out standing water from the field immediately after rainfall.
- Rogue out any infected plants and burn them.

3.9 Common disease of Vegetable crops

a) Club root(Plasmodiophorabrassicae)

This disease affect roots of vegetables. It is a soil borne disease. The disease causes yellowing and wilting of above ground parts and large spindle-shaped gall on the roots. It can be controlled by following control mechanisms:

- selecting seedbeds not cultivated before, expected to be disease free.
- avoid growing Cole crops in the same field for 10 years or so. Follow crop rotation with non-Brassica crops.
- increasing the soil pH above 7 reduces the incidence of disease.

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b) Bacterial wilt (Pseudomonas solanacearum)

Bacterial wilt is a major problem of tomato. Tomato plants that are infected wilt rapidly especially during the warmest part of the day. The growth of the infected plant is stunted and leaflets and leaf stalk curl down. Stem and leaves are affected by this disease. This disease can be controlled by:

- following crop rotation with non solanaceous crops like cereals to check disease incidence.
- grow Cole crops like cabbage, cauliflower in the infested field.
- uproot and burn the infected plants.
- flood the plot or land to be used for tomato cultivation.
- use clean bacterial wilt free seedlings.

3.10 Cultivation practices of some important vegetable crops

a) Cabbage;

Dzongkha Name: Dama kopi

This is a biennial grown as an annual with a very short stem supporting a mass of overlapping leaves which form a compact head. It is an excellent source of vitamin C, Vitamin A, thiamine, riboflavin and niacin.

Figure 3.10 Cabbage

Cabbage grows best under cool and moist conditions. Optimum temperature for growth is 15-20°C.

It will grow on all soil types provided it is not water-logged. pH should range from 5.5-6.5. The soil needs to be well consolidated (pressed down to make a firm seedbed).

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Table 3.8 Some of the common verities of cabbage and cultivation seasons

Varieties	Planting time
1. Copenhagen market 2. Golden acre 3. Green Coronate (Hybrid) 4. Gainty (Hybrid) 5. Bonday Cross (Hybrid) 6. Lucky Ball (Hybrid) 7. T1-163 (Hybrid) 8. Golden cross	1. High hills (up to 3000m): February-July. 2. Mid hills: October-December. 3. Low hills: October.

i. Nursery preparation

- Prepare a pulverised seed bed of one metre wide incorporating well-decomposed FYM.
- Seed rate =1-2 g/10m^2.
- Water once per day if it is not raining.
- Thin out seedlings to leave one strong seedling every 7.5 cm.
- Transplanting stage is at 3-6 leaf (around 28 days after sowing).

ii. Transplantation

- The transplanted vegetable crop needs adequate manures for healthy growth.
- Make well prepared beds.
- Spacing: R-R = 60 cm and P-P =45 cm.
- Water the nursery the day before transplanting.
- Uprooted seedlings should be transplanted immediately.
- Transplant the seedlings in the late evenings, press the soil down firmly around the plant and irrigate immediately.

iii. Care and Management

The transplanted vegetable crop seedlings are regularly monitored for watering, weeding and checked for the symptoms of diseases and pests and accordingly

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appropriate actions are followed up as per the guidance provided in the first section of this chapter.

Harvest stage is when the heads are firm but tender (90-100 days). Cut with a sharp knife at ground level. Some cabbages will ratoon if the lower leaves are left on. On an average cabbage can yield 15-30 kg/ 10 m^2. Harvested cabbage can be stored for up to 3 months at 0°C either store in boxes or leave in the ground.

b) Cauliflower (Brasiccaoleracea var. botrytis)

Dzongkha name: Meto kopi

Although grown in a very similar way to cabbage, it is much difficult to grow compared to cabbage. The curds are rich in vitamin C, iron, thiamine, riboflavin and niacin.

Figure 3.11 Cauliflower

Although it also needs cool, moist conditions like cabbage; it is not frost tolerant. Any checks in the growth result in poor curd formation e.g. high temperature, dry conditions, strong winds, heavy frosts.

Cauliflower prefers well drained soils with plenty of organic matter and a pH of 6-7. Intercrop with onions, carrot, legumes.

Table 3.9 Some of the common verities of cauliflower and cultivation seasons

Varieties	Planting time
1. Snowball 16 2. White summer 3. White top 4. Khangma Kopi 1 5. Khangma Kopi 2 6. Snow Mystic hybrid	1. High hills (up to 3000m): February - May. 2. Mid hills: October-December. 3. Low hills: October.

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i. Nursery preparation

Prepare beds same as cabbage. It is very important that both the nursery and field are prepared well to avoid checks in growth. Water frequently but do not flood. Seed rate - 0.5 g/10 m^2. Thin as cabbage.

ii. Field preparation

Make well prepared beds. Transplant seedlings at 3-6 leaf stage (around 28 days after sowing)

iii. Transplantation

Water the nursery the day before transplanting to allow easier lifting. Transplant under cool conditions and water immediately. Soil needs to be pressed down around the base of the plant. Do not delay transplanting as bigger seedlings give small curds. Spacing: varies with variety but generally R-R= 50-60 cm and P-P =45-50 cm.

iv. Care and Management

It is important to visit the field after the transplantation regularly for monitoring the growth of the crop and care to be provided by

- Weeding – to be done time to time. Care should be taken to ensure the cauliflower plants are not up rooted as their roots are shallow.
- Watering –to ensure the transplanted seedling get adequate water, especially in the early stages. However, do not overwater.
- Earthing-up to be done after 4-5 weeks of transplantation.
- Monitoring plants against pests and diseases and removing /controlling the affected parts of plants on time.

v. Harvest

The normal time of cauliflower to mature after transplantation is within 100 to 120 days. However, adverse conditions may affect its growth. Cauliflower can yield 20 to 30 kg grown in an area of 10 metre square.

Cutting the whole head with a sharp knife is a proper way of harvesting the cauliflower. After harvest, it can be stored for 2-4 weeks only under cool conditions. Hang the curds up- side down and mist occasionally to prolong the life of harvested cauliflower.

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c) Broccoli

Dzongkha name: Metohoentse

Broccoli is grown as an annual crop. A head of broccoli is a cluster of flower buds. When the head is young its individual buds are packed very tightly. Once the head begins to loosen and spread out, they are about to bloom and the head should be cut immediately, regardless of the size.

Figure 3.12 Broccoli

Once the main head has been cut, many smaller heads, called side shoots, will form on other parts of the plants.

It is a good source of Vitamin A, potassium, iron, calcium and fibre. It also contains important photochemicals like beta-carotene, indoles and isothiocyanates. Phyto-chemicals prevent carcinogens (cancer causing substance) from forming. They also stop carcinogens from getting to target cells and help boost enzymes that detoxify carcinogens.

Broccoli require cool weather to reach maturity. All of the Cole crops grow well in reasonably fertile, well-drained, moist soils with plenty of organic matter. The pH should be between 6.0 and 7.0 for optimum growth.

Table 3.10 Some of the common verities of broccoli and cultivation seasons

Varieties	Planting time
1. Desico 2. Centauro hybrid	1. High hills (up to 3000m): March - June. 2. Mid hills: September - January. 3. Low hills: October - November

i. Nursery preparation

Nursery preparation is same as those of cabbage and cauliflower. However, a soil test is the most accurate guide to fertiliser requirements. Soil test results,

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field experience, and knowledge of specific crop requirements help determine the nutrients needed and the rate of application. The fertiliser application should insure adequate levels of all nutrients. Optimum fertilisation is intended to produce top quality and yields in keeping with maximum returns.

ii. Transplantation

Transplant during the evening and irrigate immediately afterwards. While transplanting the spacing should be R-R= 60 cm and P-P= 45 cm

iii. Care and Management

Care after transplantation include 2-4 weeding/hoeing may be necessary depending upon the weed pressure, soil structure, and weather conditions. Keeping soil moist by frequent watering helps the plant to grow quickly. It requires less water as heads begin to mature. Check for disease and pests for early detection and control.

iv. Harvest

Harvest the centre green flower bud cluster of broccoli while the buds are still tight and before any yellow petals begin to show. Cut the central stem five to six inches below the head. Broccoli can yield: 3-4 tons/acre. Broccoli is highly perishable and it is usually stored for only a brief period.

d) Peas(Pisumsativum)

Dzongkha name: Boesem

Peas are annual bush or vine rich in protein, thiamine, iron and niacin. Peas can grow best in relatively cool conditions with temperatures of 12-18°C. It can be grown on all types of soil except waterlogged or compacted ones. So choose a well-drained, loose and friable soil with a pH of 6-7. Ensure adequate organic matter is present.

Figure 3.13 Peas

Peas plant can fix nitrogen form the air thereby improving the soil fertility. Peas are legumes that are ideal partners for intercropping with non-leguminous vegetables.

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Table 3.11 Some of the common verities of peas and cultivation seasons

Varieties	Planting time
1. Usui	1. High hills: January-November
2. Bonneville	2. Mid hills and Low hills: September-December

i. Field preparation

A thorough preparation is necessary to give loose and friable soil. Large clods cause poor emergence. As peas are legumes, they does not require much nitrogen, and excess N will decrease the amount of nitrogen fixation. However, Apply a small amount to get the crop established.

- FYM/compost-20 kg/10 m^2
- N P K: 25:50:75:40 kg/ha basal dressing only. This is: urea = 50-90 g/10 m^2; SSP = 310-470 g/10 m^2; MoP = 70 g/10 m^2.

ii. Transplantation

Seeds are directly sown on the beds prepared. Ensure sufficient moisture at the time of sowing. Spacing will depend on the variety either dwarf or non-dwarf.

- For dwarf variety use R-R = 50 cm and P-P= 5-10 cm.
- Similarly, for non-dwarf variety adopt R-R = 80-100 cm and P-P = 10-15 cm.
- Seed rate of 90-100 g/10 m^2 can be used and seed placed at 4-6 cm.

iii. Care and management

Irrigate the crop as and when necessary during dry spells. This should be done at 15 day intervals. The key times are flowering and fruit set. Provide support (stake) particularly for tall types to reduce the losses from rotting.

Plant protection against:

- Powdery mildew is a serious problem in peas. It occurs late in the season infecting leaves and pods. It is worse in dry weather and on dry soils. Use disease free seed, resistant variety to minimise the loss from powdery mildew.
- Leaf and pod spot is another disease that affects peas. Light brown spots on leaves and pods, cankers on stems occur. This is a seed borne disease, so use clean seed. Crop rotation and disposal of crop debris also help to control it.

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iv. Harvest

Harvesting can be done by successive pickings when peas reach full size. Peas rapidly lose their flavour if harvest is delayed. Hold the stem when you pick; do not just pull the pods. Peas can yield 3-6 kg/10 m^2.

e) Bush Beans

Dzongkha name: Sem chum

Beans are the general name for a large group of crops, all of which belong to the legume family. This information refers to bush beans which is the main type grown in Bhutan. Beans are good source of protein, rich in vitamin A, thiamine and potassium.

Figure 3.14 Bush beans

They grow best under cool temperatures (optimum 19-23°C). Under very hot conditions, beans suffer from blossom or pod drop. Germination is very slow under cold conditions.

Beans can be grown on a wide range of soils provided the soil has a good structure, adequate humus and is not prone to water logging. pH should be 6-6.8. They can be intercropped with maize and most vegetables.

Table 3.12 Some of the common verities of bush beans and cultivation seasons

Varieties	Planting time
1. Top crop 2. Borlotto 3. Pusaparvati	1. Upper hills: March-August. 2. Mid hills: February-September 3. Low hills: October-December.

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i. Land preparation

Beans need well-prepared beds incorporating plenty of FYM. Apply 20 kg of FYM/compost at land preparation. Like peas, only small amounts of nitrogen will be needed to boost early growth. N P K=25:50:75:40 kg/ha basal dressing. This amounts to: urea= 50 g/10 m^2; SSP =310 g/m^2 and MoP= 470 g/10 m^2.

ii. Transplantation

Beans are also directly sown with spacing of dwarf Row X Row (R-R) = 45 cm, Plant X Plant-(P-P) = 10 cm and climbers R-R = 100 cm P-P= 50 cm. Depth = 3-4 cm. Seed rate = 80-100 g/10 m^2.

iii. Care and Management

For a legume to fix nitrogen, the correct species of Rhizobium bacteria must be present. The bacteria should be present in the soil, if beans have been grown on the land before, if not seeds should be inoculated prior to sowing.

- A mixture of soil and bacteria is used to coat seed before sowing.
- Support for climbing types.
- Weeding as necessary.
- Irrigation will be necessary around the flowering period if dry. Do not over irrigate as beans are shallow rooted and sensitive to water logging.
- The main disease is anthracnose which causes dark brown cankers on stems and brown sunken spots on pods. It can be controlled by using disease free seed, crop rotation and disposal of crop debris.
- Other diseases, is bean rust and is favoured by the same weather as anthracnose and can be controlled in the same way.

iv. Harvest

The harvest stage is when the pods are fully grown but seeds are small. Some varieties become very stringy when old, although most are string less varieties. Test by bending beans to see if they snap. If they do, they are ready for harvest. Successive pickings give best results. Good crop of beans can yield 2-5 kg/10 m^2.

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f) Mustard Green (Sag):

Dzongkha name: Hoentshe

This is a very general group of often Brassica crops which are grown for their edible leaves. It is very good source of vitamins A and C and iron. Generally they will grow on any soil type but heavier soils with adequate organic matter and good drainage give best results. Example, clay loams with pH 6-6.8.

Figure 3.15 Mustard green

Broadly two varieties of sag such Mustard green varieties can be cultivated in altitude ranging from 1200 to 2600 masl. They mature in 50-60 days and yields 2500-3000 kg/acre and the Japanese green varieties can be cultivated in areas above 2600 masl. They mature in 40-50 days and yields 3000-4000 kg/acre.

Table 3.13 Some of the common verities of mustard green and cultivation seasons

Varieties	Planting time
1. Mustard green varieties • Phulmaya Tasai • Him Beauty (local) 2. Japanese green varieties • Tasai • Mibuna	1. Upper hills: March-May 2. Mid hills: September-January 3. Low hills: September-December There can be variations and growth can occur if moisture retention in the soil and nutrition is available.

There can be variations and growth can occur if moisture retention in the soil and nutrition is available.

i. Land preparation and plantation:

Mustard Green (Sag) variety can be either direct sown or transplanted but generally is direct sown and grown with little attention. There does not seem any great advantage of transplanting unless insufficient land is available at the time

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of sowing for direct sowing:

Make well prepared beds and use spacing as:

- R-R= 30-45 cm
- P-P = 5 cm
- Depth =1 cm
- Seed rate = 6-10 g/10 m^2.

If a nursery is used, raise a standard nursery with spacing of R-R= 10-15 cm; P-P = 3 cm; depth= 1 cm. Transplant when seedlings are 12-15 cm high (3-4 leaf).

ii. Harvest

Harvest: Crop matures at 45-60 days. Sequentially harvest by cutting off the leaves with a sharp knife. Good crop of sag can yield 15-40 kg/10 m^2.

g) Potato

Dzongkha name: Kewa

Potato is predominantly cultivated as a cash crop than as a staple food by the Bhutanese farmers. It is mostly eaten as vegetable. It is a versatile crop which fits very well in the various cropping systems and is cultivated up to 3000 masl.

Figure 3.16 Potato

Changing the crops every year will allow better utilisation of the different layers of soil as the roots of some crops are deep while of others are shallow. A good crop rotation particularly with legumes will help to maintain soil fertility in the long run.

Potato is propagated through the vegetative seed tuber. To be able to grow a potato crop with high yield and good tuber quality, the use of good seed is essential. The use of good seeds gives a good start to the crop.

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Table 3.14 Some of the common verities of potato and cultivation seasons

Varieties	Altitude	Planting time
Desiree	It is red skin variety which can be grown in areas between 1000-2000 masl, and it matures in 90 days.	March
Kufri Jyoti	A white skin variety that can be grown in areas below 2500 masl, matures in 100-120 days.	March
Yusikaap	It is a white skin variety, in areas below 2500 masl. It matures in 100-120 days.	March

i. Land preparation

Potato requires a deep, loose, friable and well-aerated soil. Ploughing and other operations should be done at optimal soil moisture condition. In slopping land where lighter soils (sandy soils) are present, it is undesirable to make the tilth too fine as heavy rain or storms may wash away large amount of soils.

ii. Manure and fertilisers

The good old practice of applying organic manure must be given due importance. Well decomposed FYM should be applied at the rate of 6-8 metric tons per acre.

iii. Plantation

Seed potatoes can be pre-sprouted by placing them in a warm place with indirect sunlight. They are planted directly following the directives provided below.

1) Seed rate: The recommended seed rate is 1000-1200 kg/ac. For early emergence and early tuber initiation, pre sprouted tubers should be planted.

2) Spacing: When the tuber size of 35-50 mm (35-60 grams) is planted the line-to-line distance should be 60 cm and the tuber-to-tuber distance should be 25 cm. After the land preparation is completed, shallow furrows are made at the recommended spacing and fertilisers are placed in the furrows and covered with a thin layer of soil. The seed potatoes are then planted on the furrows with the above spacing and the soil is ridged. The ridge height should be 5-10 cm or 2-4 inches above seed tuber.

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iv. Crop care and management

1) Weed Control: One to two hand weeding should be done at 2- 4 weeks after the emergence of potatoes shoots.

2) Earthing-up: The stem needs to be covered up with soil when it reaches half feet (15 cm) above the soil surface in order to enhance the productivity. Earthing-up improves soil aeration, reduces weed pressure and increase stem density. Normally hand weeding, earthing-up and top dressing of nitrogen can be combined. The remaining 20% nitrogen kept after basal application can be applied at the time of earthing-up.

3) Monitor to check early symptoms of pests and diseases.

4) Approximately after 90-120 days after sowing depending on the variety, tubers will mature and plants start to dry up.

v. Harvest and storage

1) As potato plants dry, harvest potatoes on sunny and dry weather.

2) Minimum damage both at harvesting and handling should be a prime objective of the farmer. This will ensure a better return to the farmer.

3) Harvested tubers should be spread and allowed to dry before packing. This will help in healing their wounds, hardening of skin and removal of adhered soil. This practice is termed as curing.

4) Best curing takes place at 15-18°C and 80-85% relative humidity.

5) Grading and storing should be carried out before the skin is hardened. After 20 days of curing in heaps, the tubers need to be graded properly according to market demand.

6) Only matured, graded tubers should be stored. Potatoes in general keep well at low temperature (2-3°C) and high humidity (80-90%) relative humidity. High altitude and cold climate allows suitable storage of potatoes. Normally potatoes are stored on the ground floors or on the top floor of the houses.

7) Potatoes should be sold when the market price is good.

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Student Activity

The AgFS teacher must ensure that appropriate seasons for growing vegetables are carefully planned. Students need to learn the art of growing vegetables – procedures correctly, however, students are able to cultivate vegetables will motivate and encourage them. Students need to understand the conditions under which vegetables are grown. Therefore, explain if you are trying to grow certain vegetables that are not appropriate to the school located. Field trips may be arranged for the students to nearby farm or ARDCs of the MoAF with proper planning and prior information to the agency or farm /ARDC.

Practical Activity 1- Growing of vegetables in school

1. Discuss with the school head on the AgFSC practical work and identify site suitable for gardening.
2. Divide the students into seven groups depending on the vegetable of their interests.
3. Instruct each group to grow different vegetables discussed in this chapter as per the cultivation guidelines.
4. Maintain records of hours spent on work, record types of work involved, observe development stages and care required till harvest and provide opportunity to share after certain interval, so that all will learn to grow different vegetables.
5. Record quantity and quality of produce.
6. Prepare and present their reports at the end of the season.
7. Assess the student's practical work using the assessment tools.

Practical Activity 2– Field trips to learn growing of vegetables from other growers

1. Plan field trips on the academic calendar at the planning period and seek permission from the school authority .
2. Write to the agency /inform the farm of intended visit with clear objectives.
3. Prepare field trip plans as per the guide provided in the curriculum guide.
4. Arranged filed trips objectively, assign task of write up on the project.
5. Assess the project (field trip write up) as per the guide.

4 Growing of Fruits I

CHAPTER

Fruits are important in everyday life, as fruits are rich in carbohydrates, vitamins and minerals. For a balanced and healthy diet, it is recommended that there should be at least 85 gm fruits per day in our diet in addition to vegetables, pulses, milk, meat, and egg. Fruit growing is one of the most important and profitable branches of horticulture. Fruit is often used in ceremonial and religious occasions, indicating their significance in our rituals, traditions and religion. Cultivation of fruits does not demand the best available land. Fruit trees can be grown in sloppy area thus preventing soil erosion and land degradation. Some fruit trees such as Indian gooseberry, guava, jamun can be grown in poor and shallow undulated soils which is considered unsuitable for growing cereals. Fruits are a good source of foreign exchange when exported out of the country. Both fresh fruits and fruit products are imported. Cultivation of fruits also generates employment as it is highly labour-intensive and skill demanding.

This chapter provides basic information on different types of fruits and their importance. Fruits included in the chapter are apple, peach, apricot, plum and walnut. A complete package of practices is given focusing on growing conditions, care and harvest of the fruit which have high commercial values in the domestic as well as international markets. The varying Agro-Ecological-Zones of Bhutan expands the scope of growing varieties of fruits in different seasons at different parts of the country. This provides immense scope for entrepreneurship development by the Bhutanese youth in gaining meaningful employment while reducing dependency on import.

4.1 Pome fruits: Apple

Dzongkha name: Appa-le

Apple belongs to family Rosaceae and is the premier table fruit of the world. The cultivated apple is reported to have originated in the temperate region of Western

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Asia between Black Sea and Caspian Sea and Himalayan region of India and Pakistan. Apple was introduced in Bhutan in the early 1960's and at present it occupies a major area among other temperate fruit crops. It is now being produced successfully and it is one of the most important cash crops.

Figure 4.1 Apples

Apple is a rich source of carbohydrates, proteins, and minerals like calcium, phosphorus, iron, potassium, and vitamins like thiamine (B1 and B6.). The major acids in apple are maleic and citric. Apple is believed to reduce the incidence of dental caries, helps to control obesity and supply extra energy for heavy exercise. Apple is chiefly used as table fruit. The various products like jam, jelly, preserves, slices, apple chips, apple rings, juice, wine, concentrated juice, cider and powder are prepared from apple.

a) Varieties of apple

There are many varieties of apple such as Red delicious, Golden delicious, Lobo, Red Chief, Red Gold, Jonathan, Jonagold, Granny Smith, McIntosh, etc. However, red delicious and golden delicious are common in Bhutan. Lobo is recently introduced for high altitudes.

i. Red delicious

It is a widely cultivated cultivar in the world. The fruits are large, oblong and conical shape.. Skin is smooth, covered with red streaks on a pale background. It ripens by end of August.

ii. Golden delicious

Trees are moderately vigorous. Fruit is medium to large, oblong, skin golden yellow with prominent small dots scattered all over. It is a good polliniser for the entire delicious group. Ripening time is second week of September.

iii. Lobo

It is suitable for high altitude. It is medium to large size. Lobo is deep red round-conical in shape.. It ripens by the last week of September.

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iv. Anna

It is also known as Bajo apple as it was released from Bajo Agriculture research Centre. It is a variety recommended for cultivation in subtropical regions. Its fruits quality is oblongated greenish shape resembling very similar look to the Red delicious apple variety. It is semi-vigorous, large oblong fruits, and harvest time is early to end of July under Bajo conditions. It has sweet and sour taste

b) Conditions for growth

Climate: Apple has diverse climatic adaptation. It is the most widely planted fruit of the temperate zone. Most of the apple varieties require 1000 chilling hours below 7°C to break the rest period but some cultivars requires lower chilling requirement of 250 hours. These conditions are available at an altitude ranging from 1500-2700m above sea level. The average temperature should be around 21-24°C during the active growing season. For optimum growth and fruitfulness, apple trees require 300mm of rainfall equally distributed over the growing season.

Soil: The ideal *soil texture* for apple is a loam but a range of texture from loamy sand to a silt loam will produce good crops provided the subsoil is well drained. The soil should be fertile with pH of 6 - 6.5.

c) Procedures and management

i. Nursery

Apple is vegetatively propagated mostly through grafting and budding techniques. Whip and tongue grafting, side grafting and budding are common. Saplings rootstock of crab apple is used extensively for grafting. In sexual propagation the seeds are stratified in sand at a temperature of 4-10°C prior to sowing. After this cold moist stratification, seeds are sown in the nursery bed and are ready for grafting by next season. Clonal rootstocks are multiplied by stooling, trench layering, cuttings, and by micro-propagation.

ii. Rootstock production by stooling

Apple rootstocks are commonly propagated by this technique (Figure 4.1). The stools are allowed to remain uncovered during the early part of the growing season, so as not to inhibit their growth. When the growth has reached to 20 cm or more they are mounded in the early spring and they are allowed to grow rest of the

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growing season and root formation takes place on the new shoot in the covered portion of the stem. In the early winter the rooted shoots are removed and grafted and the cycle repeated.

Steps:

1. In February or March, plant the rootstock in the ground.
2. The plant should be relatively large and vigorous by Oct-Nov.
3. A year after planting, cut the plant to near ground level.
4. A cluster of small shoots should form in the spring. When the shoots reach a height of about 6 inches, probably during July, earth them up with fine soil or compost, pressing it down firmly to a depth of about three inches.
5. Continue to earth up the plants for the rest of the season, but do not swamp the shoots, and don't earth up to more than about 6 inches in total.

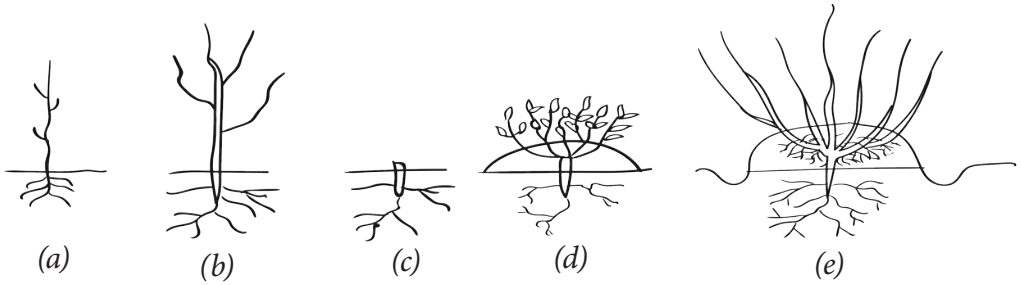

Figure 4.2 Stooling in Apple

Apple rootstocks used are: MM106 – semi-dwarf rootstock is commercially used, MM9 – dwarf, has numerous thick, fleshy brittle roots and requires a fertile soil; trees require staking. It is resistant to collar rot but susceptible to mildew, crown gall, fire blight, and woolly aphid. MM111- It is vigorous and is smaller than trees on seedling roots. It is susceptible to mildew but not to collar rot or woolly aphid.

iii. Orchard layout plan

In hilly terrain, terracing of land is important. Planting should be done in the contour system in terraces. The saplings are planted in the middle of the terraces. In flat areas square, rectangular or hexagonal system can be followed.

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iv. Spacing

Depending upon type of cultivars and rootstock, spacing may be:

- Vigorous: 6 x 6 m,
- Semi dwarf: 4.5 x 4.5m and
- Dwarf: 3 x 3 m

v. Pit digging

For good plant establishment and development dig a pit of 1m deep and 1m diameter if the soil type is stony or clay types, otherwise pit size of 0.5 m x 0.5 m is good enough. While digging the pits ensure the topsoil from the upper one-foot is heaped separately. Digging of pits should be completed before November. Mix $\frac{1}{2}$ kg bone meal, 20 kg FYM with the topsoil to fill the pits.

vi. Planting

- Planting is done from January to mid-March and planting should be 2-5cm deeper than what it was in the nursery to reduce or eliminate cold injury to roots and improve the poor anchorage of dwarfing rootstocks.
- The grafted joints should be kept at least 10-12cm above the soil.
- Staking and tying the plants with rope is essential.
- Roots should be placed in their normal position during planting.
- Prune and treat for fungicide solution for damage roots.
- Irrigate immediately after planting.
- Mulching will help retention of moisture and control of weed growth.

vii. Manures and fertilisers

Periodical assessment of growth and fruiting characteristics must be combined with leaf and soil analysis for formulation of an economic fertilisation programme for apple orchard. It should be noted that leaf and soil analysis is necessary before using fertilisers. The fertiliser recommendation is given in Table 4.1.

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Table 4.1 Fertiliser requirement for apple of different ages

Age of tree (years)	FYM/ compost (kg/Tree)	Calcium Ammonium Nitrate (CAN) (gram/Tree)	Single Super Phosphate (gram/Tree)	Muriate of Potash (MOP) (gram/Tree)
1-3	5 - 15	100- 300	40-120	25-75
4-6	20 - 30	500-1000	240-500	150-300
7-9	35 - 45	1200-1400	700-900	500-700
10 above	45 - 60	1600	1100	900

Use $\frac{1}{2}$ dose of CAN in March, and the remaining half in June. During December and January use full dose of SSP and MOP under canopy of the tree followed with light irrigation to stimulate uptake of nutrients.

d) Pruning of trees

Correct pruning and training make a major contribution to producing quality fruit. The main objectives of pruning and training apple trees are to:

1. promote regular cropping and discourage biennial bearing habits.
2. maintain fruit size colour and quality.
3. maintain the tree at convenient size and shape.
4. maintain the tree in a healthy condition.
5. develop strong tree structure.

The best time to prune is during late winter or early spring just before the beginning of active growth. The main reasons you should prune during the late dormant period are:

- wounds heal quickly when growth starts.
- undesirable branches and other wood to be pruned can be easily seen since there are no leaves on the tree.
- the bark is less likely to tear when cuts are made.
- trees pruned in early winter may be damaged by low winter temperatures that occur after pruning.

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i. Principles of Pruning

- Hard pruning promotes excessive shoot vigour and reduces total growth and cropping on the tree but light pruning gives moderate shoot vigour and high fruitfulness.
- Horizontal shoots produce less vigorous growth and are more inclined to fruitfulness than upright shoots.
- Pruning dwarf trees.
- Pruning the young tree delays fruit bearing.
- Pruning depends on growth habit of the cultivar (e.g. Golden Delicious requires less pruning whereas Red Delicious needs heavier pruning).

ii. Main techniques of pruning

- *Heading Back*: The removal of the end portion of shoot to encourage new growth.
- *Thinning Out*: The removal of inside shoots for more air and light penetration.
- *Notching*: To promote the growth of a bud into a shoot, a slice of bark is removed from above the bud.

e) Training of trees

There are many systems of training apples such as open centre, centre leader, modified leader, espalier, etc. but the most common ones are centre leader and open centre system.

i. Centre Leader

This system has a central trunk from which the scaffold branches develop. The scaffold branches should form wide angles (crotch angle) with the trunk. About 60 to 80 degrees is best. It should be distributed on different sides of the tree for good balance and it should also be spaced about 6 to 10 inches apart on the trunk with no branch directly opposite or below another.

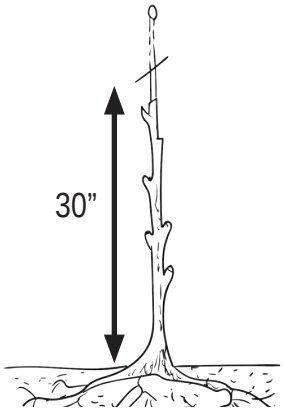

Figure 4.3 Centre leader

Dormant pruning, second year

- Select a shoot to continue as the leader. Select two or three more shoots growing from the leader for more scaffold branches. Compare the length on them with the leader and prune them 6 to 12 inches shorter than the leader.

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- Scaffold branches developed in previous seasons will have formed secondary shoots. On each scaffold, save two to four of these new shoots that are growing 6 inches or more away from the leader. Remove shoots that are growing upright or below the main scaffold. Be careful not to remove the spurs.
- Prune the scaffolds of the tree so they are in balance. Do not let lower branches outgrow the upper portions of the tree, nor the upper branches grow longer and "shade out" the lower ones.

Succeeding years

- Maintain framework of tree to keep it in balance to ensure good light penetration into all parts of the tree.
- Tree shape should be primarily cone-shaped such as a Christmas tree – narrow at the top and wide at the bottom.
- Maintaining fruiting wood and spurs should be the foremost priority.
- Continue to thin out undesirable growth and any growth that is competing with the leader. Also, continue selective heading back cuts on the leader and vigorous scaffold limbs.

ii. Open centre

Open centre training has been described as an inverted umbrella without the handle. This type of system has two to five well-spaced scaffold limbs.

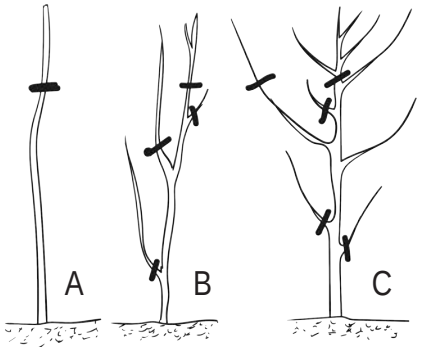

Figure 4.4 Open centre

Year of planting

Unless all desired scaffolds are present at planting (C), cut back all limbs almost to the trunk (B). Select the desired scaffolds the first summer and prune back all unwanted new shoots after they have reached 6 to 8 inches in length. (A) Newly planted tree; (B) Cut off 'whips' or side shoots to 1" (C) Maintain the well-spaced scaffolds.

Dormant pruning, third year and beyond

- The final desired height for a tree is usually the height at which fruit can be picked from the ground without a stepladder.
- When pruning along the scaffolds and sub-scaffolds of mature trees, remove a considerable portion of the shoots produced the past season. However, these

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shoots represent the fruiting wood for the current year, so do not remove all of the shoots. Retain shoots that are 12 to 18 inches long and evenly spaced throughout the scaffolds and sub-scaffolds.

Pruning a bearing tree

- Observations during the previous growing season should indicate where changes in the pruning programme are required.
- Older branches of many cultivars tend to become droopy and shade to the lower parts.
- The balance between vegetative and fruiting growth is influenced by the crop load, fertiliser and pruning.
- Pruning should be done on regular basis and consist of moderate cuts made throughout the tree to distribute vigour and provide good light penetration

f) Pollination

The most of commercial apple cultivars are self in-compatible although there are very few cultivars which are partially self-fruitful. Therefore 15% of the trees in an orchard should be polliniser trees such as Golden Delicious. Polliniser trees should not be more than two rows from the cultivar to be insect pollinated. Pollination is mainly by insect as the pollen is heavy. Keeping honey bees in the orchard during pollination is practiced in many parts of the world. Pollination by wind is negligible.

g) Fruit thinning

Thinning is one of the major techniques employed to regulate fruit quality which tends to deteriorate with too many fruits on the shoots and sometimes induced alternate bearing.

h) Harvesting and yield

A combination of maturity indices such as fruit colour, firmness and starch test is conducted to optimise the date of harvest. In case of red colour delicious varieties, the ground colour, which is green, should start turning yellow and should have yellowish tinge. The fruit should attain red colour. In case of Golden Delicious, paling of green is associated with the best stage of maturity for picking. Fruits should be picked during cool period of the day to minimise respiration and mentain fruit quality,

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i) Postharvest handling operations

Grading involves sorting of the fruits based on quality criteria such as colour and defects such as cuts, bruises, scars, and cleanliness of the fruits. Grading is followed as per the guidelines of Bhutan Agriculture and Food Regulatory Authority. There are two export grades Grade 1 and Grade 2. Apples from both these grades are exported to Bangladesh and India. Rest are either consumed or processed into various value addition products such as jams, juice, pulps and RTS (Ready to serve).

4.2 Stone fruits: Peach

Dzongkha name: Kham

Figure 4.5 Peaches

Peach belongs to the family Rosaceae and has origins in Persia and China. It is mainly taken as table fruit. Some of the stone free varieties are suitable for canning. Cultivation of peach in large scale is impeded due to its perishable nature. It is a good source of iron and phosphorus. It is mostly grown at the household level. No large scale production is being practiced in Bhutan though it is picking up gradually.

a) Varieties of peach

Local: Baekham and lhosukham

- *Flordasun* and *July Elberta* were released in 2004 as Bajokham-1 and Bajokham-2 respectively for general cultivation in mid altitude conditions (1300-2000masl).
- *Bajokham-1*: Semi-vigorous and spreading, early maturing harvest time is 1st week of May, fruits are round with red blush
- *Bajokham-2*: Semi-vigor plants, late flowering, and late maturing cultivar, fruits are round with pointed tips and heavy pubescence. Fruits are matured in the month of July.

b) Conditions for growth

Climate: Peach requires the warmest climate among all the temperate fruits. Though peach is a temperate fruit there are varieties which do well in sub-tropical

climate too. Peach prefers dry weather at blossom and is very sensitive to low temperature injury and swelling buds are injured below 7°C.

Soil: Peach do well in wide range of soil. Deep, well-drained light texture soil providing adequate moisture is good. pH of 6.0-6.5 is preferred.

c) Procedures

i. Nursery

Local peach saplings are usually used as rootstocks for vegetative propagation. It requires three months of chilling treatment at 4°C prior to sowing in the nursery bed to break dormancy for better germination. Then the superior scion wood of known cultivar is grafted or budded on the rootstock.

ii. Orchard layout plan

Square, rectangular, hexagonal or contour depending upon topography of the site. *Planting* is done at a spacing of 4.5 m x 4.5 m, in the pit dug of size 1 mx1 m and filled with top soil and FYM at least one month before planting. Planting is usually done in *dormant season* (December-February). The graft union should be 25 cm above the soil level to avoid collar rot.

iii. Manures and fertilizers

Table 4.2 The recommended manures and fertilisers

Age of tree (year)	FYM (kg)	N (g)	P2O5 (g)	K2O (g)
1	10	50	25	50
2	15	100	50	100
3	20	150	75	150
4	25	200	100	200
5	30	250	125	250
6	35	300	150	300
7	40	350	175	350
8	45	400	200	400
9	50	450	225	450
10 & above	50	500	250	500

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d) Training and pruning

Trees are natural bushy and adapted to open centre. Peach bears fruits on the previous year's growth; both on laterals and on short spurs. It is important to note that both laterals and spurs are only good for one season. To renew the fruiting wood, the tree must be kept in good vigour. Regular cutting of old wood will encourage fresh laterals to develop. Pruning procedures are similar to apple for open centre system.

e) Fruit thinning

Fruits are thinned to produce marketable sized fruits and to prevent breakage of overloaded branches. It also promotes early ripening and sustains winter hardiness and stimulates flower initiation for next season's crop. Thinning should be done within 40 days after full bloom.

f) Harvesting and Yield

Peach starts bearing fruits at the age of 3-4 years after planting and reaches full production by 6-8 years. The productive life of a peach tree ranges from 20-30 years. A tree at full production age produces about 40-70 kg of fruits per season. The main maturity index is the change in skin ground colour from green to yellow in most cultivars. Harvest during the cooler part of the day. Harvest peach when it is fully coloured and matured and it also depends on distance from market. The fruits must also be firm enough to stand handling for market.

g) Postharvest handling and storage

Peach is very perishable in nature therefore handling should be done carefully. Proper sorting and grading is necessary. At -0.5°C it can be stored for 2-6 weeks depending upon variety.

4.3 Apricot

Dzongkha name: Khamchung

Figure 4.6 Apricots

Apricot is native to China and Siberia. In Bhutan apricot cultivation is limited to backyard gardens since time immemorial. The oldest apricot trees could be found in places like the backyards of few Dzongs. Apricot is mainly eaten as table fruit. It is rich in Vitamin C. It also contains carbohydrates, proteins, iron, calcium, niacin and phosphorus. Fruits are canned, frozen, dried and processed into jam, nectar, etc.

a) Varieties of apricot

Varieties: New Castle variety was released in 2003 by RNRRC-Bajo as Bajokhamchu-1. It is a low chill and early maturing cultivar, ripening in the mid May under Bajo condition, the exact period depends upon the altitudes, the fruits are round, medium-sized and barium yellow in colour, flesh is very sweet and juicy, its cultivation is recommended in mid hills (altitudes range: 1200 -2000 masl).

b) Conditions for growth

Climate: Apricot can be grown from 1200-2000 masl. It prefers cool winters and warm spring for fruiting. It is susceptible to frost due to early flowering. The minimum temperature of 7°C during the peak flowering and 15-19°C during fruit ripening is required.

Soil: Apricot needs well-drained loam, rich in humus. Prefer good deep soils of at least 2 m deep without rocks or hardpan. Avoid heavy wet areas. pH of the soil for apricot should be near about neutral. Acids soils should be corrected by adding lime to bring pH to 7.

c) Procedures

i. Nursery

Apricot is propagated through seeds and vegetative propagation is more popular.

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Apricot, plum and peach saplings are used as rootstock. Tongue and side grafting methods are successful.

ii. Orchard layout plan

Square or contour layout plan is practiced depending on the slope of the area with pit size of 1mx1m should be dug and filled with topsoil, farm yard manures about a month before planting. Maintain spacing at a distance of 5 x 5 m between plants. Planting of apricot in early dormant planting (December-February) is done to allow the plants to establish well before the onset of flowering. The graft union should be 25 cm above the ground level to avoid collar rot.

c) Training and pruning

Trees adapt well to vase or open centre training. Fruit set in apricot is rather heavy, and can result in under-sized fruits. It can also increase the tendency of biennial bearing. Fruit thinning prevents branch break due to heavy crop load and maintains the tree vigour. Thinning should be done within 40 days after full bloom.

d) Harvesting and Yield

The apricot plant starts bearing at the age of 3-4 years and attains full bearing at about 8-10 years. The productive life of an apricot tree is about 30-40 years. Fruits are picked when they change colour from green to yellow and lose flesh firmness. Fruits are picked more than one picking as and when they mature. On an average an apricot tree yields 30-70 kg.

e) Postharvest handling and storage

In Bhutan fruits are consumed fresh and it cannot be stored for long due to its perishable nature. Therefore it is suitable for canning or can be dried for preservation. Since canning needs special equipment, for Bhutanese farmers drying would be more appropriate. At temperature of -0.5°C fresh apricot can be stored for two weeks.

4.4 Plum

Dzongkha name– Chu-li

Figure 4.7 Plums

Plum is from Rosaeceae family and European type (PrunusdomesticaL.) is native to North America while the Japanese type (Prunussalicina L.) is native to Japan. Wild species are found growing in the Himalayas. Plum is grown mainly for self-consumption and small quantities are sold in market. Large scale commercial production has not picked up mainly because of the perishable nature of the crop. It is a good source of vitamin C, calcium and iron. It is also processed into jams, juice, purees and as dried products.

a) Varieties of apricot

Santa Rosa, a medium size, red skin, matures by May to June and Alfred, as mall, red fleshed, matures by June, are two varieties grown in Bhutan.

b) Conditions for growth

*Climate:*The domestica species is cold resistant suitable for higher elevations while the salicina species require less winter chilling of 700-1000 hours below 7.2°C. They are more suited for lower altitudes ranging from 650m to 1650 masl. They are damaged by frosts at -4°C to -5°C during bud swell, -2°C to -3°C during blossom and at -1°C at small fruit stage. In general plums require cool winter and warm summers for successful cultivation. Plum is moderately tolerant to drought but require adequate moisture especially during the final growth stage.

Soil: Well-drained, clayey loam type with good subsoil in the rooting zone works better for plum. European type can tolerate heavier clay soils and also tolerance to wet soil is moderate to good.

c) Procedures

i. Nursery

Normally the seed of Myrobalan are used for getting a seedling rootstock and it

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is almost compatible with any variety. The plum is usually propagated through chip budding or whip grafting.

ii. Orchard layout plan

Square and rectangular system is easy to layout while hexagonal system accommodates 15% more trees per acre. However, these are suitable only for flat areas. On the sloppy area, contour system is most appropriate, with spacing distance of 6m x 6m between plants may be planted. The distance between plants is regulated by the fertility of the soil and rootstocks used. *Pits size* of *1 m x 1 m* are dug and filled with FYM, one month before planting to allow sufficient time for soil to settle. Plum saplings are planted from December to February when the plants are dormant.

d) Care and management

i. Training and pruning:

The procedures are same procedure as apricot.

ii. Thinning of fruits

Fruits should be thinned just after the natural fruit drop. Hand thinned to a spacing of about 5-8 cm. Japanese varieties being heavy bearers need more thinning. Thinning reduces the chances of branch breakage, increases uniformity in size and colour of the fruits besides ensuring regular cropping. If the fruits are close enough the spread of brown rot disease is encouraged in humid regions.

iii. Manures and fertilisers

Since not much experience is there for commercial plum orchard management, correct dose of fertiliser requirement is not available but the following information should help. Newly planted plum trees may be given 450 grams of CAN, 190 grams of SSP and 150 grams of MoP besides 10 kg of compost. The fertilizer dose is stabilised at the age of six years.

iv. Weed control

Eliminating weed competition around young trees is critical for survival and rapid growth. Heavy weed competition results in severe nitrogen deficiency resulting in poor or no growth.

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v. Irrigation

Irrigate to keep the soil moist and especially during the initial growth irrigation is critical. In intense summer heat provide a deep soaking irrigation at least weekly. Avoid over watering especially in clayey soils as plum is susceptible to water logging.

e) Harvesting and Yield

Plum starts yielding fruits 2-3 years after planting. Immature stage harvesting will cause poor fruit quality and very late harvesting will result in poor quality, fruits, so harvesting at optimum maturity normally from August to October. A full-grown tree gives about 30-50 kg fruits/tree.

f) Postharvest handling and storage

It is highly perishable fruit and mostly sold as fresh fruits. Canning is done for long-term preservation. At temperature of -0.5°C it can be stored for 2-7 weeks depending upon variety.

4.5 Walnut

Dzongkha name –Taago

Figure 4.8 Walnut

The Persian walnut also referred to as the English walnut (*Juglansregia*) belongs to Juglandaceae family and the growing areas extends from the Carpathian mountain of Poland through the mountain chains of Central Asia, Afghanistan and Northern Pakistan, Tibet and Southern China to eastern Himalayas. Bhutan falls within this zone, and currently walnut is widely grown in Bhutan, both as native forest trees, and as introductions in the past from Tibet and Kashmir. Nut crops offer opportunities for the more remote areas, in that they are not so perishable, are relatively resistant to transport damage, are relatively high value and low weight commodities.

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a) Varieties of walnut

While walnut with hard shell grow wild in the forest abundantly in many part of Bhutan, the exotic germplasm of walnut has been introduced in the past along the trade routes into Bhutan, mostly consisting of seeds from parent trees either from Tibet or Kashmir. These of course have not come true to type but several superior selections have already been identified. The newly released cultivars for general cultivation in Bhutan by the Ministry of agriculture are:

- *Kanthel Selection*: Big nuts, long trapezoid shape, thin shelled, harvesting towards end of September under Yusipang condition.
- *Yusipang 2*: Big and long ovate nuts, thin shelled, harvesting towards end of September under Yusipang condition.

b) Conditions for growth

Climate: The walnut is well adapted to the higher altitude valleys of Bhutan (1300 to 2700 masl) but walnut is not doing well beyond 2500 masl. Presently, walnut is produced mostly for subsistence; any surplus is sold in the domestic markets. In general walnut is adapted to cold temperate zone, requiring cool period in autumn to promote leaf fall and induction of dormancy. Winter chilling is very important. If insufficient chilling occurs, it results in seriously delayed bud break, poor crop, and die-back of branches. The other problem with walnut is its sensitivity to high summer temperatures. Temperature in excess of 38°C results in sun scorch of hull and shrivelled kernels, with severe damage occurring at temperature over 40°C. Walnut requires approximately 800 mm rainfall or irrigation equivalent.

Soil: A good orchard soil should have proper water drainage permitting good aeration and extensive root development. For optimum performance walnut requires slightly acidic soils between 5.5 and 6.5. Walnut grows best on soils where roots can develop to a depth of 3-4 m.

c) Procedures

i. Nursery

Propagation is normally grafted and occasionally patch budded. *Juglansregia* saplings are the most commonly used as rootstocks for propagation in the world. This is vigorous and trees on this rootstocks fruits after 6-8 years after planting.

ii. Orchard layout plan

Though it is convenient to layout the orchard in square or rectangular design, for hilly situation contour planting is recommended with spacing of the plants depending on the tree type and vigour. As a general guide these spacings are recommended: 15 m x 15 m for seedling trees, 12 m x 12 m for those grafted on *Juglansregia* rootstocks and 9 m x 9 m for seedlings grafted on *Juglansnigra* rootstocks.

iii. Pit digging

On clayey or not very fertile soil, dig a pit of 1m deep and 1m diameter. But for a loamy soil 0.3 m deep and 0.3 m diameter is good enough. Fill the pits with mixture of well decomposed FYM and top soil at the ratio of 1:2 during November.

iv. Planting

Planting should be done in the late dormant/early spring season. Prepare a hole just enough to accommodate the entire root system. Spread roots around in all sides and cover with soil. Irrigate immediately after planting. Graft union must be 40 to 50 cm above the soil zone.

d) Care and management

The amount manure and fertiliser application depends on age of the tree and soil fertility and type. Appropriate amount of NPK for the walnut is recommended on Table 4.3.

Table 4.3 Fertiliser dose required for walnut as per age

Year	N Dose (g/tree)	Location: circle around the tree (m)
1	100	1.0
2	200	1.5
3	300	2.0
4	400	2.5
5-7	500	3
7-9	600	3.5
10-full production	900	-

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In the first few years, it is usually sufficient to give small amounts of K and P. From fifth year up to full production, a quantity of 60 – 100 kg/ha of K and 40 – 80 kg/ha of P is recommended.

Walnut is trained as central leader or modified central leader system. The pruning operations are carried out in the dormant season but early spring is preferable. Further delay causes excess bleeding. All the cut surfaces should be treated with a tree wound dressing.

It is usually adopted to convert wild large saplings into production of commercial plants or inferior cultivars to improved ones or to provide pollinisers. A large number of the wild saplings walnut trees (*J.regia*) found in the farmers' fields can be top-worked with improved cultivars. The local hard-shelled walnut (*J. regia*) saplings that grow faster than the soft-shell walnut can be transplanted and topworked when they are 3-5 years old.

i. Bark grafting

It is found to be the best for top working in late spring (end of March to April) or when new growth has taken place. The dormant scion wood should be cut from the parent tree quite in advance and stored in the refrigerator after proper packing. Disease free young trees should be selected for top working. Sap bleeding is a problem in walnut top working especially when it is done in early spring. This can be avoided by heading back the stock two weeks before the actual operation. After grafting, the open wounds must be covered by the grafting wax and, if required, re-waxing may be done. The thick plastic wrapping encourages callus formation and hastened the tissue union.

ii. Weed control

Weed as and when required. Mulch helps control weeds and retains moisture in the soil reducing water stress during dry period. Intercropping during the first few years after planting would generate a valuable income for farmers. Intercropping could be done with fodder crops or vegetables or legume crops.

e) Harvesting and Yield

Full commercial bearing commences after 18-20 years in seedling trees and after 8-10 years in grafted trees. Harvesting time is from August-October. The nuts fall on the ground as they mature. Harvesting is done 2-3 times at few days interval.

Yield varies according to the age, size and variety of trees. A fully grown, big size tree may bear 150-175 kg nuts but an average yield is around 40 kg.

f) Postharvest handling and storage

The nuts are collected from the ground, cleaned, washed and dried by spreading them on a sheet or floor. Delay in drying causes rapid loss in quality and makes it susceptible to mould. Walnuts are dried to remove excess moisture from the shell and kernel. The nuts are dried up to 8% moisture level. Walnuts are stored in gunny bags in small well-ventilated rooms free from excessive humidity.

4.6 Strawberry

Dzongkha name–Pangotshelo

Figure 4.9 Strawberry

Strawberry belongs to Rosaceae family. The Romans were believed to have cultivated strawberries before the Christian era (B.C.). In Bhutan it is grown by few farmers at commercial scale and is sold to processing industries. It can be grown in kitchen garden for home consumption. Although there is a tremendous scope for cultivation of strawberries, its perishable nature deters the farmers in venturing into large scale production. It is most often eaten fresh or used as garnishing the desserts. Strawberries can also be dried and added to breakfast cereals and sweets. Strawberries are also used as flavouring for dairy products such as ice cream and yogurt and processed products such as jams and used as a natural acid base indicator.

a) Varieties of walnut

Varieties: There are so many varieties developed all over the world. In Bhutan Chandler is grown. It is a vigorous, high-yielding, and June-bearing.

b) Conditions for growth

Climate: Grown under a wide range of temperature conditions throughout the world but needs a period of colder conditions to break dormancy. High temperature of 30°C may cause fruit damage. Selections of varieties to suit temperatures and

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day lengths are important. Strawberries will withstand low temperatures of –15°C to –20°C while dormant. Flowers and young fruit are damaged at –1°C to –3°C. Strawberries are often grown under plastic tunnels to counteract low spring temperatures. Nevertheless, most are grown without frost protection. Strawberries are highly susceptible to Botrytis under humid conditions.

Soils: Strawberries cannot tolerate poor drainage. They are particularly subject to the disease red core (*Phytophthorafragariae*) in water logged conditions. Therefore, avoid heavy poorly drained soils, and light stony soils. Pulverised loamy soil with good water holding capacity is preferable for its good growth.

c) Procedures

i. Nursery

One-year old runners are used for propagation by separating adventitiously rooted runners from parent plant. The parent plants should be free from viruses. Meristem propagation is being increasingly used for rapid increase of new cultivars.

ii. Spacing

30 cm plant to plant and 60 cm row to row but depends upon varieties. More leafy varieties are spaced widely.

iii. Planting and mulching

Planting should be done in well prepared raised beds during March to April at higher altitudes in Bhutan, and September to October in the lower plains. Late plantings do not do well since the plants do not establish well. Early autumn plantings produce more crowns and heavier crop in the first season than when planting is delayed until winter or spring. Mulch with straw or pine needles so that the weed is controlled, soil moisture is maintained and more importantly to avoid contact of berries with soil. About 7 tons of straw per acre will be sufficient for mulching. If polyethylene mulch is to be used, laying down polythene should be done when the soil is moist. Soil must be in good tilth, moist and free from lumps. Poorly prepared or cloddy soil will rip polythene, reducing its effectiveness and provide an unfavourable environment for strawberry.

d) Care and management

Runners are removed so that the available nutrients are utilised by the mother plants.

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i. De-blossoming and removal of trusses

Flowering can start soon after growth begins. To encourage plant growth, the first flowers and flower buds that emerge in the spring can be removed by de-blossoming. The small weak first truss is often removed. Energy is directed first into foliage growth and root system development to support later flowering and fruiting. The need for de-blossoming tends to be variety specific. De-blossoming is not usually necessary in areas where the early flowers have been frosted.

ii. Irrigation

The polythene mulch helps conserve water, but strawberries require irrigation during dry conditions to maintain fruiting over an extended period. Irrigation is essential to encourage plant establishment and to maximise growth and cropping, particularly on annual strawberry plantings. Irrigation can be done by using an overhead sprinkler system. Irrigation systems placed under the polythene mulch can also be used successfully and make better use of limited water supplies. In Bhutan hand watering may be required on small areas under polythene.

iii. Manures and fertilisers

Apply 40 kg nitrogen per acre in two split doses. First top dressing after establishment of crop and next half before blossoming should be applied.

e) Harvesting and Yield

Depending on climate, strawberries can be harvested after 3-6 months after planting. A yield of 3-6 MT can be harvested under normal crop management practices. In cooler climates, higher production occurs in second year only. They remain productive for 3-4 years. Harvest when 50% of the fruit surface has retained red colour. Harvest manually along with the calyx and cool immediately to prevent deterioration. Successive harvest should be done daily in warm weather and 2-3 times a week under cold conditions.

f) Postharvest handling and storage

Care and gentle handling are essential during harvesting and handling. Cool fruit as soon as possible. The cool store temperature should be between 2-5°C and the humidity at 85-90%. Strawberries can be held for a maximum 7-10 days at 0°C.

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Student Activity

Some schools may have favourable AEZ to grow fruits and many schools may not be able to grow fruits discussed in this chapter. However, students can still learn growing of fruits from others who are able to grow. This requires the AgFS teachers to plan for field to the places where these fruits are grown. All the concepts of growing and caring of fruits can be learned from observations and experiences of others. For the school that are able to grow fruits trees have better opportunities to learn the joy of growing fruits trees. Therefore, different activities are designed, discuss with the students and carry out practical activity in schools that is most appropriate.

Activity I – Growing of fruit trees

1. Plan the practical work of growing fruits in the campus,
2. Write down the objectives of practical work.
3. Visit school campus for the selection of most appropriate site for growing fruits taking cues from the chapter.
4. Group students in 5 and ask them to prepare detail plans of where, what, why and how school should grow fruits and vegetables in their compound.
5. Each group prepare a presentation on growing of fruits. Presentation can be done using charts.
6. Invite the Principal and other management team to the class to hear the students' presentation of the project of growing fruits.
7. Present to the school principal and others seeking suggestions for improvement of the project and approval to start the practical project of growing fruits.
8. Start practical work – prepare land and lay out plan as per the guide.
9. Record input of care required, development of plants, write report and assess the practical work of the students

Activity 2 – Learning to grow fruit trees from other growers

1. Plan field trips
2. Divide the class into six groups
3. Assign fruits to each group and design observation checklist and questions through students can learn concepts of growing fruits, care and management.
4. Carry out field trip as per the procedures of trips provided in the curriculum guidelines on the implementation of AgFSC.
5. Assess the report of the field trips following the assessment of field trip reports.

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5 Starting a Poultry Farm

CHAPTER

The traditional Bhutanese integrated farming consist of poultry, pig, cattle and crops that played significant roles in increasing food production for family consumption, household income to meet domestic needs, and partake in the religious offering and other feastivals in the community. The egg and meat production from rural native poultry is low but production can be maximised through genetic improvement and proper management. In the recent years poultry has been proven to be very profitable, and is providing ample income generating opportunities to rural dwellers. Socio-economic development of the country.

This chapter provides basic ideas of how to start a poultry farm, care for the birds and do well in business of poultry. It is hoped that more literate youth will take interests in poultry farming as a business and contribute to the nation's self-reliance on livestock products and contribute to To start with, we define poultry that can help us to understand the management system of poultry.

5.1 What is poultry?

Those birds kept by people for eggs, meat, and feathers is called poultry. Chicken, duck, turkey, pigeon, quail, geese, ostrich, swan and other game birds are examples of poultry. In Bhutan chicken is dominant in number although few ducks, pigeon and turkey are kept. Thus, chicken production will be used interchangably with poultry production.

With rapid urbanisation, the demand for animal products is growing and is true for for poultry products. Why not take advantage of this demand. After all this industry provides eggs and meat a rich source of protein in human diet. Rearing poultry can generate income immediately and constantly. There are many advantages of starting a poultry farm. Poultry does not need a huge area of land and inputs unlike other major livestock species. Keeping chickens means you also obtain manure for your crops, vegetables and orchards.Chickens are kept for religious and social ceremonies (festivals and cock fighting events) in Asia and a

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method to control pest in African countries. We could do the same in our places as the need arises.

5.2 Starting a poultry farm

Beginning to establisha poultry farm is determined by your objective. For example, you would like to keep chicken for household and/or business purposes. However, setting up a poultry farm requires capital. The money would be used to procure land (if you do not own), chickens, shed construction, feeds and others. Fortunately, you can avail loans offered for starting business such as Bhutan Development BankLimited. Importantly, you need to have knowledge on chicken rearing.

5.3 Poultry breeds of Bhutan

Chickens in Bhutan and can be classified into two groups: native/local and commerical/exotic breeds (Table 5.1).

Table 5.1 Difference between native and exotic chicken breeds

	Native/local chicken	Exotic/commerical chickens
Define	Belong to specific place/local area and is not introduced from other countries	Are introduced to new place from other countries.
Performance	Production is usually low	Production is high
Care	Require less care and attention.	Require more care and attention
Adaptability	Are highly adaptable to local environment	Are poor adaptability
Purpose	Kept by farmers for home consumption	Kept for business
Production system	Free scavenging and extensive system	Confined and intensive system
Example	***Yuebjha Narp*** (Black), ***Khuilay*** (Naked neck)	Hy-line, White Leghorn, Rhode Island Red

5.4 Poultry production systems in Bhutan

There are bascially three types of system from which you can make a choice to take poulty as business enterprise based on objective, skills and knowledge,

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socio-economic aspects, homestead area and availability of local resources. Types of production system are:

a) Traditional scavenging/ free range system

This is the oldest form of rearing chickens. Under this system, the chickens roam around the house and agricultural fields feeding themselves. Chicken roost (sleep and rest) on trees, bamboos or along with other livestock. The eggs production ranges from 20-60 per hen/year and there is no proper nest for laying. Hen hatch chicks and broody hen take care of chicks from predators and bad weather without human interference. However, the chickens contact with other animals/human is more, they may be infected with diseases and parasites.

b) Semi-intensive system

Under this system you provide house, nests, feed and medicine. The house is especially meant for night shelter and during the daytime they are allowed to roam freely.The loss of chickens and eggs to predators is comparatively lower than the traditional system because you provide night shelter. With improved feeding management, local chicken on an average produces 85 eggs per year.

c) Intensive system

This system is suitable for full time self-employment of youths. For this system, consider a location where it is accessible to markets. A permanent shed is constructed and feed and medicine are necessary. Therefore, there is no or less chance to make contact with other animals, reducing mortality due to diseases or parasites. This system is suitable for exotic breeds(improved breeds) and the eggs production is 240-270 eggs per hen/year.

It is important to understand that poultry involves production of eggs and meat after the chickens has stopped laying eggs. It also involves making choices of how egg production system is to be pursued in a poultry farm. They are:

i. Egg production cycle

At the age of 18-22 weeks old (about five months), the birds begin to lay her first egg and they continue to lay for 17 months (or 72 weeks). After one and half year, the egg production decreases. Therefore, replace with new stock of hens. Have you ever wondered where the chickens that you eat come from? The obvious answer is

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the egg. The egg is different from those eggs that come from the shops or stores. In otherwords, the eggs from the shops or markets are not fertile but the eggs for hatching are fertile. The egg hatches in 21 days. You need incubators to artificially hatch many eggs.

ii. Purchase birds

If you do not want to hatch eggs using your hen, it is always recommended to purchase a day-old chicks (DOC) because it is most economical and the safest choice. DOC of native chickens can be obtained from your friend, neighbour or whoever keeps native chickens on their backyard. In case of exotic DOC you can get from the National Poultry Research&Development Centre (NPRDC), Sarpang) and Regional Poultry Breeding Centre (RPBC) Lingmethang and Khangkhu, Paro). The DOC(layer and broiler) are sold at a subsidized cost by the centres.

iii. Care of chicks

The initial rearing period is very important because of high mortality during first four weeks of age. The main causes for mortality are due to bad weather, predators and diseases.

5.5 Managing the artificial brooding

1 Clean and disinfect house and equipment thoroughly before bringing in the day old chicks.
2 Take sufficient time to warm the floor with litter to 28–30°C prior to chick arrival.
3 Chicks on arrival should be surrounded with chick guard to keep the birds near the source of artificial warmth such as electric bulb or other means of warming.
4 In the beginning brooder temperature should be between 29–32°C. As the birds become older, the brooder temperature is lowered 5°For (3°C) each week until the temperature is 21°C. The chick guard is removed at one week of age to allow them to run around.
5 Feeders and Drinkers should be well distributed in the pen.
6 Clean drinking water and fresh feed (chick starter) in a clean container should be provided.
7 Besides chicks should be vaccinated as per following schedule:

- Marek's Disease: day 1 (DOC) (at hatchery)
- Newcastle Disease: Day 7, repeat at 8 weeks, 16-18 weeks

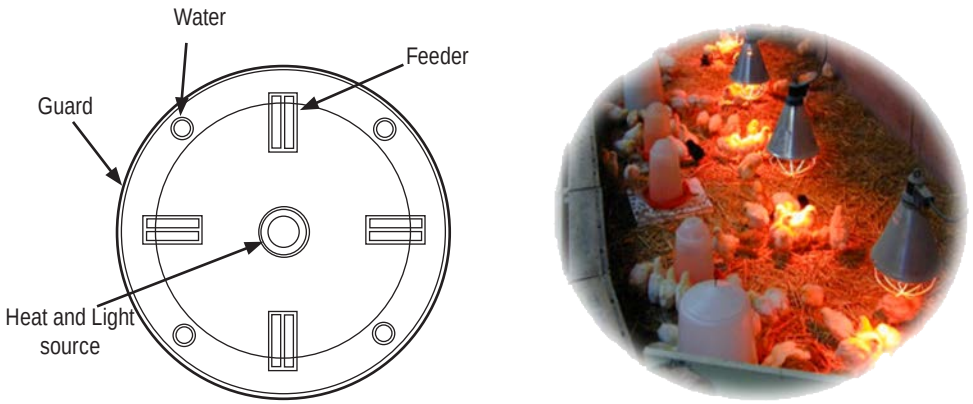

Figure 5.1 Arrangement of brooder

a) Care for growers and layers

Most of the family poultry keepers provide night shelter and women and children are involved in production. Under natural conditions, hen lay eggs in simple nests, perch on trees and spend their much time scratching and looking for food. You need to improve management practices to improve the production. The management requirement of growers and layers are as follow:

b) Management of pullets (9-18 weeks old birds)

- Grow pullets in strict isolation from older birds.
- Maintain good sanitation so that disease-causing agents cannot be carried from older birds to the growing pullets.
- During the first few weeks of transferring to pullet (grower) shed, provide grower feed, at least twice daily and check water availability daily.
- Vaccinate as required in consultation with local livestock extension staff
- Weigh at least 100 pullets weekly during the growing period to know whether management is adequate for optimum growth
- Three days before moving pullets to the laying house, begin using water-soluble vitamins and electrolytes in the drinking water to minimize the stress of moving.

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c) Management of Layers

- Birds should be fed balance diet (see section feed and water)
- Provide artificial lights greater than 15 hours of total light per day; light is an important factor in sexual maturity bringing them to lay sooner. A dark house leads to lethargic, inactive, unproductive birds. Light is also important for feeding, as poultry identify food by sight feed.

5.6 Poultry housing and its equipment

To save cost of investment, a poultry house must be constructed from cheap locally available materials such as bamboo, planks, off-cuts, clay and/or waste wire mesh (Figure 5.2).

1 A good house should provide protection against rain, wind, cold and predators. It should reduce parasites and diseases outbreak.

2 A good housing provides enough space, fresh air and light. For comfort, enough floor space should be provided to poultry birds. The recommended floor space requirement for poultry birds is given in Table 5.2.

Figure 5.2 Poultry house with egg-laying box at village level

Table 5.2 Floor space requirements for bird

Age of birds (weeks)	Space in square feet per bird	Age of birds (weeks)	Space in square feet per bird
Day old chicks to 4	¼	12-16	2
4-8	½	16> above	3
8-12	1		

3 Feeders (to feed birds) and drinkers (for water) placed at sufficient distance. Feeders will prevent any wastage of feed and the drinkers will avoid damping the area. Recommended number birds per feeder/drinkers for commercially available feeder and drinkers in market nowadays are given in Table 5.3.

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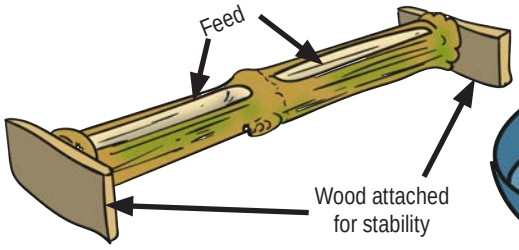
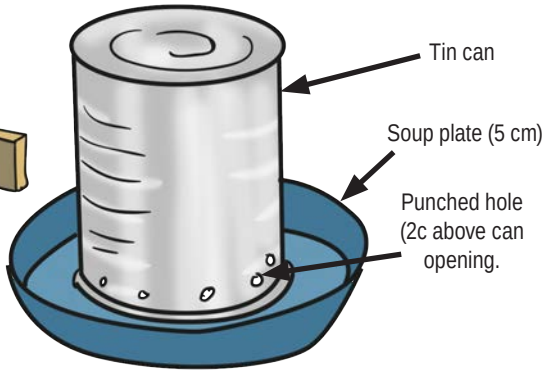
Table 5.3 Specification for commercially available feeder and drinker

Type of feeder/ drinker	Standard
Chick feeder	75 chicks/feeder
Grower feeder	50 birds/feeder
Layer feeder	18 birds/feeder
Chick drinker	75 chicks/drinker
Grower drinker	50 birds/drinker
Layer drinker	90 birds/drinker

(a)



(b) Bamboo feeder



(c) Metallic drinker

Figure 5.3 Feeders and drinkers locally made and available in market

4 Enough and comfortable nests to lay, providing one egg laying box for every five hens. Laying boxes are usually made of wood, and should measure approximately one foot on all sides

5 Perch for resting.

6 Disinfectant dip for disinfecting your and other visiting people's foot before entering and leaving the house to prevent spreading of diseases.

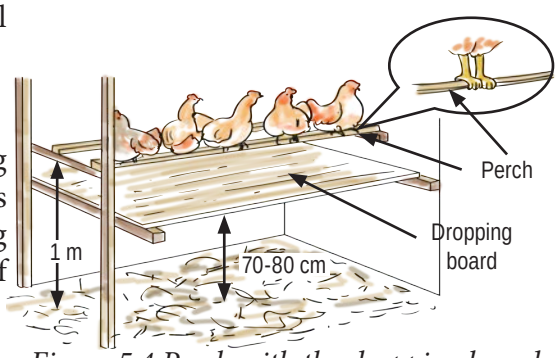


Figure 5.4 Perch with the dropping board

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5.7 Management of Poultry

Feed and water: Like other living beings, chickens require balanced nutrients feed for best physical condition. Chickens find their own feed around the house and in the fields by scratching the ground for grains, insects, worms, snails, seeds and grass and kitchen wastes. This is a good mixture of feed (quality) but usually not enough (quantity) for them to perform well (egg and meat production). In other words, the bird's performance depends on the quality and quantity of feed given (Table 5.4).

Table 5.4 Standard feeding regime per bird

Feed type	Average daily feed required(gm)/bird
Chick starter (0-8 weeks)	60 gm
Grower (9-18weeks)	70 gm
Layer(19-72weeks)	122 gm

Adequate feed (either your own homemade or the commercial feed) should be provided to your chickens for optimum performance. The commercial feed available are:

- ***Chick starter feed*** is given to day old chicks until eight weeks old. The feed contains about 18% of protein.
- ***Grower feed*** contains about 16% protein. It is provided to young chickens from eight to 17 weeks of age.
- ***Layer feed*** contains 16-18% of protein and is given from 18 weeks of age.

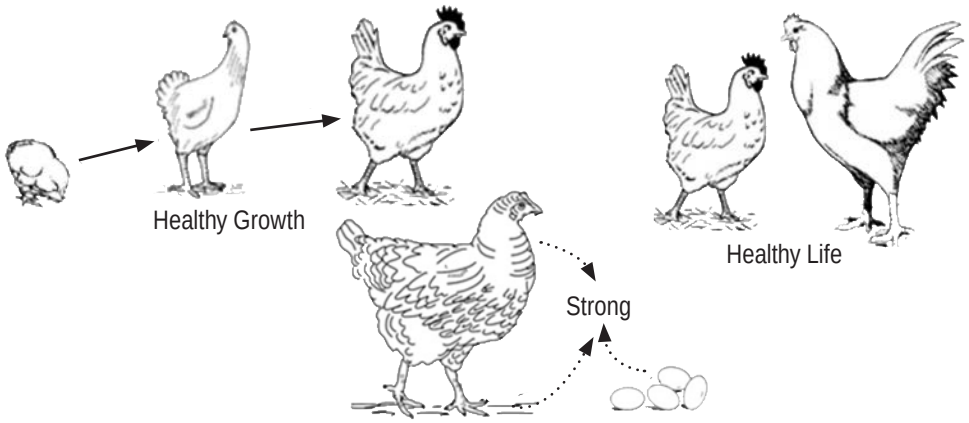

Figure 5.5 Different nutrients needed by chickens to live healthy and produce healthy

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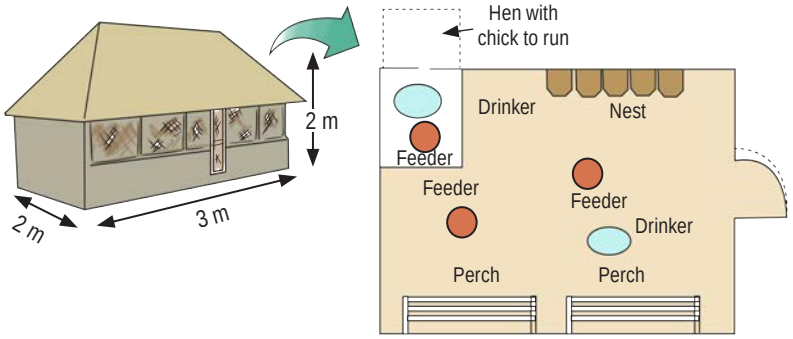

Figure 5.6 Layout of chicken pen for keeping 15-20 birds

Diseases come from other animals, feed or water, air, feed bags and equipment. We also take diseases on the feet, clothes and body especially coming back from the market. Infections may transmit from the bird to bird (via saliva, droppings or contaminated eggs) and hen to her chicks (through the egg).

a) Identifying a sick chicken

When sick they are less active (does not run, eat less or stops eating), eyes are dull, ruffled and dirty feathers. Moreover, you may also observe abnormal breathing (sneezing and breathing difficulty), droppings watery or bloody or movement disorders (limping or paralysis). Older birds may develop sore on their comb and wattles.

b) Causes for diseases

The diseases are caused by germs. Those germs causing diseases are called as pathogens. Pathogens are generally not visible to our naked eye and therefore require special microscopes to see. Virus (Newcastle Diseases, Gumboro, fowl pox, Avian Influenza (Bird flu), Marek's Disease), bacteria (fowl cholera, Pullorum disease) and fungi (*Aspergillosis*) are example of pathogens. Parasite is also another cause for disease and/or retard growth. It is of following types:

- ***Ectoparasites*** are those organisms that parasites externally such as lice, mites and tick.
- ***Endoparasites*** are those that parasites internally. Worms and coccidiosis are examples.

c) Avoiding or preventing the disease

Provide a good house for your chicken that is cleaned with disinfectants. Keep your chickens healthy by providing clean feed and water regularly (better twice

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a day). Maintain a good hygiene and sanitation because droppings, feathers and dead birds are sources of pathogens. Make sure the person entering poultry house change dress and footwear. Sell chickens, eggs or old litter outside your farm or at the farm-gate. A sick bird should be removed from the rest of the flock and housed separately. Provide a separate house for birds of different age. Practice good quarantine housing to ensure the new arriving birds (brought form market or received as gifts) do not carry any diseases and/or parasites. Vaccinate and deworm your birds at young age. These measures will minimize mortalities due to disease and parasites outbreak.

d) Hygiene and bio-security

It is a way to minimize a contact between animals, men and pathogens. This is done by cleaning and disinfecting house and premises to reduce the number of pathogens, rats and wild birds (Figure 5.7). Ensure feeders and drinkers are cleaned regularly. Remove and replace litter regularly and never store old litter near chicken house.

Figure 5.7 Biosecurity on the poultry farms

Steps to follow when a chicken dies or is sick

Step 1: ***Quarantine***: Chickens appearing unhealthy must be isolated from the flock immediately. Observe the chickens in quarantine house and note for the signs. Eliminatethem if they cannot be treated. If you find a dead chicken with no apparent injury then you should not eat. Burn or burry all dead birds as soon as possible and make sure any possible remaining source of the diseases is eliminated too. Do not give left-over feed from sick chickens to your healthy chickens.

Step 2: ***Call for veterinary assistance***: Call the nearest livestock extension centre with animal health worker for assistance and request to treat the sick chickens. It is better to treat all the chickens that have recently in contact with the dead chicken.

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Step 3: ***Vaccination***: The vaccines can be given along with drinking water and feed, beak dipping, eye drops or spray (Figure 5.8). Vaccination is very important for preventing viral diseases. Seek advice from the Gewog animal health workers regarding vaccination schedule for different poultry disease.

Figure 5.8 Ways to vaccinate chickens

Step 4: ***Treatment or elimination of sick chickens***: If the disease is identified you probably need to treat whole flock. If the diagnosis is very bad, it is better to slaughter your whole flock but do not eat sick chickens. The carcass or remains must be burned or buried (Figure 5.9).

Figure 5.9 Disposing dead chickens

e) Pecking and cannibalism

Pecking is an abnormal behaviour. Chickens pull out feathers from each other and make the skin bleed (Figure 5.10). Therefore, the birds are quick to fight and may even kill one another. The chicken starts to peck because of boredom and frustration. The reasons could be because of overcrowding, feeders and drinkers small, too little feeding and/or drinking space, insufficient laying nest,

Figure 5.10 Feather pecking

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lack of litter, lack of perches to rest on, lack of sand to take a dust bath, ectoparasite infestation and other poor management.

What should I do if I examine pecking?

- Some birds can be 'initiators' of pecking and other follows because chickens imitate. Therefore, remove them immediately from the flock.
- Allow and stimulate young chickens to scavenge and peck on the soil frequently. Scattering grain on the soil will stimulate them.
- Let them learn to use perches for resting. The chicken resting on perches does not peck.
- You can also hang bundles of vegetables or green grass from the roof of the poultry house. This is to make your chicken tired and become less furious for pecking.
- Treat the wounds with a bad-smelling medicament.
- The last resort is to de-beak (cut off the tip of the beak).

f) Improvement of local chicken

The local chickens are well adapted to harsh environmental conditions such as poor feeds, improper shelter and exposed to sudden changes of weather and diseases. Their meat and eggs are argued to be tastier than commerical breeds. However, a local chicken to attain market weight (1-1.5 kilograms) takes a year and a hen gives about 30-50 eggs in a year.Thus, to improve the production of local chickens it can be done by:

- Hatching exoticchicken eggs: Using native hens to hatch and raise the exotic chicks.
- Rearing exotic chicks along with native chicks: Place a day old chicks of exotic with broody native hen rearing day old chick native also.
- Crossbreeding or upgrading: Crossing local hens with purebred rooster. The chicks so produced have a potential to lay more eggs and growth faster. They are adaptable to local environment.

5.8 Enhancement of poultry production

There are many ways of improving your poultry production via selection and breeding, and good management practices. Selection is a method to choose chickens from rest of the flock based on certain criteria such as physical appearance, egg or meat production. In otherwords, the kind of birds you select will depend on whether you want fresh eggs (layers), meat (broilers) or exhibition(game birds).

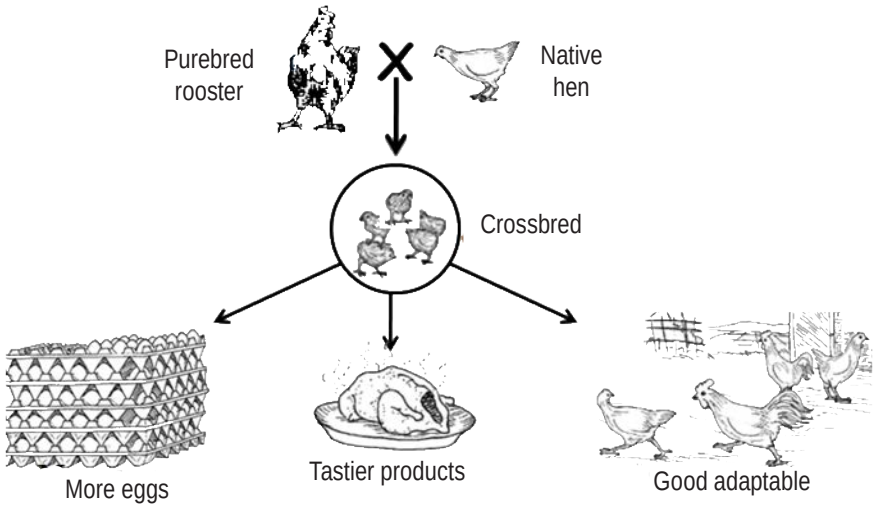

Figure 5.11 Crossbreeding programme

Considering you have four hens, two cocks and four chicks. After following the suggested management practices, you may have flock size as eight hens, one cock, four grower (less than a year but more than 17 weeks) and 10 chicks. However, the flock size that you want to keep may be justified by few guiding questions: Will I able to give good feed (quality and quantity) to my chickens? Is my house of chicken constructed comfortable and prevent overcrowding? How much do I want to produce eggs and chicken meat for consumption and sale?

We try to select productive hens and well-sized and active cock. While the rest birds should be sold as soon as they reach proper market size and is called as culling. It is done timely so as to prevent wastage of feeds, especailly cocks.

A few guidelines on selecting and replacing your flocks may invlove at least four steps:

Step 1: ***Selecting eggs for hatching***: The basic principle is that hen passes her good traits (potential for good lay) to her chicks. Therefore, good hatching eggs should be selected from healthy and good egg producing hens. For example, first, second

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and third hen clutch size is six, 10 and 15 respectively. Evidently, you will prefer and select the third hen for her performance. The eggs for hatching should not be dirty and/or misshaped eggs, damaged and normal shape and size (Figure 5.12).

Figure 5.12 Good hatching egg selection

Step 2: ***Selecting the growers***: After about 17 weeks of rearing chicks, the best fast growing and healthy females are selected based on the size. Then selectfemales that look continuously far and wide for food. Once selected the growers, remaining unselected ones should be sold soon.

Step 3: ***Selecting productive hens***: Not all the hens begin to lay her first egg at same age. Choose those hens that start laying early.(Figure 5.12 to 5.18)

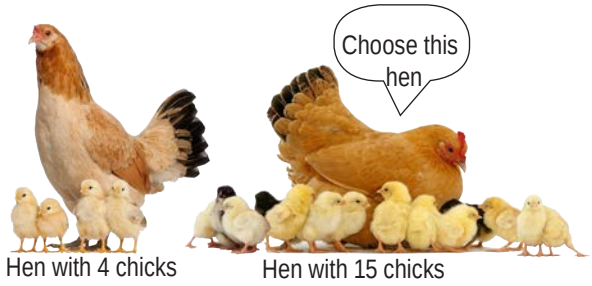

Figure 5.13 Healthy growers from good hen

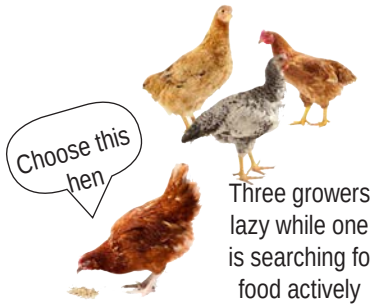

Figure 5.14 Grower actively scavenging for feed

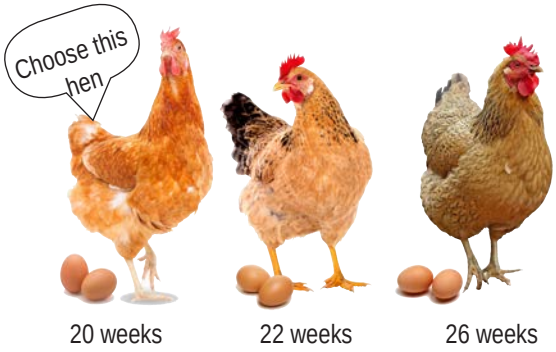

Figure 5.15 Age at first lay

Figure 5.16 Choose ahen that is active

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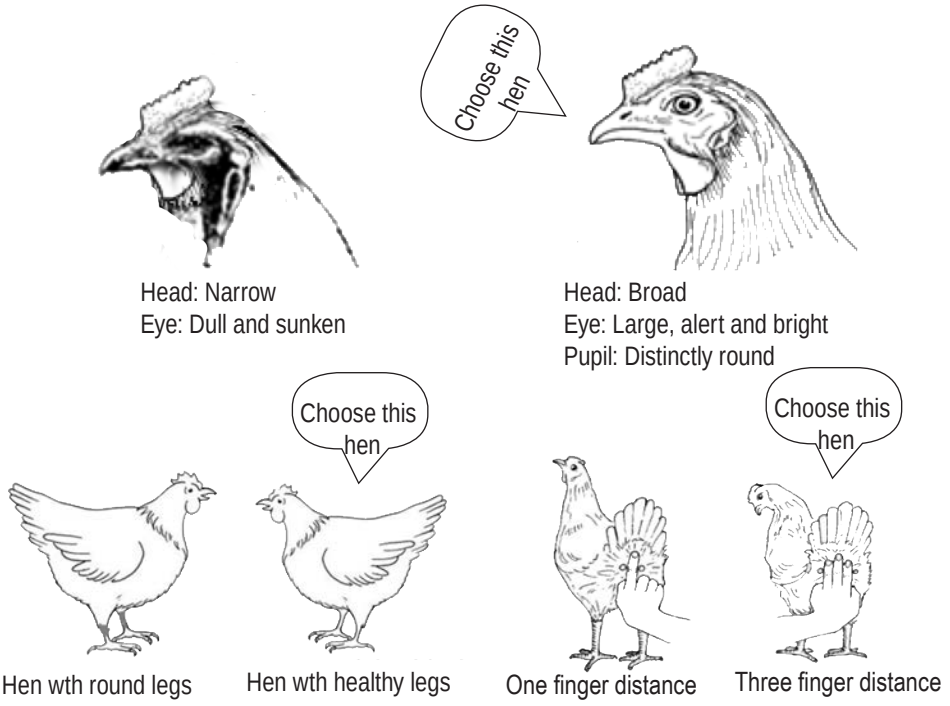

Figure 5.17 Selecting the good layers based on phenoyptes and bodyconformation

Choose active hens that look continuously far and wide for feed. You can tell and differentiate them from others as their beak is strong and short and toenials has become short due to scavenging. Moreover, the phenotypes will tell if the hen is a good or poor layer.

Step 4: ***Selecting breeding cocks:*** Cock is equally important because it equally transmits traits to his offspring. Therefore, select a cock from a good producing hen. Select a fast growing cock. A cock with bright and alert eyes and large red comb and wattles should be selected. Importantly, do select a cock that chase hens.

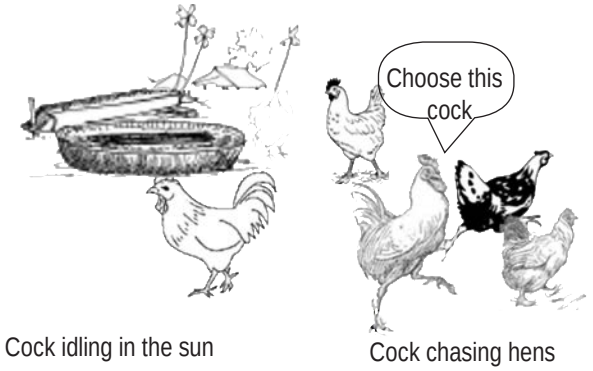

Figure 5.18 Choose a cock that run after the hens

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It is not good to cross a father cock with daughter hens, because it will lead to inbreeding. Therefore, replace your cocks with new one for every generation. Inbreeding will lead to poor egg production, weaker and deformed offsprings. Besides,fertility and hatchability is greatly decreased.

5.9 Record keeping and its use

The information that has been carefully collected and stored properly for intended use is called record keeping. The farm records are maintained for keeping track of economic enterprise and for decision making on your poultry farm. For example, records are kept to control inbreeding and develop breeding plans, to assist in disease management, feed planning and for future references.

For these purposes, record should be done daily or weekly basis for production, diseases, malnutrition, or other problems in poultry. Records should be simple, easy and quick to interpret and have remarks for unusual observation (Table 5.5).

Table 5.5 Record of expenses

Month:……..Year:……..Date of hatch:……..No. of birds:……..

Date of purchase	Feed			Miscellaneous expenses		Remarks
	Amount purchase (kg)	Types of feed	Cost (Nu.)	Description	Cost (Nu.)	
Gross income earned from sale of eggs / meat/manure	Nu.....					
Summary						
Total cost this month			Gross profit or loss this month			
Profit or loss this month			Profit or loss to date			

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5.10 Challenges and scope of poultry farm in Bhutan

Poultry production is an extensive system owned at family level in Bhutan. Chicken provides a good source of protein and immediate cash for family. It may also be regarded as one means of sustaining the rural economy and possibly will prevent urban migration in near future. However, family poultry production faces serious constraints including disease, insufficient feeding and lack of proper housing. Poor health is one of the challenges for farmers because they lack awareness on diseases. Many diseases are highly contagious, spreading by contact between birds, excreta, wild animals and even human.

Housing is another problem needing immediate attention. Farmers face major problem such as loss of their birds to predators. To start a commercial/semi-commercial poultry farm for higher income, a simple but proper shed should be constructed from locally available materials.

Feeding of nutritionally balanced feed from locally formulated, or purchase of commercial feed from feed manufacturers will increase production. This combined with good farm management is likely to increase profit.

Marketing is an essential element one has to consider while starting a commercial farm. This is another factor that many of us underestimate it. A cost-benefit analysis should be done periodically to know the status of your poultry business and to take suitable interventions to make the venture profitable/ viable.

Poultry farming especially for egg production is picking up well in the country. Many farmers and youth who are managing their poultry farm well, are able to earn good income out of the farming business This also is paving way for secondary business such as establishing of feed plant, retailing of feed, supply poultry equipment and medicines thereby giving ample self-employment opportunities for youth and early school leavers.

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Student Activity

Student Activity –start of a small poultry or review for improvement (to be done by observations & inquiry based on the theory given in the chapter)

1. Discuss with the class to start a small poultry farm in the school as a project of the class in detail of it entails starting of a poultry farm.
2. Prepare a draft proposal where, when and how a poultry farm is being proposed to start and support required from the school management – a class presentation proposing to start a poultry farm in school.
3. Invite school principal and other members of the management team to the class for the presentation.
4. Present the proposal, seek suggestion and advice on how to go about starting a poultry farm in the school and the kinds of supports school leadership would be able to provide and also the benefits of the poultry to the student's learning and the school.
5. Seek approval to start, fix datelines for the support required and the start of the work from the school leadership and the management team, especially writing to the agencies for the supply of DOC layers and the feed at the dates likely to complete poultry house.
6. Discuss in detail on starting the poultry – such as drawing of the poultry house, materials required and procurement, share responsibilities and get total commitment from the class.
7. Start construction of poultry house following the theory learned from the chapter.
8. Collect the feed for DOC layers and the layers on an auspicious day with the principal, the staff and the students witnessing the start of the class poultry.
9. Care for the birds as per the guidelines discussed in the chapter analytically and wisely – timely feeding, observing behaviours of the DOC layers and record development, eggs laid, sale and expenditure incurred on caring of the poultry farm.

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6 Chapter

Starting a Pig Farm

The pig is one of the oldest domesticated animals. The domestic pig originated from the Eurasian wild boar (*Sus scrofa).*The pig production trend in Bhutan is slow but positive. Proper strategic production system still needs to be developed. We have still large number of domesticated native pigs (widely known as *Sapha* and *Dompha*). Pork is a very important source of animal protein in human diet.

Traditionally, pigs were reared for manure for their crops and a source of income for the farmers. With the passage of time, most of the farmers in Bhutan follow the semi-intensive system of pig production and is becoming more popular because of its favourable returns to investment.

In areas where pigs are reared, they are most valued as kind of "savings' to the farmer from where he can tap in times of cash shortage and in emergency needs. More so, if improved way of pig farming is practiced with suitable breed, proper feeding and management it can provide ready employment to the youths and enable them to have good earnings to lead a comfortable life.

This chapter provides basic ideas on different types of pig breeds, breeding, farrowing and piglet management, and housing of pigs to enable youths to equip themselves with required knowledge, values and skills to start a pig farm.

6.1 Pig breeds in Bhutan – Exotic breed

The exotic breeds of pigs have been imported from abroad for cross breeding with our local pigs and they are *Large White, Landrace, Duroc, Saddleback* and *Large Black*.

a) The Large White

It is also sometimes called Yorkshire (Figure 6.1) is a popular English Bacon breed which had its origin nearly a century ago in Yorkshire in northern England.

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Yorkshire sows are noted as good mothers. They raise large litters and are great milkers. They are entirely white in colour with moderately long and slightly dished face. Mature boars weigh from about 300 - 450 kg while average sow weighs from 250 to 350 kg.

b) Landrace

Figure 6.1 The Large White

The origin of this breed is Denmark, where it has been bred and fed to produce the highest quality bacon in the world (Figure 6.2). The breed is white in colour, although black skin spots "freckles" are rather common. The breed is characterized by its long, deep side, square ham, relatively short legs, trim jowl and heavy lop ears. The breed is noted for prolificacy and for efficiency of feed utilization.

c) Duroc

Figure 6.2 Landrace

This breed originated in north eastern part of United States of America. The breed is moderately red coloured with shades varying from a golden to cherry red colour (Figure 6.3). The Duroc is noted for excellent rate of gain and feed efficiency. Maturing early, the Duroc sow gives large litter size and is a good mother. The weight of mature boar is about 400 kg and of sow it is normally 350 kg. Duroc Jersey breed was imported into Bhutan in the year, 1981 from Philippines for cross-breeding purpose with our local pigs to produce better and productive offspring.

Figure 6.3 Duroc

d) Saddle back

The Saddleback has the striking colour marking of a white belt on a black body (Figure 6.4). The pigs of this breed have drooping ears. Strong points of the

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Saddleback breed in its reputation as a mother sow (good mothering ability). The sows have large litters and are said to be excellent milkers.

e) Large Black

All black in colour. Head is medium in length with slightly dished face and large lopped or drooping ears (Figure 6.5).

Figure 6.4 Saddle back

The sows are good mothers. Not as prolific as the White breeds and generally inferior in growth, food conversion and carcass performance. The Large Black is used for crossbreeding with the local pigs in our country.

The *improved breeds* of pigs are the offspring obtained from crossing between an exotic breed of pig and local pig. Improved breeds of pigs are easier to rear as compared to exotic breeds of pigs.

Exotic x Native = X (cross) Breed = "Improved"

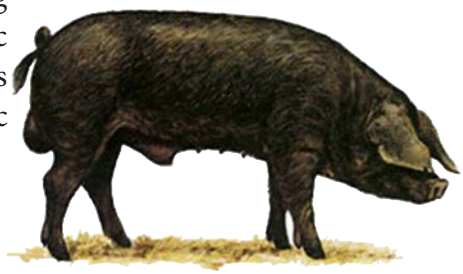

Figure 6.5 Large black

f) Native Pigs

Native or indigenous pigs are found throughout Bhutan (Figure 6.6). They are smaller in size as compared to improved or exotic breeds of pigs. They are more resistant to diseases and they take longer time to mature. Some of the native pigs are *Sapha* and *Dompha*.

Figure 6.6 Native breed

6.2 Pig Breeding

Pigs are reared for breeding and fattening purposes. To establish a pig breeding farm to produce and sell piglets to other farmers, the first step toward this is to procure intended number of gilt (female) and boars (male). Gilt should be ready for mating at five or six months of age, and be receptive for two or three days. The oestrus

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cycle for pigs is 21 days. Gilts should be mated on their first day of heat and older sows on the second day of heat (oestrus). The boars for mating should be 8 – 12 months old. Usually one boar is required per 20 sows with supervised hand mating, but in small herd actual boar requirements would have to be determined for each herd, based on the number of sows to be mated in a given period and the boar's replacementage. If artificial insemination is utilised, fewer boars are required. The gestation period for pregnant sow will be approximately 114 days, or as the old saying goes, three months, three weeks, and three days.

a) Farrowing and Piglet Management

The cubicle/farrowing pen must be cleaned and disinfected one week before the pregnant sow is moved into it. Some soft straw or dry leaves can be provided as bedding. The sow will give birth to its piglets within 24 hours if the milk comes out when the teat is being squeezed.

After farrowing, the piglets must be kept warm and colostrums must be provided equally to all the piglets. Colostrums will provide energy and more importantly develop resistance (immunity) to diseases in piglets. Piglets usually have sharp teeth at birth. Those sharp teeth have to be clipped so as to prevent injury being caused to their mother while suckling and also to themselves while fighting. Three days after farrowing, the piglets have to be given iron injection. This will prevent them suffering from anaemia. Stunted growth, reduced resistance to infections and increased pig mortality are the main consequences of anaemia. It is general practice to introduce creep to suckling pigs at seven to ten days of age. Creep feeding is done to get the piglets used to eating solid feed so that they will have no problem in eating solid feed at the time of weaning. Creep feeding is to be done @0.5 kgcreep feed/piglet/day. The creep ration should contain 18% crude protein (CP).

i. Fattening

If pigs are reared for fattening purpose, they must be marketed within 8 to 12 months of age. By that time the pigs must have gained up to 60 – 100 kg of body weight. Usually the pigs are fed with finisher ration when they have attained the body weight of 60 kg. The finisher ration should contain 14% crude protein (CP) and water must be available to the pigs at all times.

ii. Feeding of Sows

Different feeds are available for feeding different categories of pigs and these feeds are manufactured by commercial feed factories in Bhutan.

iii. Sow ration

This is the ration/feed meant for feeding sows. There are two categories of sows. Dry and pregnant sow are those pigs which are not producing milk. For dry and pregnant sows, the ration to be given is 1.5 kg/sow/day. Lactating sow is the female pig that gives milk to its piglets and the ration to be given to a lactating sow is 1.5 kg/day + 0.5 kg provision for each piglet.

iv. Feeding and Watering

Feed twice everyday with plenty of water = minimum of 5 litres/pig

b) Systems of housing pigs

Pigs are kept under two systems – indoor system and outdoor system. A combination of the two can also be practiced. While choosing the housing system, factors such as the size of the enterprise, the type of pigs to be produced, the availability of land and the climatic conditions must be taken into consideration. In small holding farms, special housing may not be necessary but in a specialised farm with a large number of pigs there is a necessity of constructing special houses for different categories of stocks such as breeding and meat stock.

c) Location

The farm should be located near the place where there is a heavy demand of pork products. This is particularly necessary to avoid the cost of transport of feed and other stuffs, and also for marketing of pork. The availability of electricity and water supply will be an added advantage to the farm.

d) Enclosure

Durable enclosures are necessary for permanent buildings. Fences of about 3 to 5 feet high usually provide permanent enclosures. Woven wire and chain linked wire netting of 2”-3” mesh is quite suitable with barbed wire closely fitted to the ground so that pigs cannot lift it.

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e) Constructional details

The availability of materials varies from place to place so it is not possible to suggest one set of plan to give a generalised idea. However, the essential requirements of pigs must be understood and considered before planning to construct a pig sty.

i. Floors

They must be impermeable, and easily cleaned with shovel and brush as well as with pressure washers. This allows eggs of parasites, particularly ascarids, to be removed and prevent spread of infection. A concrete floor laid on a hard foundation with a rough surface provides most satisfactory floor. The floor should have a sufficient gradient, of the order of 3% or slightly steeper to allow adequate drainage.

ii. Walls

They should be 4'-5' high from the floor. Brick and concrete are the best materials for the construction of walls which should be strong and smooth. Wood can also be used but it must provide a flush surface, otherwise pigs will gnaw it.

iii. Roof

It should be water proof and must ensure maximum shade. Polished aluminium roof will make satisfactory roofing. Tiles, when available may be used but can be very heavy and need a very robust and well-maintained framework. It must be noted that roofing types and materials used must provide protection to pigs from extreme weather.

iv. Windows

In case of completely enclosed pig sty, there should be a provision of good windows and roof lights. The windows would allow the entry of sun rays, fresh air necessary for the pigs. In colder places windows of pig sty could be smaller, to reduce the escape of heat.

v. Doors

They should be strong and fitted close to the floor so that the pig may not lift it by putting its snout under it. Doors may be prepared by sheet metal (preferably) or wood. In any case a door should cut off the entry of air and rain water in the pig sty. The width of the door should be 2'6" to 3'.

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vi. Troughs

The cost of food for the pigs is one of the major production parameters. So lot of care must be taken with feeders to avoid feed wastage. Fixed concrete troughs may be used but they should be easily cleaned. According to Serres (1992), the depth of feeding troughs should be around 20 cm so that food only occupies the bottom and cannot be flicked out (Figure 6.7).

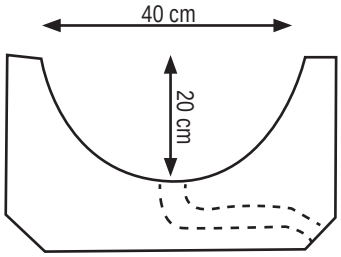

Figure 6.7 Feeding trough

vii. Water supply

It is required for cleaning and drinking purposes. Fresh drinking water should always be available to the pigs throughout the year. Pigs in hot weather conditions, particularly lactating sows, must be given plenty of water. Clean feeding trough with bung can be used for providing clean water which must be offered every after and in between each meal.

viii. Drainage facilities

There should be good drainage system for the removal of wastes (urine, faeces and some food wasted) and washing with a suitable system for their disposal. The slope of the floor should be directed towards the drain for rapid removal of liquid.

Floor space requirement depends on system of management, age and size of animals. Suggested floor space requirements:

- Fattening pig: 30 - 40 square feet(sft)/pig,
- Farrowing pigs: 60-80 sft./pig and
- Boar pens: 40-50 sft./pig.

However, bigger floor spacing is always better keeping in mind the welfare aspects of pigs. It must be put into record that the efficiency of production always goes parallel with the welfare of animals.

Elements of good housing

The picture below illustrates the element of a good housing:

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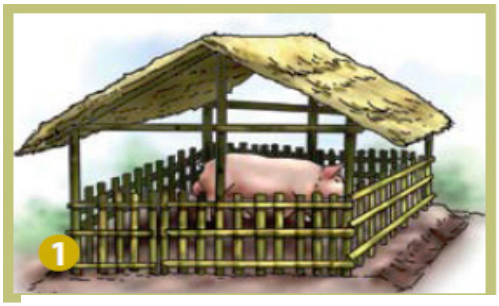
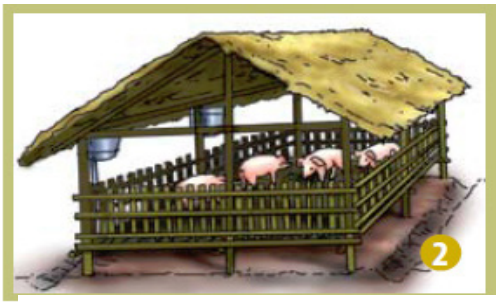
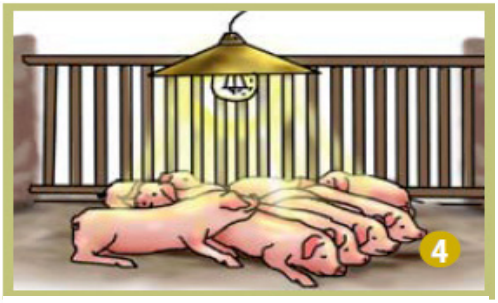


Seperate house for breeding boar/pregnant sow

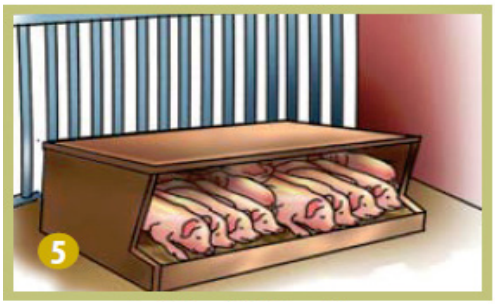


Seperate house for gilt and dry sows

Provision for farrowing pan



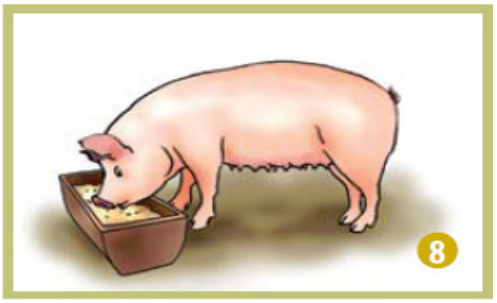
Heating and cooling arrangement



Provision of piglet nest/box

Provision of creep feed/starter feed

Suitable size of drinkers



Suitable size of feed trough

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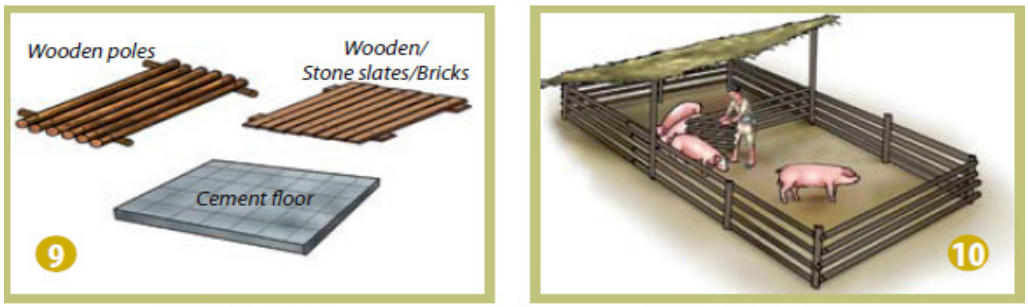

Suitable floor space

Sufficient space for exercise

Figure 6.8 Good housing *(Source: FAO, 2009: Farmer's Handbook on Pig Production)*

6.3 Common diseases of pigs and their management

a) Classical Swine Fever (CSF)/ Hog Cholera (HC)

Classical swine fever, otherwise known as hog cholera or just swine fever, is highly contagious disease caused by virus. The disease spread through contact with other animals, contaminated urine and faeces or other body secretions. No vaccination except in extreme emergencies should be given to pigs less than six weeks old; unhealthy, weak, sick or parasitised pigs; pregnant sows; pigs exposed to infection; during inclement weather; and during conditions of stress.

i. Symptoms

Loss of appetite in affect animals, inflammation of the eyes, high body temperature, severe diarrhoea, and discharge in the eyes causing the eye lids to stick together, trembling and death often results after 7 – 8 days.

ii. Prevention and Control

For prevention of disease swine fever vaccine 1mL subcutaneous should be given at 45-60 days of age. There is no effective treatment/control measures except vaccination programme to be instituted if there hog cholera/swine fever infection in the locality. Avoid contact with infected animals.

b) Parasite control

1. *Ascaris* (roundworm): It can be controlled with piperazines.

2. *Sarcoptic mange:* This parasite may be confined to the ears or other parts of the body. Even mild cases can cause itchiness and reduced gains. Ivermectin injectable solution (1% w/v) is highly effective against Sarcoptic mange in pigs.

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Nearest livestock extension centre/ veterinary hospital may be contacted for any assistance.

3. Tape worm (*Taeniasolium*) :Tape worm infection termed as *cysticercosis* or *measly pork* is infection with larvae of Taeniasolium (*Cysticerci*). Larvae develops in pigs after ingestion of ova excreted in human faeces (Figure 6.9). *Cysticerci* (larvae) are found mainly in the muscles of the heart, tongue, forearm, thigh and neck, but can occur in other parts of the body of pigs. Human get infected by eating raw or uncooked pork containing *cysticerci* which develops into adult worms. *Cysticercosis* is common in traditional rearing pigs system in villages.

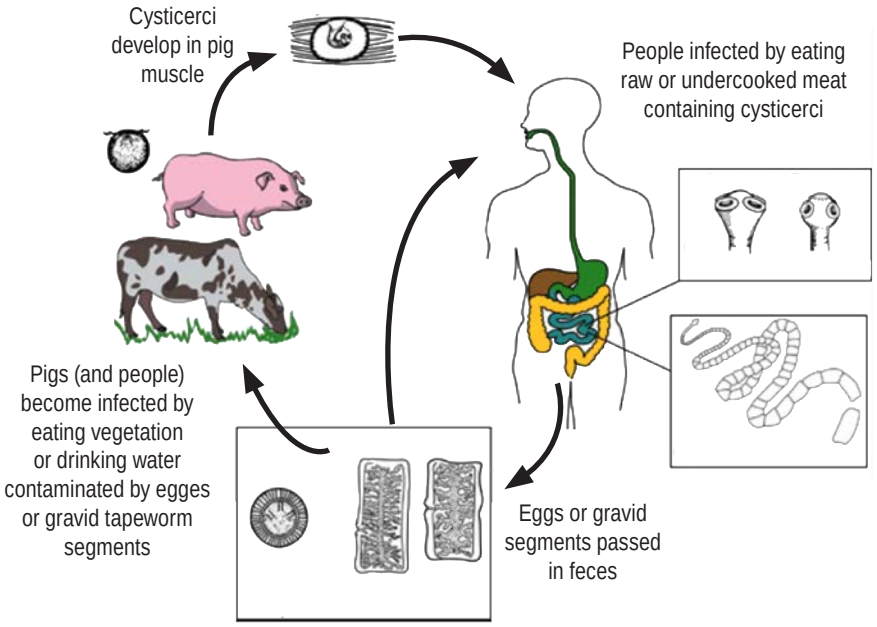

Figure 6.9. Life cycle of the pork tapeworm.

c) How to prevent yourself and your pigs from becoming infected?

Food, water or soil may become contaminated with tapeworm eggs from human feces. Prevent exposure by:

- cooking pork thoroughly,
- washing hands frequently when preparing food,
- using clean utensils,

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- to break the life cycle of tapeworm properly dispose human waste to prevent contamination of food and drinking water sources so as to minimise ingestion of ova by scavenging pigs, and
- Adult tape worm infestation is treated with anthelminthic drug – paraziquintal.

6.4 General bio-security measures and hygiene

Good hygiene and bio-security is essential to prevent the introduction of animal disease, protect the health of farm animals and workers, and reduce the risk of disease exposure to any members of the public who visit farm. The key to good bio security is reducing and controlling the movements of people, vehicles or equipment into areas where farm animals are kept. Protective clothing, footwear, equipment and vehicles should be cleaned before and after contact with farm animals and where practicable, disposable protective clothing should be used.

a) Sanitation

Liquid disinfectants should be applied liberally to all surfaces, crevices and cracks allowing about a week for the disinfectant to work. A sick animal can easily be detected at feeding time, because it does not eat. Its temperature should be taken. If lack of appetite is accompanied by fever, antibiotics and Vitamin B complex are needed. An animal under treatment must be restrained properly.

b) Pest control

Flies are controlled by proper disposal of manure. Pets must be kept away from buildings and feeding floors. There should be protection from rodents in all buildings.

c) Waste management

Contaminants from animal wastes can enter the environment finding its way into surface water such as streams and ponds. Therefore, it is necessary to collect and stack the manure in such a way that it decomposes without contaminating environment. Proper disposal of manure also contributes effectively to the control of flies. The compost formed after decomposition can be used as fertiliser on cultivated lands. The pigs manure can also be utilised to produce biogas for household use. Liquid waste may be allowed run into fish pond if integrated pig and fish farming is practiced.

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If individual practice improved way of pig farming, with suitable breed, proper feeding, management and health care, it can provide a ready employment for youth and early school leavers and enable them to earn a good living.

Student Activity

Different practical exercises are suggested to enable schools to adjust practical work as per the paradoxes of life of our complex society. We have school leaderships with wide range of expertise, experiences, principles and ideologies. Educational leaders who understand the purposes of education and the realities of life of Bhutanese society and its needs, provides educational experiences in schools with which students become productive leaders of our society, generating self-employment and employment of others. Others provide educational experiences that enable students to be literate, capable of seeking for job if available. The latter is not an option for the Bhutanese youth of 21st century Bhutan. However, students have no choice but to comply by the type of schools that they are in. It is hoped that students will be able to carry out at least one of the three activities if not two in two years of schooling in classes IX and X.

Activity 1 – Starting a Pig Farm

1. Discuss with students what they are capable of doing after having studied the chapter.

2. Float an idea of starting a pig farm in school – a project of starting a pig farm in school (or for exhibition if not real project).

3. Prepare a proposal write up on (as learned from the chapter):
   a) Number of pigs to get from & capacity of pigsty (projected capital & profit),
   b) Likely location of pigsty (create one for exhibition),
   c) Construction of pigsty (or model house),

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d) Feed to get from and feeding (or sample feed and timing),

e) Care of pigs and sanitation of pigsty (or type of work and routine),

f) Marketing survey and sale of pork and organic manure for garden,

4. Divide students into 6 groups, assign them to write detail proposal and compile.
5. Present to the class to improve the project proposal (exhibition on pig farming),
6. Invite the school principal, present proposal and seek advice and support needed.
7. Prepare a plan of action, start construction work collectively, writing letter for the supply of piglets and feed, assign task of looking after the pig farm (prepare model pig farm)
8. Start pig farm on an auspicious day (fix a date for exhibition on a week end)
9. Record care provided, feed routine, sanitation and weigh piglets weekly to check the progress of development (write up on 'how to feed, care piglets, manage sanitation and hygiene, growth and profit likely to fetch from sale of meat and manure for garden.

Activity 2 – Reviewing an existing Pig Farm

1. Divide students into different groups of tasks involved in managing the pig farm.
2. Assign different tasks to different groups to find out how the pig farm is being managed.
3. Different groups design questionnaires based on the theory of this chapter.
4. Present to the class for improvement of the questionnaires and their focus.
5. Carry out the study through observations, interview of the managers/workers and study of records.

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6. Compile study report group wise and present to the class for improvement.

7. Assess the study report as per the guidelines given in the curriculum guide.

Activity 3 – Field trips to learn how a Pig Farm is managed

1. Plan field trip and reflect on the academic calendar at the beginning of the academic session.

2. Discuss field trips with the students at an appropriate time of the academic session.

3. Prepare field trip plan as per the guidelines suggested in the curriculum guide.

4. Prepare study questionnaires based on the theory learned from the chapter.

5. Carry out field trip, write report, present in the class and assess the field trip or study report as per the assessment guideline tool.

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7 Forest for Agriculture

CHAPTER

Forests have been the main source of construction materials, timber for making furniture, for firewood, leaf litters for making farm yard manures and fodder for the livestock of Bhutanese society Forests are the source of raw material for a number of industries like sports goods and matches. Many kinds of medicinal plants and other useful materials like gums, resin, turpentine oil are made from the raw materials found in forests. However, there is a limit to what natural forest can sustain these resources. There is a need to create 'human made forests' that can supplement natural resources and support agriculture activities.

This chapter provides the basic concept of forest, its importance linked to 'Agriculture for Food and Nutrition Security', services derived from forests, water and watershed and home for biodiversity. Types of forestry such as community forestry, private forestry, agro-forestry and management of nursery and plantations are being discussed. These topics are expected to provide basics knowledge, skills and values to the learners with which they will be able to start entrepreneurship in private forestry or agro-forestry for self-employment and employment of others.

7.1 Forest and its Importance

Forest is not only a large area of land thickly covered with trees and bushes, but homes of biodiversity and its sustenance. Forests are sources of numerous natural resources for the people and also help to preserve agricultural land from erosion.

Forests keep the environment pleasant because they draw moisture from earth through their roots and transpire it in the air through their leaves. Decomposed leaves form humus which is the biggest source of soil fertility help agriculture. Forests are the biggest source of oxygen which is essential for human, animals and plant life. This isn't new knowledge, remember your biology lessons? Let's recap.

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Forests are crucial for the well-being of life on Earth. They provide foundations for life on earth through ecological functions, by regulating the climate and water resources, and by serving as habitats for plants and animals. Forests also provide a wide range of essential medicines, in addition to opportunities for recreation, spiritual renewal and other services. There is no end to the list of importance of forests if one adds. However, it is important to understand essential ones provided hereunder.

a) Services derived from the forests

Broadly the services derived from the forests can be categorised according to the criteria and specific objectives. Some important service functions of the forests are discussed under ecosystem services, recreational services, water and watershed services, forests as a carbon sink, forests for bio-diversity and leaf litter services.

i. Ecosystem services

An ecosystem is a community of living organisms and non-living components of the environment interacting in a system. These components are linked together through nutrient cycles and energy flows. Therefore, the ecosystems can be defined as the network of interactions among and between organisms and their environment. Mankind benefits in number of ways from ecosystem and collectively the benefits from ecosystem are known as ecosystem services. Ecosystem services can be further classified as economic service, socio-cultural services, landscape and scenic services.

ii. Recreation services

Forest provides recreation opportunities which include host of other specific sub-activities. Recreation is very important part of human life and these recreational activities may be in many different forms which are shaped naturally by individual interests but also by the surrounding social settings. The growing number of towns will require recreational areas like parks etc. within or near the towns. With the urban dwellers getting more environmentally concerned, they will start demanding the authorities for providing the facilities in the urban areas. Recreational activities can be community based or individual based, outdoor or indoor. It is, therefore, very important to plan properly and initiate recreational programmes that will benefit to the society as a whole. Production of recreational facilities requires inputs like labour, capital and entrepreneurship.

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iii. Water and watershed services

Forests are one of the sources of water. A watershed is an area of land that catches rainfall and other precipitation and funnels it into a stream, river, lake, or other water body. Healthy forests provide a host of watershed services, including water purification, ground water and surface flow regulation, erosion control, and bank stabilization. The loss and degradation of forests can reduce their ability to provide the watershed-related services.

iv. Forests as a carbon sink

Forests also act as a carbon sink whereby tree leaves absorb carbon dioxide from the atmosphere during the process of photosynthesis. Bhutan has a very good opportunity to reap the benefit derived from the forest, as a major carbon sink and engage in carbon trading (deriving monetary benefits from maintaining forest cover).

v. Forests for biodiversity

Forests are important habitat for biodiversity of both plants and animals. It means the more forest we have, the more number and kinds of plants and animals we have. Such diversity of plants and animals is important for people.

vi. Leaf litter

Leaf litters are the dead leaves and other debris that have fallen on the forest floor where they decompose and form organic manure which is essential in agriculture. Our farmers collect leaf litter from the forests and heap it in their fields where it decomposes and provide manure for crop production.

Almost all the services discussed are from natural forests which is being depleted due to rapidly expanding urban and semi-urban population and their construction industries. However, the Bhutanese rural population is also migrating to urban and semi-urban centres seeking for an easier life, leaving behind their fertile arable land. This trend of rural population provides opportunities for entrepreneurship in private forestry or human made forests to expand forests services. Some categories of forestry are discussed which are opportunities for entrepreneurship for the Bhutanese literate youth.

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7.2 Types of human made Forestry

There are many grouping of forests based on the management. There are some which are directly related to agriculture and where farmers are involved in managing and utilising them. These forests are community forest, private forest and agro-forestry. Let us briefly discuss what they are.

a) Community forestry

It is the practice of forestry where any area of government reserved forests, that are suitable for management by a community, is handed over to the community for management. Such forest area is designated as community forest.

The people living in the rural areas depend on forest resources for their day to day requirement like fuel wood, timber, grazing areas for their cattle and edible non wood forest products. The communities manage their forest in line with the management plans which are normally for ten years. The plans are prepared by the communities with technical support from forestry extension staff. The community forests have the potential to produce wood products, such as construction timber and firewood, and a range of non-wood forest products, such as mushrooms, medicinal plants, fodder for animals, cane and bamboo.

The importance of community forests for the country and farmers in particular cannot be overemphasized. Besides harvesting the timber, firewood and non-wood forest products for meeting their needs, the community forests help in protecting the environment and ameliorating the local weather condition. Farmers obtain fodder for their animals from these forests besides serving as grazing area for cattle. The community harvests the timber, firewood and non-wood forest products and use for their own requirements. The excess is sold in the market and earn substantial income which they deposit in the bank. The fund is managed by elected committee members of the community forests.

b) Private Forest

It is the practice of forestry in private registered land of the individual and constitutes planting or nurturing of trees growing on such land. The owners have to register such forest through the Dzongkhag Administration. The Department of Forests and Park Services do not levy royalties on the timber grown in private forest if the owner wants to sell, use or transport the timber within the country.

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However, export of timber, in primary form, is not allowed.

Private forests also contribute to food security in many ways. The type of trees commonly selected for planting in private forests include those for household use and as well as having commercial value, mainly fast-growing trees. Timber and firewood produced in excess of household requirement are sold in the market and the owners earn extra cash income. People also integrate multi-purpose trees and grasses in the private forests which have become very helpful for soil conservation and improving the nutrient level of the land.

The Department of Forests and Park Services provide technical backstopping to anybody who is interested to establish private forests within their registered land. The private land other than wetland (chuzhing) within 25 acres ceiling including any marginal land registered as private land are most suitable for raising private forests. The owners of private forests are allowed to sell their forest produce by paying a token royalty to the Government like any business. Therefore, there is a better scope for starting enterprise in private forestry.

c) Agro-forestry

Agro-forestry is defined as an efficient, integrated and sustainable land use system that combines agricultural crops, forest crops and/or livestock together on the same unit of farmland at the same time or in sequential manner. In agro-forestry, there are both ecological and economical interactions between various components. It is an approach to alternative land use based on deliberate integration of trees with crops and livestock production systems. It combines agricultural and forestry technologies to create more diverse, productive, profitable, healthy and sustainable land use systems. It is a land use management system in which trees or shrubs are grown along with agricultural crops and pastureland.

Agro-forestry includes various types of practices; including alley cropping, forest farming, shelterbelts, riparian buffer strips, and silvo-pastoral systems. In dry and waterless environments, agro-forestry systems support livelihood improvement through concurrent production of timber, food, and fodder for animals, fuel wood and livestock rearing without affecting the ecosystem.

In our country, the concept of agro-forestry was in practice since time immemorial. Farmers practiced the system by combining trees, crops and animals in their farms. The system combines production of multiple outputs with protection of resources.

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It places emphasis on the use of multiple indigenous trees and shrubs requiring low inputs where the environment is fragile. In structures and functions, agro-forestry is more complex than single crop culture.

The choice of species combination (trees-crops) is very important in agro-forestry. The trees-crops association is decided in such a way that it produces beneficial effects to each other. Wrong combination of species leads to plants interaction – some plants producing harmful effects known as allelopathic compounds. These compounds when released in the environment through leaves or exudation from roots, effects exclusion of shrubs and herbs beneath the trees producing such compounds. This condition will eliminate crops that are planted below or in between the trees. The knowledge of trees-crops association is very important and select plant species that have effect that is mutually benefiting or facilitating to each other's development instead of mentalism or competing each other.

d) Benefits of agro-forestry

Agro-forestry not only produces goods and services but also supports soil conservation and produces timber for fuel wood and construction materials. Like any other natural forest, it also controls of air pollution, reduces greenhouse gas effect and protects watershed. It may be good to learn more about the benefits of agro-forestry.

i. Soil conservation

Agro-forestry play very important role in conserving soil and controlling soil erosion. Soil erosion is one of the important causes of land deterioration. Soil, when eroded, plants nutrients associated with the soil are removed to places where they are not required. The sediments eroded from the catchment act as pollutants and affect the environment. Top soil contains nutrients and when it is washed away the productivity of the soil is reduced and the crops growing in the locality will be greatly affected.

Soil conservation measures using engineering structures are very expensive for the developing countries as the soil conservation measures require multiple activities integrating conservation measures and production systems. In agro-forestry practice, conservation of soil is placed very high priority in the use of vegetative measures and not on engineering works. Vegetative method is a low cost but very effective in controlling the soil erosion. The agro-forestry activities are concerned

with the production system and biomass production becomes prime objectives. Activities like pasture development, annual crop production, fodder and fuel wood production is given high priority which generates many tangible benefits within a reasonably short period of time for the local people of the area who are involved in agro-forestry practices.

ii. Production of small timber and fuel wood

Trees are important component both from ecological and economic point of view of agro-forestry and therefore timber, fuel wood and non-wood forest products production is main components followed by agricultural crops, fodder for animals and leaves for enriching the soil. Farmers have additional income through the sale of timber and fuel wood in addition to agriculture products such as crops and animal products. They have better chances of sustaining their farm at the times of natural calamities or insects/disease with the opportunities of harvesting diverse products at different time of the year. There is great opportunity for farmers to earn extra cash income through the sale of small timbers, fuel wood, medicinal products, and non-wood forest products. The agro-forestry system has great potential as a tool for poverty alleviation and practicing climate smart agriculture practices in Bhutan where more than 69% of its population lives in rural areas and depend on agriculture, livestock and forestry for their livelihood.

It is very extremely important for the farmers or farm workers to take agro-forestry, understand clearly the importance of managing the agro-forestry sustainably by incorporating all the principles of good forest management practices. Forest management starts with the management of nursery. It means raising tree seedlings so that we can plant them wherever necessary. Let us discuss the nursery management.

7.3 Management of Forest Nursery

Forest nursery is an area where plants are raised for planting out in the barren and eroded land. The objective of forest nursery is to produce the healthy seedlings required for plantation. Therefore, the choice of the site for nursery is influenced by several factors as location, accessibility, topography of the land, soil conditions, water and other vegetation. The factors, essential for consideration while selecting the site for forest nursery is provided in Table 7.1 below.

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Table 7.1 Important factors for selecting a nursery site

Factors	Specific feature
Central location	located centrally with reference to plantation site to avoid higher transportation cost.
Accessibility	should be accessible with the road so that it will ease the supervision and transportation of materials
Topography	should be preferably flat or with gentle slope. Uneven of steep slope will incur more cost for levelling and terracing.
Soil condition	should be well drained, sandy loam to loam in texture, rich in nutrients and humus is preferable. If seedlings are raised in containers, then topography and soil factor becomes less important.
Water	availability of water is very important for good nursery.
Vegetation	should not be much wooded, at the same time it should not be without trees also. Nursery requires sunlight as well as shade.

a) Nursery size

Size of nursery means area of the nursery. The area of the nursery depends upon the species, age of seedlings or transplants required at the time of plantation. The number of seedling required depends upon the plantation space.

b) Preparation of the nursery site

Once the site of the nursery is selected, depending on the requirement of the seedlings, the area is determined and its layout is finalised and prepares the nursery as per the layout.

c) Seed bed

A seed bed is a prepared area in the nursery where seeds are sown or raised. These beds are very important component of the nursery. During the preparation of bed shape and size of the bed, types of bed and surface of the bed are to be taken into consideration. Most of the time rectangular beds are preferred than other shapes. The width of the bed should depend upon the area available. However, width of the bed should be kept such that it can be weeded from both sides without entering into the bed. Three types of beds are usually practiced in forestry such as:

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- ***Raised bed*** – made in high rainfall areas. Raised beds are made 10-15cm above ground level to prevent water logging with the support of local materials (e.g. stone).
- ***Sunken beds*** – made in dry areas. These beds are usually 15cm deeper than the normal ground level which allows retaining water with in the periphery of the bed and keeping the bed moist.
- ***Level beds*** – made in normal rainfall areas.

d) Method of sowing

Usually two methods of seed sowing in the nursery beds are:

i. Broadcast sowing

In broadcast sowing, desired quantity of seeds are sown by hand when seeds are larger in size. The smaller/minute seeds should be mixed with earth or sand and then broadcasting should be done. After the broadcasting soil can be spread across the bed and pressed to ease the germination and also avoid the birds to eat up the seeds.

ii. Dibbling

Dibbling is usually practiced with the larger seeds which can be handled easily. Though dibbling is a good method because both spacing and depth of sowing are controlled, but it is difficult to practice on a large scale.

iii. Shading

Figure 7.1 Shades used in the nursery

The objective of shading is to provide protection to the plants from the sun, frost, rain, and hail. Shading protects tender seedlings from intense solar radiation and high temperature. It also reduces evaporation and transpiration. Shading is provided to several seedling species which are not able to tolerate very hot and cold temperature. Common types of shades are thatch, grass, and bamboo mats. The cheapest shading can be provided with materials which are cheap and available locally. When shades are provided over the seed beds, it is necessary to harden-off

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the seedlings by removing the shade gradually before seedlings are taken out for planting. This hardening enables the plants to withstand the temperature outside.

e) Use of containers

Use of containers for raising seedling is common. Either seeds are directly sown in the containers or the seedling raised in nursery beds are transplanted into containers and allowed to grow for some time before it is planted out in the field. The plants from the seed beds should be transplanted into containers early after germination and not after the period when four leaves appear and turn green. The most commonly used container in our country is polythene pots. This polythene pots are found in various sizes for meeting diverse requirements. The container (polythene pots) planting gives better result compared to others because as this causes minimum disturbance to the root system, less damage during transportation and can be kept for longer period of time in the field before actual plantation.

f) Care and Handling of seedling

From the time you receive your seedlings until they are planted, proper care is vital to maintain their healthy condition. Remember, seedlings are perishable. So, it's best to plant them as soon as possible once you have received them. Here are a few seedling care and handling tips to keep in mind:

- Minimise exposure to wind and sun during transporting seedlings.
- Allow for ventilation around stacked seedling packages.
- Protect seedlings from freezing temperatures.
- Mend any accidental tears in the seedling package with tape to reduce moisture loss.
- Protect seedlings from direct sunlight and wind before and during planting

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7.3 Plantation

The plantation site needs to be made ready much before the seedlings are ready for the plantation. Various types of plantation are there according to the function of the plantation. Some of the plantations are landslide plantation, riverbank plantation, road side plantation and agro-forestry plantation. The plantation is on the unused or on a private land which cannot be utilised for other purposes. This provides an opportunity for the landholder to come up with the plantation on the barren land or on a land which could not be used for other purposes due to marshy area or rocky site suitable only for growing trees but unsuitable for agricultural purpose.

The plantation done on private land becomes the property of the individual and can be managed as a private forest. The timber/ wood obtain from the such forest can be used for various purposes such as, building a house, cowshed, making furniture, poles for fencing, handles for the agriculture tool, and many more. Private forest not only serves the purpose at the individual but also helps in protection of our natural forest from overuse. Different plantations can be carried out to make forest resources more sustainable.

a) Types of plantation

i. Afforestation

It is used in describing forests established artificially on land that previously did not have forest for at least 50 years. For example, when people establish a new forest on grassland or barren land, such afforestation is clearly artificial and can be termed afforestation plantation.

ii. Reforestation

It is used when forests are established artificially on land which had forest or trees within the previous 50 years, involving the replacement of the previous crop by an essentially different one.

iii. Enrichment plantation

It is referred to planting trees within existing forests to rejuvenate forest by "inter planting". Trees are planted in existing forests for "enrichment" by filling in of natural gaps in forest regeneration with the planting of young trees or sowing of

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tree seeds, usually spaced systematically under most or all of an existing forest.

Enrichment plantation is required in the forest where forest resources have been over used by commercial economic activities or livelihood activities of rural communities. It may also be due to natural calamities such as forest fire that has destroyed smaller tress and undergrowth making the forest difficult to regenerate its richness. Continuous exploitation of forest resources will inevitably result in the depletion of forest resources which the life on this earth cannot afford. Humans are responsible and therefore a need for intervention, if this earth needs to continuously support life on it.

There are opportunities for young Bhutanese to understand the science behind maintaining forest and the opportunities for entrepreneurship that the forestry offers. NWFPs provide income for the farmers during off season and also food, medicinal and aromatic products and fodder for the animals. NWFPs often are a safety-net for poor people during off-farm season or whenever needed. The contribution from NWFPs to peoples' livelihoods and the potential for commercialisation has been widely acknowledged in Bhutan over the last few years.

(a) Handle seedling carefully in the polythene bags

(b) Remove the impervious polythene bag before planting

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(c) Place the seedling carefully inside the pit

(d) Fill the pit with the soil

(e) Firm the soil around the seedling by foot

(f) Water the seedling after planting

Figure 7.2 Diagrammatic representation of planting

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Student Activity

Activity 1 – Writing an assignment on Agro-forestry, private forest and community forest.

1. Instruct students to choose Agro-forestry, private forest or community forest and ask them to write assignment of 250 words answering:
   a) How is natural forest useful to humans?
   b) How might agro-forestry, private forest or community forestry support humans with required natural resources.
2. Set a dateline to submit the assignment, collect, correct assignment and award marks as per the assessment tool suggested in the curriculum guide.
3. Record assignment mark.

Activity 2 –Start forestry in the school campus

1. Study the school campus of its land use for construction, gardening activity, footpath, types of plants, and recreation, against the climatic conditions and the requirement of the school children.
2. Plan land use for different activities of the school and plantation suitable for the climatic conditions of the school.
3. Propose to the school principal on the project and support required.
4. Prepare nursery of different plants as per the guide, raise seedling, and transplant plants as per the plan of plantation of the campus.
5. Care for the plants and records of development.
6. Assess the work of students using the assessment tools provided in the guide.

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8 Establishing an Entrepreneurship in Agriculture

CHAPTER

In the earlier chapters of AgFS, you have learned agriculture practices, their suitability linking to agro-ecological zones and how agriculture activities contribute to Bhutanese economy for its sustenance. To make this subject more relevant and holistic, this chapter links agricultural activities to the concept of business and entrepreneurship in agriculture. The growing of vegetables, fruits and other horticulture crops, rearing of livestock, forestry activities will now be connected to the idea of business and commercial purposes.

This chapter attempts to deepen understanding of the concept of enterprise in agriculture. Small scale entrepreneurships are the drivers of competitiveness and innovation in many economic sectors and impact directly on employment. Starting a small scale entrepreneurship in agriculture is increasingly becoming important and gaining popularity now in the light of rising unemployment. It is hoped that this chapter will be useful and interesting to those students who are interested in self-employment or employing others in agri-business. .

8.1 Establishing an Enterprise

It is not an easy task to start any business or an enterprise, especially if anyone want to start without any business experience but it is not impossible. One must have interest and determination or will power to make a living honourable and help other benefit from one's good actions. This driving force will facilitate learning different tricks of the trade in taking up agriculture for business. Some basic concepts are mentioned hereunder.

a) Understanding the Concept of an Enterprise and its Entrepreneurship in Agriculture for Food Security

This involves understanding the business of agriculture for food security – what is it all about and how do we go about starting this business or an enterprise of agriculture. It is essential to have clear ideas to perform any work successfully.

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If the concept of the work is not clear, it is not possible to start the work with success. Therefore, any aspirant entrepreneur should acquire sound idea and clear concept of what he/she intends to do as an entrepreneur. Clarity on this helps you to run the enterprise smoothly and also to explore the possibilities of taking new initiatives. It further helps you take right decisions.

b) Procedures of starting a business/enterprise in Agriculture

To start any business in agriculture, learn more about the business as in (a) and follow specific procedures as follows but notnecessarily in this sequence.

i. Identification of Economic Activities for the business

For example: 'growing vegetables and fruits for sale'. The ideas of growing vegetables and fruits were already learned in earlier chapters. Here you are now to link growing and you are going to do it as a business. You are making a decision to take this activity as a business. However, before you really start working on it need to find out next step. That is

ii. Assessing the available Capital and other resources/assets.

It is important for you to calculate the cost of starting this business. It is to find out how much you can afford verses the amount that you want to invest in this business. You may have the capital or you have other sources that you can depend upon. This also involves making decision but you have at this stage you have no risk.

iii. Calculating all variable costs, fixed costs required for production and finding out the gross margin analysis and other budgeting and planning required for the business.

The costs may change with time. It may become more of less depending on the market. To calculate variables costs one needs to think of farming processes starting from land preparation to sowing seeds, care of crops, harvest to reaching harvest to the customers – such as the cost of hiring labour or machinery, cost of seeds, repair of fence or cost of fence, watering facilities, transporting and marketing. The calculation is approximately done based on the existing market value with a small percent provision for inflation.

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iv. Careful identification of Marketing channel and marketing strategy for selling the product.

This refers to deciding how and who may be involved in selling your agriculture produce at what cost and conveniences. This may be included as an item along with marketing survey and confirm how you may go about selling your products.

v. Understanding Risks in Business and having a back-up plan.

All business entrepreneurs need to take some calculated risks in taking up business. The risk may be for any activity, machinery, seeds, care of crops, harvest, water, fence, market, transportation, etc. and the management need to have a backup alternative plan in case the original plan does not work or face problems.

vi. Conducting market survey to assess the demand for the product.

This is perhaps the most important aspect of business management that will determine the success of a business. Ample of time and resources need to be invested in marketing survey. It must be done well. This not only to find out how much to produce and at what cost the customers are willing to pay for the products but the quality they demand, when, where, in what form, and potential competitors.

vii. Carrying out strategic planning for growing vegetables and fruits for sale as an Enterprise.

The marketing survey will can help you determine approximately what should be grown and how much fruits and vegetables (examples) to grow. Based on this survey, your business can be planned, using the resources available as the capital within specific period of time with proper timeframe. Strategic planning is predetermining what is expected to happen in the project of growing fruits and vegetables business carefully considering all aspects of growing fruits and vegetables and recording systematically, stepwise and reflectively.

viii. Keeping proper records and detailed accounts.

In any business, record keeping is an essential element of management of business. It is not only important to record the decisions and resources being invested for accountability and calculating cost of produce but to make decisions on the assessment of business for innovation andexpansion. Detail records of:

1. decisions taken,
2. resources invested,
3. detail accounts of what goes in the business project of growing fruits and vegetables from
    i. planning stage,
    ii. purchase/hire of tools and equipment,
    iii. hiring of people,
    iv. engaging them to work with tools,
    v. starting work,
    vi. taking care of workers with food, medicine, shelter, and payment,
4. preparing the land,
5. seedling/sapling for plantation,
6. plantation,
7. watering the crops,
8. providing manures and other care for healthy growth and development till the time of harvest,
9. preparation for harvest,
10. preparation for market,
11. transporting to the market for sale and the provision of care till the produce is sold,
12. keeping records of what are being sold and money entered into account register. The account settlement includes making the payment, add up income and calculate balance.

This will enable the management to see at a glance cash position of the project.

8.2 Writing a Business Proposal

It is essential for an entrepreneur to acquire the skills of writing project proposals. Writing a project proposal not only will help one to determine pros and cons of the entrepreneurship that he/she intends to start but also help understand business and business procedures of starting an enterprise. Writing project proposal is an

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important skill for any entrepreneur. It will come handy whenever one wants to get loan to start a business. This skill will be useful if you want to start an agriculture farm on a barren land. Here is an example of writing a project proposal to start Agriculture – a mixed farm?

Outline of a standard business proposal (any business proposal should contain at least the following information in their proposal):

✓ ***Executive Summary*** - Write this last. It's just a page or two that highlights the points you've made elsewhere in your business plan – a mix farm/Backyard Poultry Farm.

✓ ***Products and Services*** - Describe what you are planning to sell (vegetables/ fruits and milk, etc.) and it is always a good idea to think in terms of customer needs and customer benefits as you define your product.

✓ ***Market Analysis Summary*** - You need to know your target market, the types of customers you will be selling your products and how you intend to sell your products. Use this section to discuss your customers' needs, where your customers are, how to reach them and how to deliver your product to them.

✓ ***Strategy and Implementation Summary*** -Use this section to outline your marketing plan, your sales plan, and the other logistics involved in actually running your business. You'll want to cover the technology you plan on using, your business location and other facilities, special equipment you might need, and your roadmap for getting your business up and running.

✓ ***Company and Management Summary*** -This section is an overview of who you are. It should describe the organisation of your business, and the key members of the management team, when your business will start, who is/ are the owner(s), how many people will you be employing, at what levels will the people be employed, who will be the overall manager and who will be operations manager, what kind of technical expertise is required for the business, etc.

✓ ***Financial Plan*** - At the very least this section should include your projected Profit and Loss, Cash Flow tables, and a brief description of the assumptions you're making with your projections. You may also want to include your balance sheet, your sales forecast, business ratios, and a break-even analysis.

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Finally, if you are raising money or taking out loans, you should highlight the money you need to launch the business.

a) Example of a Business Proposal

i. Project title

Backyard Poultry Farm/mixed farm: Specify the title of the entrepreneurship. For example, students of Lango Middle Secondary after carrying out market survey have come up with a plan to start Backyard Poultry Farm in their school. So they may write, "Backyard Poultry" as a project title.

ii. Project site

Lango, Naja Gewog, Paro: Choose a site which is centrally located. The location should be based on the market survey.

iii. Location

Lango Proper, 500 m towards upstream from Lango Market : The aspirant entrepreneur should be able to choose a suitable location considering the accessibility to optimal facilities.

iv. Beneficiaries

Get the details of the end users of your services.

Table 8.1 Estimated beneficiary population

Sl. No	Potential Market/ Beneficiaries	Approximate Distance	Approximate Population
1.	Kichu Resort	1 km	100
2.	Residents of Geog	2kms	300
3.	Inhabitants of in and around Lango Township	1km	550
4.	Employees of Lango MSS	1km	150
5.	Employees and local inhabitants of Drugyel	3kms	500

v. Rationale

The population of Lango is rapidly growing. As a result, the demand for goods

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in is increasing. There are many shops that supply essential food items. However, the poultry farm products do not seem to meet the demand of the population.

vi. Goal

The main goal of the poultry farm is to supply fresh and prompt supply of farm products.

vii. Structural Plan

The structural plan is designed as per the technical requirements.

viii. Manpower

The management of the farm will require:

a) Manager 1
b) Accountant 1
c) Marketing officer 1
d) Care Taker 1

v. Plan of action

The following tentative plan of action will guide the implementation of the project (as an example).

Sl. no.	Activities	Time Frame	Cost Estimate
1	Acquisition of land (purchase or on lease)	Dec. 2015	555,000.00
2	Completion of formalities to establish the farm	January, 2016	25,000.00
3	Site development	Feb.2016	150,000.00
4	Procurement of materials	Feb.2016	250,000.00
5	Development of infrastructure	March, 2016	75,000.00
6	Establishment	April, 2016	50,000.00
7	Maintenance		10,000.00
		Total cost Nu	**1115,000.00**

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vi. Strategies

The step wise strategies should be mentioned. For example, the establishment of the farm will require adequate space located within easy access of users. The space will have to be obtained on lease after thorough consultation with the concerned authorities. The expenditure for the site development and construction of wall is estimated to cost Nu. 1115000.00.While the source of fund to establish the centre will be made available from personal contribution about 60 to 70% of the expenditure shall be met from loan which will be acquired from one of the financial institutes.

The construction of the farm will be done in two phases. In the first phase the construction of one block of building with 10 units to suit to the needs of rearing birds will be completed. In the second phase the construction of the second block for the staffs and manager will be completed.

vii. Profit analysis

The monthly revenue to ensure the sustenance and the efficient functioning of the farm will be generated from the users.

- ✓ ***Collection***: The monthly income is mentioned here. For example, the monthly collection of income on sale of eggs and chicken products is estimated to be Nu. 80,000.

- ✓ ***Expenditure:*** The estimated list of expenditure including the costs on establishment, daily expenses on operation, and so on should be calculated and mentioned below.

1. Total payment of salary	Nu. 20,000
2. Payment on rent & electricity	Nu. 10,000
3. Purchase of feeds	Nu. 15,000
4. Expenditure on other areas	Nu. 3,000
Total expenditure	**Nu. 48,000**

Profit or loss = (i - ii): The profit or loss is calculated by subtracting money spent / expenditure on running the project from the money collected from selling produce and related product from the farm. The project earns a monthly profit of (Nu. 80,000 – 48,000) = Nu. 32,000.00).

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b) Investment in project development:

The business proposal prepared for seeking support from the financial corporations like Bank, BDBL or RICBL need to mention the amount required as loan and how loan will be repaid in an affordable instalment term. It is also important to save certain percentage of income for further improvement or further development of the firm.

c) Roles and responsibilities

Roles and responsibilities of the staffs/manager are mentioned below.

- ✓ The manager is the over all in-charge of the farm. His/her responsibilities include planning, execution and evaluation of daily activities of the farm.
- ✓ The manager is also responsible for up-scaling the business after careful assessment of the business performance from time to time.
- ✓ The manager is the Public relations officer and should be responsible for developing linkages and seeking services from government agencies for example in this case; from the Department of Livestock for various services that could be disease control, inputs, etc.
- ✓ The accounts officer will maintain up to date records of daily income and expenditure. He/she is responsible for all kinds of cash transaction.
- ✓ It would be the duty of the marketing officer to plan the purchase of necessary materials required for the farm and ensure the sale of farm products efficiently.
- ✓ It is the joint responsibility of the marketing officer and the manager to plan increase in sales projection by exploring new markets.
- ✓ It is also the role of the marketing officer to forecast future sale and plan production accordingly.
- ✓ The care taker looks after the property and the health of the birds.
- ✓ With the changes in the business operation the roles and responsibilities will also change for all personnel engaged in the business. Therefore, it is the responsibility of the manager to review and amend the Terms of Reference for all staffs from time to time.

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Student Activity

For an effective management of business entrepreneurship, leadership is vital. It is important to spell out details of how the business entrepreneurship would be operated. The management based on democratic principles of collaborative decision making, collective efforts based on a shared vision of accountability, transparency and effectiveness is bound to bring success in any business.

Activity –writing a proposal of starting an entrepreneurship in Agriculture and forestry

1. Choose any Agriculture activity which can be taken up as an entrepreneurship in your locality.
2. Write a concept paper of the entrepreneurship of Agriculture activity that has been chosen in a particular locality – what, why, how, resources required and when the entrepreneurship is proposed to begin.
3. Prepare a feasibility and marketing survey of the proposed entrepreneurship project.
4. Conduct a mock survey and write a report on the entrepreneurship survey.
5. Assess the project as per the assessment guide of AgFS

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ABREVIATION

Ac	Acre
AEZ	Agro-ecological Zone
Asl	Above sea level
BAFRA	Bhutan Agriculture and Food Regulatory Authority
Ca	Calcium
CAN	Calcium Ammonium Nitrate
Cm	Centimetre
CNR	College of Natural Resources
DAMC	Department of Agriculture Marketing and Cooperatives
DoA	Department of Agriculture
DOC	Day Old Chick
DoFPS	Department of Forest and Park Services
DoL	Department of Livestock
FYM	Farmyard Manure
g	Gram
GDP	Gross Domestic Product
GNH	Gross National Happiness
Ha	Hectare
HH	Household
IU	International Unit
K	Potassium
K_2O	Potash
MoP	Muraite of Potash
N	Nitrogen
NPDC	National Poultry Development Centre
NSB	National Statistical Bureau
NWFP	Non Wood Forest Product
^oC	Degree Centigrade
OXFAM	Oxford Famine Relief Organisation
P	Phosphorus
P_2O_5	Phosphate
P-P	Plant to plant
RH	Relative humidity
RNR	Renewable Natural Resources
RNRRDC	Renewable Natural Resources Research and Development Centre
RPBC	Regional Poultry Breeding Centre
R-R	Row to row
SAP	School Agriculture Programme
SSP	Single Super Phosphate

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GLOSSARY

Acid soil	-	refers to any soil with a pH below 7. The lower the number the more acid the soil.
Additives	-	substances added to a product, usually in small quantities, in order to alter its characteristics or quality.
Aggregate Fruit	-	a clustered fruit composed of numerous fruitlets each with its own seed, (e.g. strawberry).
Agri-business	-	the group of industries dealing with agricultural produce and services to agriculture.
Agriculture	-	anything having to do with farming (raising crops or livestock for food, fibre or fur; or the industry which includes marketing, processing and trade in these products).
Agro ecological zones	-	land areas classified by their biophysical attributes, (such as rain fed soil moisture availability, temperature, length of growing period), in order to cluster land use types into homogenous units for agricultural production considerations.
Agro ecology	-	the design, development and management of sustainable agro ecosystems based on the application of ecological principles while considering existing social, cultural, and economic factors of farming communities.
Agro ecosystems	-	a system where communities of plants, microbes and animals inhabiting farmed land, pastures, grasslands or rangelands, interact with each other and their physical environment.
Agroforestry	-	an agroforestry system is a form of multiple land use where woody perennials (trees, shrubs, bamboos, palm trees, woody lianas) are grown on the same land management unit with crops and/or animals.
Agronomy	-	the science of crop production and soil management.

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Alley cropping	-	a cropping system that involves growing crops in a wide strip, typically 6 metres in width, between lines of closely planted, fast-growing trees or shrubs. These woody species are usually leguminous and are pruned frequently to provide a mulching material and nutrients to the crop in the alley.
Alternative farming	-	production methods other than energy- and chemical intensive one-crop (monoculture) farming. Alternatives include using animal and green manure rather than chemical fertilisers, integrated pest management instead of chemical pesticides, reduced tillage, crop rotation (especially with legumes to add nitrogen), alternative crops, or diversification of the farm enterprise.
Animal Welfare	-	the proper care of animals.
Annual	-	a plant that grows one season and produces seed for next year, (e.g. peas).
Aquaculture	-	the cultivation of aquatic animals and plants, including freshwater and marine species, for food or other purposes.
Artificial insemination	-	the delivery of semen into the uterus of the female animal usually by injection with a syringe-like apparatus for the purpose of achieving fertilisation and sexual reproduction.
Avian	-	relating to birds.
Avian influenza	-	an Influenza A viral infection of wild birds or domestic fowl, certain strains of which cause high mortality in poultry.
Bacteria	-	microscopic, unicellular organisms found almost everywhere, appearing singly or in chains. Some cause disease and some are beneficial.
Baler	-	a machine used to compact and package roughage such as hay or straw.
Barn	-	a building used to shelter animals or store hay.
Basal dressing	-	the application of compost or fertiliser in the soil before planting in the field (or application during the land preparation).

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Basin irrigation	-	an irrigation system in which a field or orchard is divided into basins which are filled with water.
Beta-carotene	-	orange pigment in plants that is a form of vitamin A
Biodiesel	-	a biofuel for use in diesel engines produced through the transesterfication of organically-derived oils or fats combined with alcohol (ethanol or methanol) in the presence of a catalyst. It may be used either as a replacement for or as a component of diesel fuel.
Bio-diversity	-	biological diversity; a measure of the variety of species of plants animals or other organisms in an ecosystem.
Biological Control	-	the use of living organisms such as bacteria, fungi, or insects to control harmful weeds or insects which infest crops; this type of control excludes the use of chemical substances and relies mainly on natural sources.
Biological corridors	-	areas connecting separated habitats which allow movement to and access by wild species. These spaces make gene flow between isolated populations possible and may ameliorate negative effects of habitat fragmentation.
Biomass	-	the total amount of organic matter present in an organism, population, ecosystem or given area.
Bio pesticides	-	bio pesticides are certain types of pesticides derived from such natural materials as animals, plants, microorganisms, and certain minerals.
Biotechnology	-	the use of all or part of an organism to perform a task, function, or produce a product.
Boar	-	male hog or pig with intact testicles or uncastrated male pig.
Bovine	-	family of animals including cattle and buffalo.
Brassica	-	cruciferous plants with tap roots and erect branched stems, including cabbage, brussel sprouts, mustard, canola, cauliflower, and kale.
Bread	-	a food baked from wheat and/or other grains.
Breeding stock	-	Plants or animals used in breeding, selected for traits desired in producing the next generation.
Broiler	-	a chicken or turkey raised for meat and slaughtered at less than half mature weight.

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Brood hen	-	a hen that is used to keep eggs warm for hatching.
Brooder	-	a heated house for chicks, piglets, etc.
Bull	-	an adult, male bovine used primarily for breeding.
Butter	-	a solid, yellow substance of fat, air and water made by churning milk or cream.
Calf	-	a baby cow or bull.
Calve	-	to give birth to a calf.
Canola	-	a crop whose seeds are used for making cooking oil; also, its meal is used as a livestock feed.
Cash Crop	-	any crop that is considered easily marketable, as wheat; a crop for direct sale in a market, as distinguished from a crop for use as livestock feed or for other purposes.
Castrated Animal	-	an animal that has had its testicles removed.
Cattle	-	more than one bovine animal (bulls and/or cows); general term for all sexes.
Cereal	-	refers to crops from the grass family grown for grain (e.g. oats, wheat, barley, rye, corn); also a processed form of breakfast food.
Chaff	-	the empty pods or scale-like seed covers which are separated from the grain in the threshing and cleaning operation.
Cheese	-	a food product made from milk solids.
Chick	-	a baby chicken.
Chicken	-	a small, domestic bird (colour varies) kept for its eggs and/or meat.
Churning	-	strongly stirring or agitating to combine or to separate a mixture (e.g. cream to butter).
Cleaned Seed	-	seed which has been screened to remove weeds, seeds and chaff.
Coat	-	the external covering of an animal (e.g. mammals have skin and hair for a coat).
Colostrum	-	the first secretion from the mammary glands after giving birth. This thick yellow milk contains antibodies that are passed on to the young to protect them from disease.

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Colt	-	a more specific term for a male foal.
Combine	-	a machine which moves down the grain field removing the seeds from the stems of ripe plants of grains.
Commodity	-	raw materials or semi-finished goods rather than goods in general (e.g. milk, beef, vegetables, etc.).
Compost	-	a combination of organic matter, soil, nutrients, moisture, and lime in a state of partial decay.
Composting	-	the bio-decomposition of organic material, such as animal wastes, plant residues or sludges, in the presence of air, by controlled methods including mechanical mixing and aerating.
Conservation	-	the management and preservation of natural resources for present and future uses.
Conservation tillage	-	any of several farming methods that provide for seed germination, plant growth, and weed control yet maintain effective ground cover throughout the year and disturb the soil as little as possible. The aim is to reduce soil loss and energy use while maintaining crop yields and quality. No-till is the most restrictive (soil-conserving) form of conservation tillage. Other practices include ridge-till, strip-till, and mulch-till.
Contour farming	-	field operations such as ploughing , planting, cultivating, and harvesting on the contour, or at right angles to the natural slope, to reduce soil erosion, protect soil fertility, and use water more efficiently.
Cooperatives	-	an organisation formed for the purpose of producing and marketing goods or products owned collectively by members who share in the benefits.
Corn	-	a crop grown for human food, and as a livestock feed.
Corral	-	a fenced-in area for animals.
Cost of Production	-	expenses incurred by a business for production of a good or service. Production costs include raw material and labour. To find out the cost of production per unit, the total cost of production is divided by the number of units produced.

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Cover crop	-	a crop grown to cover and protect soil from erosion by wind and water, especially in winter.
Cow	-	mature female bovine; some used for milk and some for meat.
Cream	-	the yellowish part of milk containing 18 to 20% butterfat that is usually removed from the milk during processing.
Crop	-	the yield of produce at harvest.
Crop acreage	-	acres of a specific crop planted in a cropping season by farmers.
Crop coefficient	-	an estimate of consumptive water use by crops based on evapotranspiration values.
Crop residues	-	any organic matter left in the field after the harvest of a crop, e.g. leaves, stalks, stubble, roots, hulls.
Crop rotation	-	system of cultivation where different crops are planted in consecutive growing seasons to maintain soil fertility.
Crop Rotation	-	planting different crops in fields than were there previously. Used as a crop, soil management and conservation method.
Crop year	-	the year in which a crop is produced and harvested. Compare "marketing year."
Cropping systems	-	the pattern of crops grown on a given piece of land, or order in which the crops are cultivated over a fixed period.
Cross-pollinate	-	the passing of pollen from the male part of one plant to the female part of another plant of the same species.
Cud	-	a mouthful of previously swallowed food, regurgitated from the first stomach of ruminants. The cud is then chewed again further breaking it down for digestion.
Culling (animals)	-	the removal from the herd or flock of undesirable and/or inefficient breeding stock or diseased animals that will be sent to slaughter.
Cultivar	-	a plant variety produced by cultivation that keeps its characteristics even when reproduced.
Cultivating	-	preparing the land for the raising of crops.

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Cultivator	-	an implement that digs into the soil. It is used for breaking up land and ripping out weeds.
Cultural Practices	-	techniques used in growing plants that include planting disease resistant varieties, rotating crops, spacing and pruning methods, providing good drainage and irrigation.
Curing	-	to preserve meat, fruit, or hides by salting, drying, etc.
Curing (crops)	-	a postharvest treatment of crops to reduce water loss and decay during storage. In root and tuber crops, curing refers to the process of wound healing with the development and suberization of new epidermal tissue called wound periderm. In bulb crops, curing refers to the process of drying of the neck tissues and of the outer leaves to form dry scales. Crops can be cured in the field or in facilities designed for the process.
Cutting	-	any part of a plant that can be severed from the plant and grow into an new plant.
Dairy Farm	-	a farm where cows or goats are kept for the production of milk.
Dam	-	female parent of an animal
De-blossoming	-	the practice of removing flowers from plants. De-blossoming is done on fruit trees in order to increase the size and quality of the fruit crop.
Desiccate	-	remove the moisture from anything.
Dioecious	-	having male and female reproductive parts on separate plants.
Disease resistance	-	describing any organism which has low susceptibility or has the ability to withstand a disease caused by infectious agents (i.e., viruses, bacteria, fungi) or by parasitic nematodes, protozoa and helminths.
Disinfectants	-	substances used on inanimate objects that destroy harmful microorganisms or inhibit their activity.
Domestication	-	the process of breeding for one or more desirable characteristics in plants and animals.

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Donkey	-	an animal similar to the horse but has much larger ears and is smaller in size. They have recently become popular as a protector of sheep against coyotes.
Double cropping	-	two different crops grown on the same area in one growing season.
Draft animals	-	animals used to supply power to pull farming implements, carts, vehicles, heavy loads, etc.
Dressed Weight	-	the weight of an animal after slaughter, defeathering, or skinning and evisceration.
Dry land farming	-	a system of producing crops in semiarid regions (usually with less than 20 inches of annual rainfall) without the use of irrigation. Frequently, part of the land will lie fallow in alternate years to conserve moisture.
Dwarfing Rootstock	-	a rootstock that limits the size of the plant that is grafted onto it.
Ear	-	the entire head of corn including the cob, husk and silks.
Ecological footprint	-	an ecological footprint is a measurement of the area, whether land- or water-based, required to support a certain level and/or type of consumption by an enterprise, activity, individual or population. The footprint calculation assesses the resources (e.g.the amount of water, energy, nutrients or land, [natural capital]) required for the production of what is being consumed and the resources required to assimilate the resulting waste.
Ecology	-	the study of relationships between the environment and organisms.
Ecoregions	-	physical regions which are characterised by their distinct species and communities and are also classified by their similar physical characteristics such as climate, meteorological factors, topography, elevation, soil types, etc.
Ecosystem management	-	a natural resource management strategy or plan which is ecologically-based and considers all organisms and their environment with regard to the social, physical, and economic needs of humans.

Ecosystem services	-	benefits people and other organisms obtain from ecosystems; examples include: pure water and clean air, scenic landscapes, wildlife habitat and biodiversity.
Ecosystems	-	a functional system which includes the organisms of a natural community together with their environment.
Ecotourism	-	travel to natural settings with focus on the appreciation, conservation, preservation and sustainability of the area's natural resources and its surrounding community.
Egg	-	a roundish, hard-shelled body which can be used for reproduction (birds and most reptiles) or consumed as food.
Elevator	-	a building or terminal where grain is elevated and transferred to an alternate mode of transportation (e.g. truck to rail, rail to ship).
Embryo Transfer	-	the procedure where a female with desirable characteristics is induced to superovulate. The eggs are fertilised, and the resulting embryos transferred to other females.
Entomologist	-	a specialist in the study of the forms and behaviour of insects
Environment	-	the immediate surroundings of a plant or animal which influence its wellbeing.
Equipment	-	any material or apparatus used in farm production and operation (e.g. machines, gas tanks).
Ewe	-	an adult female sheep.
Factors of production	-	factors of production are the resources required for production of goods and services. They are generally classified into four major groups such as land, labour, capital and management (Entrepreneurship)

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Family farms	-	an agricultural business which (1) produces agricultural commodities for sale in such quantities so as to be recognised as a farm rather than a rural residence; (2) produces enough income (including off farm employment) to pay family and farm operating expenses, to pay debts, and to maintain the property; (3) is managed by the operator; (4) has a substantial amount of labour provided by the operator and family; and (5) may use seasonal labour during peak periods and a reasonable amount of full-time hired labour.
Farm	-	an establishment or plot of land, usually with a house, barn, silo, etc., where food is produced by growing crops or raising livestock.
Farm area	-	the area of agricultural land used for farming (crop and livestock production).
Farm enterprise	-	a farm enterprise is a component of a farm business. For example a farm may include crop enterprise and livestock enterprises.
Farm Gate Value	-	the cash value of a product when it leaves the farm.
Farm household	-	a farm household is a complex and dynamic decision making unit with multiple objectives where the family members manage the different farm activities.
Farm labour	-	people gainfully employed by a farm operator to assist with the farm work, including regular, seasonal, local, migratory, full-time or part-time employment.
Farm supplies	-	the different inputs (tangible and intangible) used for the production of farm outputs.
Farmer	-	a person who is engaged in the raising of crops, poultry or livestock.
Farmstead	-	an area that includes the human dwelling and other building which are often part of the farm.
Farrowing	-	act of giving birth in pigs
Feed Conversion Rate	-	the rate at which feed is converted into weight gain.

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Fertile	-	a) of soil; capable of producing an abundance of crops, b) of animals; able to reproduce.
Fertilisation	-	the joining of male and female to produce offspring.
Fertilisers	-	any organic or inorganic material of natural or synthetic origin which is added to soil to provide nutrients, including nitrogen, phosphorus, and potassium, necessary to sustain plant growth.
Fire break	-	a natural or constructed barrier used to stop or check fires that may occur, or to provide a control line from which to work.
Fixed costs (Ownership costs):	-	costs of goods that last more than one production cycle. For examples on the farm expenses incurred on machinery, equipment, land, house, etc.
Flora and Fauna	-	plant and animal.
Flour	-	cracked or powdered grain used in baking.
Foal	-	a general term for a baby horse (noun); to give birth to a baby horse (verb).
Food Processing	-	operations which are done to prepare food for storage or sale (e.g. canning, freezing, pickling, drying, etc.).
Forage	-	grass and legume crops used for livestock feeds.
Fowl	-	any kind of bird.
Free Trade	-	international trade left to its natural course without tariffs, quotas, or other restrictions.
Free Trade Agreement	-	an agreement between countries of a particular region to allow certain goods and services to be traded among them without tariffs, quotas, or other restrictions.
Fresh	-	produce which has not undergone processing, such as freezing or canning.
Fructose	-	a simple sugar found in honey and fruits.
Fruit	-	the edible, mature, seed-bearing product of a plant.
Fungicide	-	a substance that kills fungus.
Furrow irrigation	-	a surface irrigation method in which water is run in small ditches or furrows, usually spaced closely together between crop rows or groups of rows.

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Genetically Modified Organism (GMO)	-	an organism that has been developed by insertion of a gene from a source other than that species, through recombinant DNA technology. (There is increasing recognition that this term is misleading, as any organism that is modified by evolution, traditional plant breeding or mutation is "genetically modified").
Germination	-	the point at which a dormant seed begins to sprout, forming a new plant.
Gestation	-	the process of carrying in the womb during the period from conception to delivery.
Gestation period	-	pregnancy period
Gilt	-	young female that has not yet produced a litter.
Gizzard	-	the second part of a bird's stomach, used for grinding food.
Grafting	-	a method of plant propagation (reproduction) in which a piece of a desired plant (usually stems, buds or rootstock) is inserted into another plant so they unite and grow as one plant.
Grain	-	the edible, hard seed or kernel from cereal plants such as wheat, barley, corn, oats and rye.
Grass	-	a narrow-leafed plant with seed-like grains grown for lawns and also used for pasture or grazing material for animals.
Green manure	-	a growing crop ploughed under and mixed with the soil to provide organic matter and fertility.
Greenhouse effect	-	a popular term used to describe the roles of greenhouse gases in keeping the Earth's surface warmer than it would be otherwise. These "radioactively active" gases are relatively transparent to incoming shortwave radiation, but are relatively opaque to outgoing longwave radiation, trapping it for subsequent re-radiation back to the surface, maintaining higher surface temperatures.

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Greenhouse gases	-	those gases, such as water vapour, carbon dioxide, tropospheric ozone, nitrous oxide, and methane, that are transparent to solar radiation but opaque to longwave radiation. Their action is similar to that of glass in a greenhouse.
Gross domestic product	-	the value of the total final output of goods and services produced inside a country during a given year. It equals gross national product (GNP) less overseas remittances.
Gross income	-	the total income derived from a given unit of production. For example total revenue generated from one acre of paddy, total revenue generated from one cow in a year,
Gross national product	-	the value of all final goods and services produced during a year by the factors in a country. It is the sum of expenditures by consumers and governments, gross investment spending, and total merchandise exports less imports.
Growth	-	the development and maturing of a plant or animal.
Growth rings	-	the layer of wood growth put on a tree during a single growing season. In the temperate zone, the annual growth rings of many species (e.g., oaks and pines) are readily distinguished because of the differences in the cells formed during the early and late parts of the season. In some temperate zone species (e.g., black gum and sweet gum) and many tropical species, annual growth rings are not easily recognised.
Habitat	-	a place where the needs for food, water, and shelter of an organism are met.
Harden Off	-	acclimatise a plant to a change in its environment by gradually increasing exposure to the new environment.
Hardwood	-	generally one of the botanical groups of trees that have vessels or pores and broad leaves, in contrast to the conifers or softwoods. The term has no reference to the actual hardness of the wood.

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Harrow	-	an implement used for light, shallow loosening of the soil, for preparing seed beds and for killing weeds.
Harrowing	-	loosening the top soil to prepare it for seeds and to get rid of weeds.
Harvest index	-	grain weight as a percentage of total above-ground dry weight at maturity.
Harvesting	-	the collecting of produce from a crop.
Hatch	-	the emerging of the baby chick from the incubated egg.
Hatchery	-	a building that has specialised equipment for incubating and hatching eggs.
Hay	-	grasses, clover, alfalfa and other legumes, or any other leafy plant material that is cut and dried to be used for animal feeding.
Head	-	the portion of a plant which contains the seed (as in grain or grass).
Heat	-	the receptive period of the sexual cycle, especially in female animals.
Heifer	-	a young cow that has not borne any previous calves. She remains a heifer until her first calf is born.
Hen	-	a female chicken.
Herbaceous Perennial	-	a soft stemmed plant that lives from year to year by dying down to ground level at the end of each growing season.
Herbicide	-	a substance that kills plants.
Herd	-	a large group of cattle, sheep, goats or other animals.
Hog	-	generic term, usually applied to growing swine
Honey	-	a sweet liquid made in the hive by bees, and it can be used for human or animal feed.
Hooves	-	hard, horny feet on some animals (e.g. horses, cattle, goats, sheep).
Horn	-	a hard bony projection from the head of an animal (e.g. cattle, goats).
Horticulture	-	the science and art of growing fruits, vegetables, ornamental trees, shrubs and flowers.

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Hybrid	-	the offspring of two animals or plants of different breeds, varieties, species, or genera (especially as produced through human manipulation for specific genetic characteristics).
Hydroponics	-	the growing of plants in nutrient solutions with or without an inert medium to provide mechanical support.
Inbreeding	-	the mating of plants or non-human animals which are closely related genetically.
Incubator	-	an apparatus used to keep eggs warm while they are being hatched artificially.
Industrial crops	-	those crops that are not specifically grown for foodstuffs (such as fruit crops, vegetable crops and grain crops), but are specifically grown to yield a useful product for man or industrial processes, such as fiber, oils, rubber, chemicals, energy, waxes, or dyes.
Inoculation	-	using a needle to give a plant or an animal a substance which can aide in the prevention or curing of disease.
Inoculum	-	collective term for microorganisms or their parts (spores, mycelial fragments, etc.) which are capable of infection or symbiosis when transferred to a host. Term is also used for the symbiotic or pathogenic microorganisms that are transferred for culture.
Insecticide	-	a substance that kills insects.
Integrated pest management (IPM)	-	A pest management strategy using a systematic approach in which pest populations are monitored to determine if and when control methods are required. Integrated pest management (IPM) uses biological, chemical, physical, cultural and/or genetic control methods in order to minimise pesticide use, reduce production costs, and protect the environment.
Intensive Cereal Management (ICM)	-	close monitoring of cereal crops enabling application of inputs at the most critical points for optimal and economical yields.

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Intensive farming	-	a system of raising crops and animals, usually on small parcels of land, where a comparatively large amount of production inputs or labor are used per acre. Compare extensive farming.
Intercropping	-	the growing of two or more different species of crops simultaneously, as in alternate rows in the same field or single tract of land.
Irrigation	-	application of water to soil for the purpose of plant production.
Kernels	-	the individual seeds from stalks of grain.
Kid	-	a young goat.
Lactation	-	the processes of milk secretion by the maternal mammary glands after parturition. The proliferation of the mammary glandular tissue, milk synthesis, and milk expulsion or let down are regulated by the interactions of several hormones including estradiol; progesterone; prolactin; and oxytocin.
Lactation Period in cows	-	the time from when a cow calves to the time when it is dried off to calve again; the period during which the cow is milked (approximately 305 days).
Lamb	-	a baby sheep (noun); to give birth to a lamb (verb).
Landraces	-	traditional crop cultivars or animal breeds with enough genetic integrity to be morphologically identifiable that evolved with or have been genetically improved by traditional agriculturalists.
Landscapes	-	the characteristics that distinguish a certain geographic area including its physical environment, biological composition, and anthropogenic activities.
Landscaping	-	the design and installation of plant materials (including turf) and architectural elements.
Laying Hen	-	a hen which is specifically raised to produce eggs. (Also layer).
Legumes	-	a group of plants that have pods containing seeds and the ability to fix nitrogen from the air. Used for food and forage (e.g. beans, peas, clover, alfalfa).

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Lethal dose 50	-	the amount of a single dose of a solid or liquid substance required to kill 50% of the tested population. It is usually expressed in mg/kg (milligram of material per kilogram of body weight) and is used for all routes of exposure other than inhalation. Compare "lethal concentration 50".
Litter	-	a litter is the offspring at one birth of animals from the same mother and usually from one set of parents
	-	straw, hay, wood shavings, o r other materials used for bedding animals.
Living Modified Organism (LMO)	-	any organism that is the result of biotechnology and is capable of metabolising and reproducing.
Lodging	-	the condition of a plant, especially a cereal, that has been flattened in the field or damaged so that it cannot stand upright by weather conditions or because the stem is not strong enough to support the plant.
Malnutrition	-	a condition caused by inadequate intake or inadequate digestion of nutrients. It may result from eating an inadequate or unbalanced diet, digestive problems, absorption problems, or other medical conditions.
Mare	-	an adult female horse.
Marketing functions	-	a role that helps a company to identify and source potentially successful products for the marketplace and then promote them by differentiating them from similar products. Some of the typical marketing functions might include such as performing marketing research, developing marketing plan, and product development, as well as advertising, promotion, distribution and customers service.

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Marketing services	-	marketing is the process of finding out what customers want and making those goods and services available at a profit. Marketing services are the methods used in the overall marketing plan of production, pricing, promotion and distribution.
Mechanisation	-	the use and development of machines to replace hand and animal labour.
Milking Machine	-	an apparatus that attaches to a cow's or goat's teats and by vacuum draws the milk into a holding tank.
Mixed cropping	-	the growing of several crops simultaneously in the same field but not in rows.
Mulch	-	a layer of material (bark, hay or plastic) put over the soil surface to protect the plants from erosion, crusting, drying, freezing or weed competition.
Mule	-	the sterile offspring of a horse and a donkey that is usually smaller in size and makes a different sound than a horse.
Multiple cropping	-	the growing of more than one crop consecutively in the same field in a single year.
National parks	-	an area of land and/or sea usually owned and administered by a national government and is protected from human exploitation and development. The area is intended to provide environmentally and culturally sensitive scientific, educational and recreational opportunities.
Natural resource management	-	the application of scientific and technical principles in the management of natural resources, such as land, water, soil, plants and animals, in order to meet ecological, economic, social and policy objectives.
Natural resources conservation	-	the protection, preservation, or restoration of natural resources such as forests, soil, water and wildlife.
Net income	-	difference between the Total Revenue and Total Costs of a given enterprise.
Organic	-	grown without the use of synthetic chemicals.

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Organic foods	-	organic food is produced without: antibiotics; growth hormones; most conventional pesticides; petroleum-based fertilisers or sewage sludge-based fertilisers; bioengineering; or ionising radiation. USDA certification is required before a product can be labeled "organic". Companies, including restaurants, that handle or process organic food must be certified also.
Oxen	-	adult, neutered, male bovines used for draft purposes; important in pioneer days.
Pasteurised	-	the process of heating to partially sterilise a food to kill bacteria.
Pastoralism	-	a way of life based on the raising and herding of livestock, such as sheep, goats, or horses.
Pasture	-	an area of grassy land where farm animals range and feed.
Pathogens	-	microorganisms, viruses and parasites that can cause disease.
Pathologist	-	a specialist who deals with the nature of disease, especially the structural and functional changes caused by disease.
Perennial	-	a plant that lives for more than two years.
Pesticides	-	manufactured chemicals, naturally occurring organisms, chemicals or devices which are used by the farmer to control plant, insect and disease pests that destroy crops or livestock. Pesticide use is carefully regulated to ensure safety to the environment, the food supply and the user.
Pet	-	an animal kept for the pleasure of its owner.
Pheromones	-	a chemical substance secreted and released by an animal for detection and response by another, especially for a member of its own species.
Photoperiodism	-	the physiological and behavioural response of an organism to the relative duration of light and darkness.
Photosynthesis	-	the synthesis of carbohydrates from carbon dioxide and water by chlorophyll using light as energy and producing oxygen.
Physiologist	-	an expert who deals with the function and vital processes of living organisms.

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Piglet	-	a baby pig.
Pod	-	the container for seeds on a legume plant.
Pollinate	-	the transfer of pollen from the male part of the flower to the female part of a flower to produce a fertilised egg that will develop into a seed.
Pome Fruit	-	a firm fleshed fruit in which multiple seeds are protected by a central core, e.g. apple, pear.
Poultry	-	a young fowl; a young turkey.
Private enterprises	-	organisations engaged in the production, distribution and/or sale of goods or services and owned and operated by a single or group of private persons or institutions.
Private forestry	-	forest operations on land owned by a private individual, group, or corporation and is not owned by a body of government.
Profit Margin	-	the profit remaining in a business after all expenses have been deducted.
Pullet	-	a hen less than one year old.
Rain fed farming	-	a system of producing crops without the use of irrigation.
Ram	-	a male sheep.
Rangelands	-	land on which the historic climax plant community is predominantly grasses, grasslike plants, forbs, or shrubs. Includes lands revegetated naturally or artificially when routine management of that vegetation is accomplished mainly through manipulation of grazing. Rangelands include natural grasslands, savannahs, shrub lands, most deserts, tundra, alpine communities, coastal marshes, and wet meadows.
Ratooning	-	production of a subsequent crop that results from the regrowth from roots of the previous harvested crop, as in sugarcane, pineapple, and banana.
Relay cropping	-	the seeding of one crop into another standing crop, e.g., winter wheat into standing soybeans. A practice of starting one crop in another.
Ripening	-	the process of maturing in plants resulting in seeds that are fully developed and can be used to grow new plants.

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Rooster	-	a male chicken.
Rootstock	-	the underground part of a plant including a short portion of the stem onto which a scion can be grafted.
Ruminant	-	an animal with four stomachs. Included are cattle, goats, sheep and deer.
Rural urban migration	-	is the movement of people from rural areas (villages) to urban centres (cities).
Saplings	-	a young tree that is more mature than a seedling but is not yet seed-producing. A silvicultural tree class in which size limits vary by region but is generally accepted as 2-4 inches in diameter and 4 to 4-1/2 feet in height in the United States.
Scion	-	a portion of a stem used for grafting.
Seed	-	the reproductive portion of a plant.
Seed Drill	-	an implement used for planting the seeds in rows along the field.
Seeding	-	the process of putting seed in the ground to grow.
Sheep dog	-	a working dog used to herd sheep flocks.
Sheep Shears	-	clippers, usually electric, used to cut the wool from the sheep.
Silage	-	grasses, legumes and corn grown, harvested and stored as a wet roughage feed for cattle.
Silo	-	a storage building or pit in which green hay or high-moisture grains are fermented and stored as animal feed.
Sire	-	male parent of an animal
Softwood	-	generally, one of the botanical groups of trees that have no vessels and, in most cases, have needle like or scale like leaves (the conifers). Also, the wood produced by such trees. The term has no reference to the actual hardness of the wood.
Soil erosion	-	the wearing away of the land surface by water, wind, ice, or other geologic agents.
Sow	-	female which has farrowed at least once

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Spraying	-	mechanically applying a mixture containing water to prevent/control the development of weeds, insects or diseases.
Sprout	-	the earliest emergence from a seed as it begins to germinate and grow.
Stalk	-	the straw or stem-like part of the plant that supports the seed head.
Stallion	-	an adult male horse used primarily for breeding.
Stem	-	the stalk of a plant.
Stock	-	animals kept on the farm for production purposes.
Stone Fruit	-	a fruit with fleshy pulp that encloses a single seed in a hard shell, (e.g. peach, plum, cherry).
Strip cropping	-	the growing of crops in a systematic arrangement of strips or bands which serve as vegetative barriers to wind and water erosion. The strips or bands may run perpendicular to the slope of the land or to the direction of prevailing winds.
Subsistence farming	-	a type of farming in which most of the produce (subsistence crop) is consumed by the farmer and his family. In other words a type of farming that that is oriented towards meeting the basic needs of the farmer without surpluses for market.
	-	a farming system where the food and goods produced are predominantly consumed by the farm family and there is little surplus for sale in the market.
Supply chain	-	the network of firms that bring products to market, from companies that produce raw materials to retailers and others that deliver finished products to consumers. Economic value is added through the coordinated management of the flow of physical goods and associated information at each stage of the chain.
Supply Management	-	a distribution system in which the total quantity of a product produced in an industry is controlled, often through quotas. This maintains a level of financial return for the farmers.

Sustainable agriculture	-	use for the practice of agriculture which supports sustained economic profitability, sustained quality and well-being of the environment, efficient use of natural resources, and the overall quality and availability of food and fibre for mankind.
	-	the practice of agriculture that over the long term conserves or enhances environmental quality and the resource base on which agriculture and society depends.
Sustainable development	-	development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
Sustainable technology	-	technologies focusing on sustainability principles: resource conservation, reuse and recycling, energy efficiency, minimising environmental impact and pollution reduction.
Swather	-	an implement used to cut down grain or grass and place it into rows for the baler or the combine to pick up.
Taproot	-	a tapering root that grows vertically downward in which a plant stores food, (e.g. carrot, turnip).
Tariff	-	a tax or duty to be paid on a particular class of imports or exports.
Thinning (plants)	-	the practice of reducing the number of plants in an area or the quantity of vegetative or reproductive structures on individual plants.
Tissue culture	-	a method of maintaining or growing tissues, organ primordia, whole or parts of organs, in a manner to preserve their structure and/or function.
Top dressings	-	the application of compost or fertiliser on top of the soil during plant growth.
Total costs	-	the sum of variable costs and fixed costs for producing a particular good or service. For example on the farm, expenses incurred on the variable inputs and fixed inputs for producing an acre of paddy.
Tractor	-	a powerful, motor-driven machine used to pull implements and do other work on the farm

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Traditional medicine	-	systems of medicine based on cultural beliefs and practices handed down from generation to generation. The concept includes mystical and magical rituals (spiritual therapies); phytotherapy; and other treatments which may not be explained by modern medicine.
Traditional technology	-	techniques that utilize indigenous, traditional methods that are often ethnic/cultural in origin. Includes methods practiced as a trade or handicraft, frequently producing in limited quantities.
Transpiration	-	water discharged into the atmosphere from plant surfaces.
Tropisms	-	movement that is inducible and takes place in a direction related to that of the stimulus, such as the movement of leaves toward light in positive phototropism or away from light in negative phototropism.
Trough	-	a container for drinking water or feed of farm animals.
Tuber	-	a fleshy food-storing swelling of an underground stem, (e.g. potato).
Vaccination	-	administration of vaccines to stimulate the host's immune response. This includes any preparation intended for active immunological prophylaxis.
Variable costs (Operating Costs):	-	cost of goods or services that are used up in one production cycle. For example on the farm expenses incurred on seed, fertiliser, fuel, wages, rent, repairs, feed, veterinary, etc.
Vegetable	-	any plant whose fruit, seeds, roots, tubers, bulbs, stems, leaves or flower parts are used for food. May be eaten raw or cooked.
Vegetables	-	any part of a plant that is commonly eaten by humans as food, but is not considered to be a culinary fruit, nut, herb, spice or grain.
Vegetative Propagation	-	ways of increasing plant numbers using leaves, stems, roots or other parts by techniques such as layering, cuttings or grafting.

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Vernalisation	-	the treatment of seeds, seedlings, bulbs, or other parts of a plant to cold conditions in order to shorten the vegetative period and promote flowering.
Veterinarian	-	a person who treats diseases and injuries of animals.
Watershed	-	the entire land surface from which water ultimately drains into a particular stream or river system.
Watersheds	-	the land area that drains water to a particular stream, river, or lake. It is a land feature that can be identified by tracing a line along the highest elevations between two areas on a map, often a ridge.
Weaning	-	separation of piglets from the sow
Weaning	-	the substitution of solid food for maternal milk or milk substitutes in the diet of a child or young mammal.
Weed	-	a plant that is not valued where it is growing.
Wetlands	-	an area that is saturated by surface or ground water with vegetation adapted for life under those soil conditions.

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