INTRODUCTION TO AGRICULTURE IN SMALL STATES

COMMONWEALTH of LEARNING

Introduction to Agriculture in Small States
Commonwealth of Learning
Paper-Based Edition 1.0
March 2010

COMMONWEALTH of LEARNING
Commonwealth of Learning
1055 West Hastings Street, Suite 1200
Vancouver, British Columbia
Canada V6E 2E9
Telephone: +1 604 775 8200
Fax: +1 604 775 8210
Web: www.col.org
E-mail: info@col.org

COMMENTS

The paper-based version of an "Introduction to Agriculture in Small States" has been adapted from the Moodle version published on the Virtual University of the Small States of the Commonwealth (VUSSC). (www.vussc-learning.org)

The assignments, activities and discussions have been modified to support either a blended learning approach or a classroom delivered course. All of the activities can be completed as small group or individual exercises. Discussions can be chaired by the instructor either in the class or if available via an online discussion board.

Access to the Internet is not required to complete this course, although the instructor is encouraged to create a course web site to support student to student communications and information sharing when not engaged in classroom work. YouTube videos have been used in the Moodle course to illustrate some of the concepts and best practices used in the agri-industry. The links to these videos has been embedded in this paper based study guide. You are encouraged to view these videos from a Internet ready computer.

The content of this study guide may be modified by your instructor or hosting institution to reflect the unique requirements within your region or within your institution.

TABLE OF CONTENTS

COURSE OVERVIEW

OVERVIEW

Agro-industries can have an important role in employment creation in small states, thus providing an opportunity for income generation in those small states. The current trend of globalization has led to 'displacement' of population. It is observed that people from different small states are now all over the world and this is actually opening avenues for exports of specific typical island state agro products all across the globe. From a small state point of view, development of agro industries to cater for the needs of ethnic communities spread across the world is a challenge. Agro industries are evolving as a means to cater for the new arising needs. In addition, consumer markets of the developed world are very receptive to new products and agro products coming from small states can constitute a niche market.

On the other hand, it should also be mentioned that many small states are facing the challenges of being competitive on the global agricultural markets. Therefore a common scenario being observed is that the new generation from small states is more and more reluctant to go into agriculture preferring other employment opportunities. The relevance of this course to small states is to stimulate and encourage people from the small states to remain and develop a sustainable agriculture sector focusing on the development of viable agro industrial sector.

COURSE GOALS AND OBJECTIVES

Upon completion of the "Introduction to Agriculture Course", you will be able to:

1. Explain the importance of agriculture to small states.
2. Demonstrate an appreciation of the relevance of agriculture to food security.
3. Understand the major factors affecting agricultural production in small states.
4. Compare and contrast the different agricultural systems.
5. Identify opportunities for entrepreneurship in agriculture using the value chain approach.
6. Demonstrate an understanding of how various agricultural groups work and where they fit in the value chain.
7. Analyze the agricultural environment within your region or small state.

COURSE APPROACH

This paper-based version of the Introduction to Agriculture course was developed and will be delivered as either a blended learning course or classroom delivered course supported by an instructor/facilitator. Participants will be required to actively engage their peers in

either classroom or online discussions exploring a variety issues that impact the agri-industry.

Learners will be required to complete a number of different activities and practical assignments. Some activities are reflective in nature and learners will only be asked to review the materials and reflect upon how they would answer the questions presented. Other activities and assignments will require that you to formulate a reply or solution to the case study or question and submit it to your instructor for feedback and grading.

Finally you will be required to complete a major project that will help you synthesize and apply the knowledge and skills you learn throughout the course. The major project description is included in this book.

The instructor will decide on how and where the assignments and discussions will be completed. Milestones for each will be reflected in the course schedule. As described later in this study guide learners will be assessed on the assignments and your active participation in the discussions.

COURSE SCHEDULE

A course schedule broken down by weeks and activities will provided by your instructor on the first day of class. It may also be published on a course web site created by your instructor.

COURSE ASSIGNMENTS

There are five unit assignments and one major project scattered throughout the course. Most are one or two page analysis papers of a specific problem or question. The assignments will be submitted to your instructor and feedback provided by way of the dropbox and gradebook. The timing for submission of each assignment is reflected in the course schedule. Ensure you read the assignment instructions and complete all activities before submitting them.

MAJOR COURSE PROJECT

As you complete your course you will be required to complete a major project. The suggested major project is described below. If you wish to complete a custom project different from the one described below than please consult your instructor at the beginning of the course.

PROPOSED MAJOR PROJECT – AGRI 001 – INTRODUCTION TO AGRICULTURE

Objective: To complete an analysis of the agriculture industry within a small state, region or local farming community.

Instructions: You have now being exposed to a variety of concepts, principles and systems that impact the agricultural industry and the production of crops and farm animals. You are now required to complete a detailed analysis of the agriculture sector within your small state or region. Some of the activities and content should have been identified during the completion of some of your unit and lesson assignments.

The paper should be no more than fifteen double spaced pages.

You need to examine the agriculture sector in your small state and describe the following:

1. What types of agricultural products are grown within your nation or region?
2. What type of climate is experienced in your location? How does the weather impact the industry?
3. What types of soil exist throughout the region? Does the soil need chemical or natural enhancements?

What types of biological threats exist in your region and what is done to combat them?

4. What is the major type of agricultural system within your small state or region?
5. What is the role of government in the management and growth of your agricultural industry?
6. What is the impact of free trade or other international agreements on your industry's ability to grow and succeed? Describe them.
7. What national or regional institutions exist that directly supports agriculture extension and research? Describe their role in the industry.
8. What types of careers exist within the agriculture sector within your small state?
9. Assess the future of the agriculture sector in your small state? Will it grow and if so what is needed? Or will it fail and why will it fail?

Submission: Once you have completed your paper submit it to your instructor through the Assignment Dropbox in the Course Summary Unit.

COURSE GRADING

Each discussion and assignment is awarded points. Five points are awarded for each discussion and ten points for each lesson/unit assignment. The final project represents 100 points or 50% of the grade. The breakdown of the grading is described below.

Unit	Class Discussions (5 Pts Each)		Assignment		Total	
	#	*Pts*	*#*	*Pts*	*Pts*	*%*
Unit 1	4	20	1	10	30	15%

Unit	Class Discussions (5 Pts Each)		Assignment		Total	
Unit 2	1	5	1	10	15	7.5%
Unit 3	1	5	1	10	15	7.5%
Unit 4	2	10	1	10	20	10%
Unit 5	2	10	1	10	20	10%
Final Project			1		100	50%
Total					200	100%

DEFINITIONS OF AGRI TERMS

The following terms and their definitions are used throughout the course.

Agranrianism: A social or political movement designed to bring about land reforms or to improve the economic status of the farmer.

Agriculture: The cultivation of plant and animal species, under man-made conditions such as land clearing or soil tillage, for meeting human needs.

Annual crop: Crops that grow and produce within a period of one year.

Biopesticides: Microbial biological pest control agents

Biodiversity: Variation of life forms in a given ecosystem.

Cellular respiration: The process organisms undergo that convert glucose to energy, usually using oxygen and glucose to produce ATP, carbon dioxide and water.

Climacterism: The phenomenon in plants whereby ripening in fruits is accomplished by an increase in the rate of respiration.

Cultivar: A cultivated variety of a plant that has been deliberately selected for specific desirable characteristics.

Crop taxonomy: Science of grouping crops into different categories according to their similarities.

Cultivar: A genetic variation of a crop species that is selected and maintained by man.

Domestication: The process of adaptation of plants and animals to meet human requirements and consequently, to depend on human beings for their survival.

Ecosystem: A complex system of all living organisms that interact with one another and their non-living environment in one ecological unit e.g a river valley, a forest, a region.

Fungicides: Chemicals used to control fungi

Genetic resources: All the plants and animals, with the full range of genetic composition, that is available in a specific area or country.

Herbicides: Chemicals used to control weeds

Hybrid: An offspring resulted from the crossbreed between different varieties

Macro-nutrient: Nutrients that are required in large quantities

Micro-nutrient: Nutrients that are required in small quantities

Marginal Cost: The additional cost incurred from producing an additional unit of output.

Marginal: Economists' term for 'extra' or 'added'.

Marginal Cost (MC): The additional cost incurred from producing an additional unit of output.

Marginal Input Cost: The additional cost incurred by using an additional unit of input

Marginal Return: (a) The return from one extra unit of output. (b) The addition to gross return from using one extra unit of input. If the marginal return of an input exceeds its marginal cost, additional profit may be made by adding units of the input until its marginal return and marginal cost are equalized.

Marginal Revenue (MR): The additional income received from selling one additional unit of output.

Marginal Physical Product (MPP): The additional physical product resulting from the use of an additional unit of input.

Marketing: As defined by www.dictionary.reference.com is "the total of activities involved in the transfer of goods from the producer or seller to the consumer or buyer, including advertising, shipping, storing, and selling."

Market Opportunity: An area of buyer need in which a company can perform profitable, such as making a buying process more efficient or providing more advice and information.

Maturity: Maturity is the stage at which a commodity has completed all phases of growth and development such that after harvesting its quality will at least be at the minimum acceptable to the consumer.

Niche Market: Is the subset of the market on which a specific product is focusing; therefore the market niche defines the specific product features aimed at satisfying specific market needs, as well as the *price* range, production quality and the *demographics* that is intended to impact.

Perennial crop: Crops that grow and produce for a period longer than one year.

Pesticides: Chemicals used to control pests.

Physiology: The processes and functions of an organism.

Postharvest handling: All activities associated with extending the life of fresh produce items after they have been harvested until they reach the final consumer.

Postharvest loss: The condition of harvested fresh produce items which is manifested by a reduction in quality or quantity which makes them unfit for human consumption.

Postharvest management: The control of all aspects of the physiology of the harvested commodities. It acknowledges that fresh produce items are diverse in nature and, therefore, have specific needs in order to maintain their quality and maximize their shelf life.

Postharvest technology: Postharvest technology applies scientific approaches and methods to harvested fresh produce items in order to improve their quality, extend their shelf life and meet consumers' requirements through packaging storage, processing, distribution and marketing.

Product development: Means offering new or improved products for present market. By knowing what the present market needs, an entrepreneur or farmer may see ways to add or modify product features, e.g. through improved best practices, create several quality levels, or add more types or sizes to better satisfy customers while seeking, also, to expand.

Secondary metabolites: Chemical compounds produced in plants which do not play a role in the primary functions such as photosynthesis and respiration.

Sustainable agriculture: Agricultural production that is profitable to the farmer and can be maintained without harming the environment.

Utility: The American Heritage Dictionary defines utility as "the quality or condition of being useful". Utility is further defined as any quality and/or status that provide a product with the capability to satisfy the consumer's wants and needs. Marketing is responsible for creating most of a product's inherent utility.

Variety: A type of a crop.

INSTRUCTOR EXPECTATIONS

MY EXPECTATIONS

As an instructor or a student participating in a distance education course we must make commitments to each other to ensure that everyone has a positive and supportive learning experience. To ensure we all start the course with the same level of commitment i would ask you to review the list below.

In distance education the instructor and student often enter with unwritten expectations of each other. If these expectations are not shared early in the course, then both parties may eventually be disappointed when individuals do not live up to the unstated expectations. Therefore we must recognize my commitment to you as the instructor and you must understand what expectations the instructor has of you, the distance learner. Below are my expectations.

MY COMMITMENT TO YOU

Instructor Commitment 1: I will respond to your email messages or online queries within 48 hours of being sent.

Instructor Commitment 2: Where appropriate I will provide constructive feedback and input during classroom and blended learning activities and discussions.

Instructor Commitment 3: Your course assignments and other graded activities will be marked and returned to you within ten calendar days after the published due date or after the date you submitted to me for grading.

Instructor Commitment 4: I will ensure I am available to you for individual discussions, consultation and support and I will keep you informed when I will not be available due to personal or professional commitments.

MY EXPECTATION OF YOU, THE STUDENT

To exercise my commitment to you I need the cooperation and commitment of all participating students. As a student engaged in my course you must commit to the following.

Student Commitment 1: As a student in this course I understand that I am ultimately responsible for my own learning and my own eventual academic success.

Student Commitment 2: As a student in this course I promise to commit the time, effort and energy required to succeed in my academic studies.

Student Commitment 3: As a student in this course I promise to regularly attend classes, complete all readings, activities and assignments, and meet all course deadlines and schedules. I will submit all of my assignments on the published due date.

Student Commitment 4: As a student in this course I will communicate with my peers in a timely, professional, non-threatening and constructive manner.

Student Commitment 5: As a student in this course I promise to review all Rubrics before submitting assignments for grading to ensure that my submission meets 100% of the assignment criteria.

I hope all parties can live up to these expectations. Thanks in advance .....

UNIT 1 - AGRICULTURE IN SMALL STATES - AN INTRODUCTION

INTRODUCTION

This unit provides a background for the rest of the course. It presents agriculture as a human activity which outlines its origin and historical development to show how its nature and scope has changed over time. Food security is an important issue in small states, and its relationship with agriculture is discussed. The position of agriculture in the economy of these states is also presented with descriptions of the situation in small states within different regions of the world to highlight important similarities and differences. Since the overall goal of the course is to help you to contribute to a sustainable agricultural sector, the concept of sustainability is explained and its relevance to agriculture is discussed. Agricultural development in small states requires creativity and innovation for it to be really sustainable; therefore, entrepreneurship is introduced and linked with sustainability. These are the two main themes throughout the course. Finally, a range of careers in agriculture are described to emphasize the many areas that contribute to sustainable agriculture and to help you to identify potential areas for entrepreneurship.

GOALS AND OBJECTIVES

Upon completion of this unit you will be able to:

1. Explain the importance of agriculture in providing security in small states.
2. Compare the characteristics of agriculture in small states.
3. Define sustainable agriculture.
4. Demonstrate an understanding of the relevance of entrepreneurship in agriculture.
5. Identify potential careers in agriculture in your state.
6. Describe the nature and scope of agriculture.

LESSON 1.1 - INTRODUCTION TO AGRICULTURE

OVERVIEW

Agriculture is a business that is essential to all societies no matter where they are located. Everyone needs safe and healthy food supplies. As we grow our agricutural output must become more efficient and more productivity. This lesson will begin the process of introducing you to a variety of concepts that are essential to the agricultural professional. We will examine the origins of the agriculture revolution and the impact of agriculture on the evolution of the small states.

OBJECTIVES

Upon completion of this lesson you will be able to:

1. Describe the origins and development of agriculture.
2. Explain the impact of agriculture on small states.
3. Discuss the role of GDP, major crop production and international markets when considering the impact of agriculture in small states.

ORIGIN OF AGRICULTURE

From the dawn of civilization, agriculture has been the foundation of human development. Scientists think that man first appeared on the earth about 30,000 years ago at the end of the last Ice Age. They estimate that plants and all the other sources of food on which human beings would later depend, appeared much earlier, millions of years ago. Human life, therefore, began in a very supportive environment for man's physical needs and food needs were met by simply gathering fruits and hunting animals. Man lived in small groups and since food had to be gathered, these groups moved from place to place depending on the availability of food.

Agricultural activity began much later when man had identified certain foods that were more desirable for one reason or the other, for example, some foods were easier to harvest or to digest and some animals were safer to hunt and capture maybe because of their size. A very important factor that contributed to the development of agriculture was the observation that seeds of discarded fruits and grains grew up where they had been disposed. These areas were typically cleared for temporary human camps. Therefore, man identified that new plants, of the same types that they had eaten, came from seeds and that many new plants could grow in cleared areas away from the original plants. The significance of this observation was that man was able to have better access to larger quantities of a desirable food, if he cleared land close to his dwelling areas, planted seeds and protected the new plants from animals. This marked the beginning of agriculture which at this stage consisted of the cultivation of plant and animal species, under man-

made conditions such as land clearing or soil tillage, for meeting human needs. Cultivation included all those activities undertaken to establish and maintain crops and livestock.

Agriculture also depended on another major process. Plants and animals species were selected based on their suitability for human needs and their adaptability to the disturbed environments. Usually, the traits for which the species were selected were disadvantages for survival in the wild; therefore, they also needed cultivation by man for their survival. This reciprocal relationship between the selected species and man was the process of domestication. Table 1 shows species that were domesticated in different parts of the world. Domestication occurred almost simultaneously in different parts of the world and the existence of a favourable climate, mainly humid, and sufficiently warm conditions it is thought to have been in a key factor that influenced successful domestication and early agriculture.

The map below illustrates the locations of early agricultural activity and growth.

Locations of Ancient Agricultural Growth (5000BC) - Extracted from Palomar Community College Web Site

Supplementary Readings: If you have an Internet connection, the following article will provide additional information about the history of agriculture.

Wikipedia. (nd.). The History of Agriculture.
(http://en.wikipedia.org/wiki/History_of_agriculture)

AGRICULTURAL DEVELOPMENT

We will now look briefly at how agriculture developed over time and how its nature and scope changed and varied in different places.

Domestication was a critical step in agricultural development civilisation. Human groups shifted from a nomadic to more sedentary or settled lifestyles to care for their crops and livestock. These species, in turn, with greater protection from the natural forces that would otherwise have eliminated them, produced higher yields which provided food for larger populations. Therefore, the human settlements became permanent, population grew and villages were established. With population increase came division of labour because the entire community did not have to be engaged in agriculture for the food needs of the population to be met. Communities became classified into groups which served different functions in the society. Eventually, as communities came into contact with one another, agricultural commodities were exchanged or traded to expand the range of food available or to acquire non-agricultural commodities for which human groups began to develop a demand.

Throughout the period from the hunter/gatherer stage to the settled cultivation of crops and animals, there were several technological developments that also facilitated the changes. For example, the discovery of fire was important not merely for cooking, warmth and protection from wild animals, but also for land clearing and for forging tools. Tools were at first quite simple, such as dibble sticks that were used for minimal soil disturbance for planting seeds and sticks for digging tubers. Later when metals were discovered, more durable tools became available that facilitated increased production; these included simple ploughs which could be used with animal power and sickles for harvesting. Increased production also stimulated more land use and the need for irrigation technologies especially in areas with seasonal rainfall, so that in some areas flood irrigation systems developed. Some harvested crops had to be processed to separate the edible parts, for example, wheat and rice had to be threshed, while those that could be produced only in specific seasons or that could not be consumed all at once had to be processed and stored. All these processes required technology development and were necessary to support agricultural development.

Early Agriculture in Africa

COLONIAL ERA AGRICULTURE

The main purpose for the movement of genetic resources during the colonial era was to facilitate greater exploitation of their economic potential by the colonizers. This allowed the development of large-scale production of crops such as sugar, bananas and rubber on large plantations far from the places of origin of these crops. The products in fresh form, for example, banana, or after primary processing, for example sugar, rubber, were then exported to markets in Europe for direct consumption or for further processing into higher valued products. In the Caribbean and other colonized areas, this required the use of external sources of labour, first enslaved from Africa, and then indentured, mainly from India and other parts of Southern Asia. Colonial governments at this time gave little if any attention to agricultural production for the local population and most food needs were met by imports from overseas. Therefore, in terms of its nature and scope, agriculture in the colonized territories, particularly small states, was dominated by large scale use of land and other natural resources such as forests that were cleared for production of export commodities and primary processing only where the rapid deterioration of the raw material made it necessary to prevent losses. All other activities such as transport/shipping, processing, distribution and marketing were managed abroad.

Early Caribbean Agriculture

The Industrial Revolution that began in the 18th century in Europe, led to a great movement of labour from rural areas, where agriculture was the major activity, to industrial centres. This encouraged the introduction of mechanization to agriculture in order to meet the food needs of entire societies in which fewer persons were actually working on farms in Europe. This trend increased in the 20th century especially after World War 2, when the use of machinery for a range of farm operations, and inputs such as fertilizers and pesticides became important technologies for increasing agricultural production for a rising population but with much less farm labour. In the early 1960s, the Green Revolution which took place mainly in Southern Asia, and was based on new, high-yielding crop cultivars that depended on high inputs of water, fertilizers, pesticides and mechanization, added further to the world's food supply.

In most small states, similar significant increases in agricultural production did not occur consistently after the emancipation of the enslaved Africans and the cessation of indenture ship. In fact, for many decades afterwards sugar cane plantations were in serious decline, while new export crops such as banana became important. As these states began gaining their independence, some of these new technologies were introduced to the export crops to boost their production. While some success was achieved, pests, diseases and periodic natural disasters, reduced the overall yields. Therefore, the levels of production of export crops from these countries were relatively small and their share of the world markets for these commodities declined generally declined over time and until the 1990s was supported by preferential trade agreements which will be discussed in greater detail in Unit Two. The production of livestock and crops for the domestic markets in many small states was not undertaken with similar levels of technical inputs, mostly because farmers could

not afford them. In many cases where these technologies were introduced, the crops became new export commodities.

SMALL STATES AGRICULTURE

Small states are those nations having less than 4.5 million inhabitants. In small states the farms can vary in size from small family run farms to large corporate farms occupying large tracts of land. But in farms that own a large amount of land that does not mean that all of the land is arable. Some of the farm land may be too rocky, too water logged, or too depleted to support crop or animal production.

In a 2005 UN Food and Agriculture Report on "Small Island Development States Agricultural Production and Trade" the authors noted that at least 28 small island states had to import more than 50% of their cereal requirements and when you add in the imported dairy requirements this represents over 50% of their daily caloric needs. The report notes that in the 1990s agricultural exports of small states went from being a exporter to an importer of agricultural products. Small states are now struggling to feed their own populations.

Supplementary Readings: If you have an Internet connection it is suggested that you review the following materials before proceeding:

Small Island Development States Agricultural Production and Trade (Read the executive summary). (ftp://ftp.fao.org/docrep/fao/007/y5795e/y5795e00.pdf)

Saldanha, J.M. (2003). Agriculture, small countries and globalisation. (http://purl.pt/915/1/cd1/ta100/ta109.pdf).

The status of agriculture is classified or measured in different ways. The three most common classification methods used by small states includes:

1. Contribution of Agriculture to the GDP (Gross Domestic Product).
2. Major Crops Produced.
3. Markets.

Let's examine each one.

HORTICULTURE AND HUSBANDRY DEFINED

There are number of synonyms for agriculture including: horticulture and husbandry. But in fact they have implied different meanings that professionals should understand.

Horticulture

Horticulture is the industry and science or art of cultivating fruits, vegetables, flowers, or ornamental plants. Horticulture deals with crop production in the agricultural industry. Some different fields of horticulture science includes:

- Floriculture: The science of cultivating flowering plants.
- Olericulture: The science of growing vegetables.
- Pomology: The science of growing fruits.
- Landscape Horticulture: The science of growing ornamentals and designing gardens.
- Turf-Grass Management: The science of growing and managing turf-grass for recreational and amenity purposes.
- Viticulture: The science of raising grapes and grape vines.
- Arboriculture: The science of cultivating and managing trees.

Husbandry

Husbandry is the science of stock breeding and animal science. This side of the industry supports the cultivation of animals for food production. It supports the science and art of raising domesticated animals including; meat and milk production, egg production, animal bi-products such as wool and other uses for domesticated animals in support of agriculture economics and growth.

CONTRIBUTION TO GDP

The acronym GDP or Gross Domestic Product is a basic measure of a country's overall economic output. It is the market value of all final goods and services made within the borders of a country in a year. The importance of agriculture in the small states is underlined by their individual contributions to the economy. They more they contribute the more dependent the country is on agriculture. Data provided indicates the dependency of the Small States on agriculture as indicated by GDP contributions.

In developed nations like the agriculture contributions to GDP are often much lower than different developing nations. According to the World Resource Institute in 2005 the GDP annual growth rate of the agriculture sector was 1.7 for the developed world and 10.2 for developing nations. This illustrates that the economic health of the developing nations are

much more dependent on agriculture then the developed nations like the US, UK and Canada.

Activity: If you have an Internet connection it is suggested you go to the Earth Trends web site (http://earthtrends.wri.org/searchable_db/index.php?theme=5) and research your agricultural contribution to the GDP within your home country. Compare your ratio to other nations. You should also explore other agricultural statistics provided on this site.

MAJOR CROP PRODUCTION

Each country produces a diversified grouping of produce. However, there are some crops that are produce in larger quantities as they may have a distinct advantage in producing these.

In the African States major crops produced fall in to the category of roots, tubers, corn, millet and cow's milk. There is a substantial amount of sugarcane being produced by Swaziland. In the case of the Caribbean the Small states located on the mainland, Guyana and Belize show the advantage of producing larger hectares of field crops. Sugarcane, Rice Cultivation and the production of other crops are agriculture main income earners. Belize is also a large sugarcane producer in addition to the production of Citrus. Even though Barbados is relatively smaller and relies heavily on the tourism industry sugarcane product is an important feature as this was the top produce in 2007. Other Islands in the region concentrate on fruit for will Bananas is particularly popular being produced in St. Lucia, Dominica and St. Vincent. The situation for St. Kitts is uncommon as their major crop is sugar cane. However, this industry is being closed. A closer look at St. Kitts show that the island is more dependent upon tourism than it is on agriculture.

The situation is different in the case of the Mediterranean countries of Malta and Cyprus where top products are crop based diversifications.

In all of the countries classified as small states, we see diversification elements of production. Owing to most of their small land areas, this characteristic helps to spread risks of production.

Activity: If you have an Internet connection it is suggested you search the Earth Trends database (http://earthtrends.wri.org/searchable_db/index.php?theme=8) to determine the economic impact of different agricultural products in your home country.

INTERNATIONAL MARKETS

The status of these states can also be grouped reference to Markets that they satisfy. In each of the countries identified, Production is both for local and international markets.

International Markets are basically dependent upon type of crop. When analyzing banana prices, it is important to note that as the world banana market is geographically

fragmented, mainly due to transport costs and diverging import policies in the consuming countries, such as the EU banana regime, it is not possible to have an international banana price as such. However, taking into account that the US banana market is free of tariffs or quantitative imports restrictions, we could consider the evolution of banana prices in USA as a useful approximation in order to obtain the historical trends.

The banana industry is a very important source of income, employment and export earnings for major banana exporting countries, mainly developing countries in Latin America and the Caribbean, as well as in Asia and Africa. According to FAO statistics, world banana exports are valued a total of US$5.8 billion in 2006, making them clearly a vital source of earnings to many countries. A strong bond exists between banana-generated income and household food security. Export volume or price changes bring about income changes for those directly employed in banana production, both as smallholder farmers and as wage earners on banana plantations. In addition, secondary and tertiary industries and their employees also feel the impacts of those changes".

Markets play an important scenario for the producer in the small states. If one trace the target markets that the small states have segmented to serve one will realize that apart from preferential markets of the ACP/EU and other similar ones, it is very difficult for Small Island states to compete with larger conglomerate companies of the developed countries who may be producing genetically modified produce. In this case more production per land area as produced by GMO varieties as the number of Small States of the world presents extreme competition.

Activity: If you have an Internet connection it is suggested you review the FAO Major Food and Agriculture Database (http://www.fao.org/es/ess/top/country.html?lang=en) and identify what major products your country produces. Find at least three other countries that produce similar products.

SUMMARY

During this lesson you explored the development of agriculture throughout history and its impact on small states. We examined the three attributes: GDP, crop production, and markets; to understand the impact these attributes have on the success of agriculture in small states. In the next lesson we will introduce the concepts of food security and agriculture sustainability.

Lesson Discussion: Before proceeding to the next lesson, you should participate in the Lesson 1.1 discussion with your peers. The question to consider is:

What is the state of agriculture in your country? What are the major crops produced and what markets does the agricultural providers sell into? Is there an international market impact on your industry? Provide data from the databases provided in this lesson to support your discussion.

LESSON 1.2 - SUSTAINABILITY & FOOD SECURITY

OVERVIEW

In 1996, at the World Food Summit, Food Security was said to exist "when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life." This definition emphasizes three major objectives:

1. Food availability, which means that the food supply should be consistently adequate.
2. Food access, which means that people should have the resources to obtain enough, nutritious and safe food that is appropriate for their age group and level of activity.
3. Food use, which means proper use of food to ensure the safety and nutritious quality.

The global food crisis experienced in 2008 in many parts of the world demonstrated that food security has not been achieved by many small states. The prices of food staples soared, and although prices have fallen, they still remain at levels that are too high for many people to have proper access. Therefore, in spite of the significant increases in food production that has been experienced in some parts of the world, which have led some people to the view that there is enough food to feed the entire world's population, in reality there is an estimated 800 million hungry persons worldwide, many of them children, and the recent food crisis has added some of those who previously had enough food to the ranks of the hungry.

Food security is a very important goal because it determines human health and productivity. In many countries, ill health due to poor nutrition has a serious impact on the capacity of a country to produce since much human resource is underutilised due to diseases such as diabetes, hypertension and cancer and related mortality rates. Via Campesina, an international movement of consisting of farmers, fishermen, indigenous people, youth and women groups from all over the world, think that the goal of food security is too narrow. Instead, this movement aims at food sovereignty, since they regard it as a right of all peoples to determine their own food, agricultural and fishery production systems free of intervention by international market forces.

OBJECTIVES

Upon completion of this lesson you should be able to:

1. Discuss food security and the causes of food insecurity.
2. Define sustainable agriculture.
3. Examine the environmental effects of agriculture.
4. Describe the best practices and management guidelines of sustainable farming.

FOOD SECURITY AND AGRICULTURE

Agriculture is or has the potential to be a major contributor to food security since domestic agriculture can be a major source of fresh supplies of food. Crop and livestock species selected from among those that grow easily under local conditions may offer the best opportunities for producing large quantities at relatively low prices because they are well adapted to local growing conditions, generally input requirements are relatively low and because of their familiarity to the local population, acceptance and the availability of suitable methods of preparation should not be obstacles.

Agriculture can meet the objectives of food security for food availability, food access and food use.

Food Availability - Production of food crops and livestock for meat, milk and eggs is a direct strategy for increasing food availability. Since climatic conditions may vary seasonally and some crops may be produced during only one period of the year, precautions have to be taken to ensure year-round food availability. These may include growing different crops in different seasons or storing food so that it is available outside the production period. Many countries, including some of those with a colonial history, use their foreign exchange earnings to import food for food security. However, during the recent food crisis some countries, such as India which exports rice, stopped exports to ensure that they had enough food for their local population. The important lesson from this is that domestic production is critical to achieving some measure, if not total food security.

Food Access - Agriculture can create access to food in at least two ways. Firstly, home gardens ensure that some food is not only available but also is easy to access even if a household has a low level of income. Where the cost of food production is low or there are government subsidies for to cover some costs, food prices can be lower, especially if there is little additional costs, for example, transport or marketing. Secondly, participation in commercial agriculture by people in rural or urban areas generates incomes which can be used by households to purchase those food items that they do not produce.

Food Use - All actors along the entire agri-food chain can contribute to the delivery of safe, nutritious food to consumers. For example, farmers can reduce pesticide use, while marketers can ensure sanitary post-harvest handling and proper packaging to avoid food contamination, and supermarkets can provide proper storage to prevent rapid deterioration. Additionally, increased households income from commercial agricultural activities, generally allow better access to education about food safety and methods of preparation that promote good nutrition and sanitation and the ability to acquire the required resources.

CAUSES OF FOOD INSECURITY

Among the major factors that contribute to food insecurity are:

1. **Poverty** - This is a major cause of food insecurity especially at the household level where many factors determine the ability of families to access adequate quantities of food appropriate for different age groups and to use food in a manner that maintains its quality. Therefore, many governments are attempting to alleviate poverty especially in rural areas.

2. **Inadequate Production** - In many countries levels of food production are low due to a range of factors such as inadequate land suitable for farming, degraded soil, lack of access to inputs, low yielding cultivars, unsuitable climatic conditions such as drought, and even inadequate labour. With respect to labour, migration, absence of young farmers and disease, for example, HIV/AIDS all deplete the labour force.2.

3. **Inadequate Distribution** - Where food production is adequate but distribution is poor, supplies are low or inconsistent and leads to high prices. Distribution is influenced by many factors including the distance from the production areas, roads and transport facilities, prices in different markets. Inequitable distribution of food is one of the major causes of hunger in the world.

4. **Globalization** - In many instances, imported food is cheaper than locally produced food. Also, the local population may acquire the perception that foreign foods are better or develop a preference for them sometimes because they are more convenient to use. In both situations, local foods become less competitive and their production declines. This is easily seen in many small states which have been colonized and a tradition of food importation has developed.

SUSTAINABLE AGRICULTURE - DEFINED

Sustainable agriculture refers to agricultural production that can be maintained without harming the environment. It can be defined as an integrated system of plant and animal production practices that will over the long term satisfy human food and fibre needs, enhance environmental quality and natural resource base upon which the agricultural economy depends, as well as making the most efficient use of non-renewable resources and farm resources. The system should also integrate where appropriate, natural biological cycles and controls, as well as sustain the economic viability of farm operations and enhance the quality of life for farmers and society as a whole. The components of sustainable agriculture are illustrated in the Figure below. They include social sustainability, financial sustainability, environmental sustainability and food security.

WHY SHOULD WE BE CONCERNED?

Why should we be concerned about sustainable agriculture and food security? Agricultural land is a finite resource. There is only so much available and as land is the world population increases the demand for residential space encroaches on the available agricultural space. Along with population growth there is an increase demand for industrial development and growth. Industrial growth often results in the destruction and pollution of our natural environment.

There is an immediate and ongoing need to address these issues as soon as possible. A move towards more sustainable farming practices is part of the solution. Especially if we want to avoid the environmental and economic issues associated with some of the farming methods currently being practiced in many developing countries.

As advocates of sustainable agriculture we must implement an agricultural production and distribution system that:

- Achieves the integration of natural biological cycles and controls,
- Protects and renews soil fertility and the natural resource base,
- Optimises the management and use of on-farm resources,
- Reduces the use of non-renewable resources and purchased production inputs,
- Provides an adequate and dependable farm income,
- Promotes opportunity in family farming and farm communities,

- Minimizes adverse impacts on health, safety, wildlife, water quality and the environment.

ENVIRONMENTAL EFFECTS OF AGRICULTURE

Agriculture profoundly affects many ecological systems and the negative effects include; decline in soil productivity that is due to;

- wind and water erosion of exposed topsoil,
- soil compaction,
- loss of soil organic matter,
- reduced water holding capacity,
- reduced biological activity,
- reduced biodiversity,
- stalinisation of soils, and
- use of large amount of water for irrigation in irrigated farming areas.

SUSTAINABLE FARMING PRACTICES

Sustainable agriculture farming practices include organic agriculture, crop rotation, agroforestry, intercropping

ORGANIC AGRICULTURE

Organic farming is the form of agriculture that relies on crop rotation, green manure, compost, biological pest control, and mechanical cultivation to maintain soil productivity and control pests, excluding or strictly limiting the use of synthetic fertilizers and synthetic pesticides, plant growth regulators, livestock feed additives, and genetically modified organisms. This enhances the safety of food, reducing the disturbances to the environment. The organic products usually have a higher market value than the products obtained from using the conventional methods of production, even though organic matter is more labour demanding.

SUBSISTENCE AGRICULTURE

A form of farming in which nearly all of the crops or livestock raised are used for the farmer and the farmer's family, consumption, leaving little, if any, surplus for sale. Preindustrial agricultural peoples throughout the world have traditionally practiced subsistence farming. Some of these peoples moved from site to site as they exhausted the soil at each location. As urban areas grew, agricultural production became more specialized and commercial farming developed, with farmers producing a sizable surplus of certain crops, which they traded for manufactured goods or sold for cash.

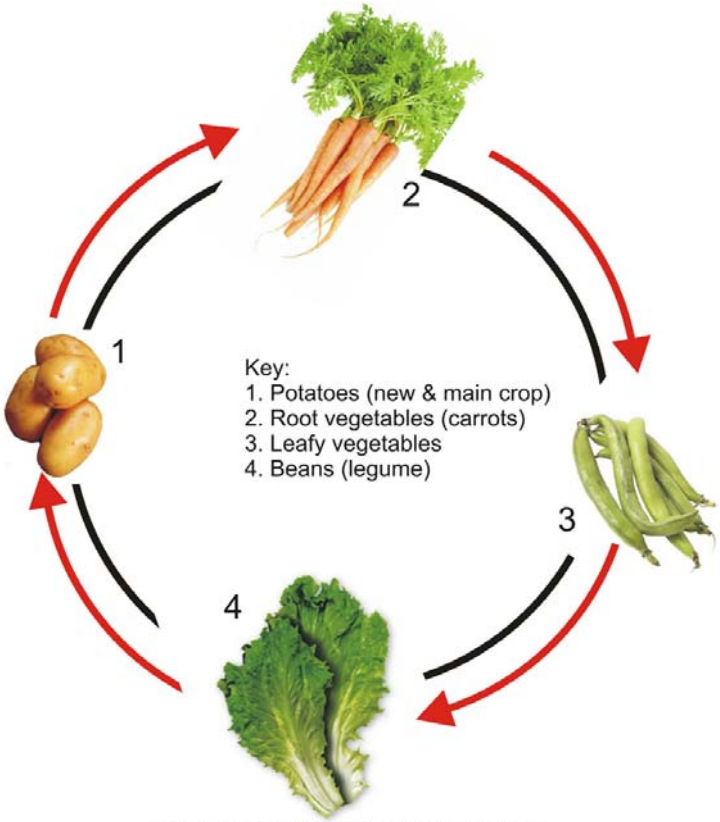
AGROFORESTRY

Agroforestry is the growing of both trees and agricultural/horticultural crops on the same piece of land. This serves the same principal as intercropping. They are designed to provide

tree and other crop products and at the same time protect, conserve, diversify and sustain vital economic, environmental, human and natural resources. Agroforestry differs from traditional forestry and agriculture by its focus on the interactions amongst components rather than just on the individual components themselves. The picture below illustrates a form of agroforestry where pastures are grown under trees.

CROP ROTATION

Crop rotation is growing crops one after another in the same area. Crop rotations; mitigate weeds, disease, insect and other pest problems, provide alternative sources of soil nitrogen; reduce soil erosion; and reduce risk of water contamination by agricultural chemicals. This avoids the development of a particular pest in an area as a result of continuously growing the same crop one after another. It also seeks to balance the fertility demands of various crops to avoid excessive depletion of soil nutrients. The picture below illustrates a typical crop rotation cycle.



Red arrows indicate crop rotation

INTERCROPPING

Intercropping is a form of multiple cropping in which two or more crops simultaneously occupy the same field. Intercropping offers farmers the opportunity to engage nature's principle of diversity on their farms. Spatial arrangements of plants, planting rates, and maturity dates must be considered when planning intercrops. Intercrops can be more productive than growing pure stands. Below is a picture that illustrates intercropping.

Sustainable Management Practices

In sustainable farming there is need to use pest control strategies that are not harmful to natural systems, farmers and their neighbours or consumers. This includes integrated pest management (IPM) techniques that reduce the need for pesticides by practices such as scouting, use of resistant cultivars, timing of planting, and biological pest controls. Sustainable agriculture also includes increased biological weed control; more soil and water conservation practices; and strategic use of animal and green manures. Agriculture in many of the small states is not environmentally sustainable as the sustainable farming practices are not practiced. Crop rotation is not practiced in many small states because of a number of factors, including shortage of land to do so.

SUMMARY

During this lesson you explored the impact of the environment on agriculture and examined some of the best practices in sustainable farming. You also considered the threats to food security and how to counteract the major causes of food insecurity.

In the next lesson you will explore the different vocations available in the agriculture sector.

Activity: Before you begin the next lesson you should participate in the following online activity. Produce and submit a short paper exploring sustainable agriculture in your country. Follow the instructions described below.

LESSON ASSIGNMENT

Assignment Objectives: Produce and submit a short paper (no more than two pages) that:

1. Describes the components of a sustainable agricultural system in your area/country.
2. Describe three sustainable farming practices that are currently used in your area.

Directions: Produce a two page paper with appropriate references. The references must support sustainable farming practices in your area. The references can come from your country's agriculture department web site, local farming or agriculture publications or articles published in journals describing the sustainable agriculture system in your country.

Once you have produced the paper submit it to your instructor by the due date. Your instructor will review it and provide feedback.

LESSON 1.3 - ENTREPENEURSHIP IN AGRICULTURE

OVERVIEW

Entrepreneurship is the practice of starting a new business or reviving an existing business, in order to capitalize on new found opportunities. Thus an entrepreneur is an individual who owns a firm, business, or venture, and is responsible for its development.

It is the task of the entrepreneur to find areas where needs are for products and services. Once a need or a demand is identified, the entrepreneur seeks to make a profit from it.

There are a number of opportunities in agriculture for entrepreneurship. These opportunities can be found in basically three categories of the agricultural spectrum.

These entrepreneurial opportunities can be found in all of the small states that have agricultural industries. The entrepreneur can identify which part of the value chain of production he can position his business.

OBJECTIVES

Upon completion of this lesson you should be able to:

1. Understand the three major categories of the agriculture business.
2. Explain what opportunities are available in the agribusiness.

CATEGORIES OF AGRICULTURE BUSINESS

With reference to business and agriculture there are three categories or areas where there is great potential for an agriculture business. These businesses can target both the domestic and international markets. These businesses can offer both goods and services. The three categories or sectors of the agricultural environment include:

1. Agriculture Inputs Sector
1. Agriculture Production Sector
2. Processing and Manufacturing Sector

Each sector mentioned in the agriculture business has some relationship to the other sectors as one feeds into the other.

Since the Agricultural Input Sector can also be seen as the lower end of the value chain where resources needed for the Agricultural Production Sector are required. The entrepreneur will identify resources that he/she determines to be critical to supply to the Agricultural Production Sector. His decisions are should be based on the level of demand in the Agricultural Production Sector and also on the levels of profit generated. It must be

noted that the aim of the entrepreneur is for profit maximization, in investment, - the more the profit, there are more chances of risk in the investment.

Supply of inputs for production is not only limited to goods, as services like extension, soil testing, plant pathology, veterinary or animal health can be supplied at a fee to the to the Agricultural Production all of which can be entrepreneurial activities.

For ease of understanding a typical farm should be considered the principal unit in the Agricultural Production Sector. It must also be borne in mind that the Agricultural Production Sector can encompass Industries such as the sugarcane, banana, rice or cattle industries. It is important that this sector/Unit be supplied with adequate amounts of inputs of production:

Land: the physical area that is available

Labour : the persons employed to carry out the costs

Capital: the investment initial and operating

Management: Human Resource to be used for the Planning, Organizing, Directing and Monitoring the activities of production.

Once good management is afforded in the units of production, the individual combinations of inputs of production generate products or other services which can be weighed as for efficiency in the generation of revenue. A high Revenue to cost of inputs ratio means a higher turn-over of investment. Another factor that the Entrepreneur needs to remember is the scale of operation. This must however match with his resource base (Land, Labour, Capital & Management) and assists him in answering the questions as to “What and how much to produce?”.

MARKET INTELLIGENCE

The key principle in business that will contribute to the success of entrepreneurial ventures is efficiency and market intelligence. Since investment is a risk, prior knowledge of markets will be important for the minimization of costs and the utilization of available resources efficiently for the maximization of profits. This is the most important element that the entrepreneur must consider if he operates in the agricultural economies in the identified small states.

There is evidence that a foreign entrepreneur will not seek to market a crop to another country where that crop is already in a bountiful supply. He may however be able to target that country with reference to input supplies, for production and even processing and manufacturing adding value to the foreign product.

It is important that an entrepreneur to first identify the target market’s ability to pay for the product prior to his beginning rendering production, here he segments the market and

knows how much of it he will service and what form will he present the product to his consumer.

VALUE ADDED PRODUCTS

The processing manufacturing sector of agribusiness provides opportunities for entrepreneurial activities. Many businesses have opted to use portions of their production for value added products. In this case there is the realization of increased revenue and chances of increased profits. Within the processing and manufacturing sector, utility measures are added onto the product. The three types of utility measures include:

Form Utility: This is done to enhance the marketability of a product by changing its physical characteristics. This makes the product more attractive and makes it more advantageous for certain consumer requirements that the entrepreneur can tap into.

Place Utility: Value can be added by placing the production in convenient locations. In the processing ad manufacturing sector packaging can assist in this measure. The package and processing can overcome the perishability of primary agricultural produce. Packages serve the purpose of protecting and even advertising and informing of the product to consumers.

Time Utility: This is the enhancement of a product's market ability by making it available at a convenient time. Also in the processing and manufacturing sector, the entrepreneur can provide services that will involve time utility. Thus it means that he can satisfy the demand for a particular produce out of season and for this, since he has expended processing costs he can charge increased prices once there is a demand for the product.

DEMAND AND SUPPLY

Entrepreneurs need to know the relationship of how price is achieved reference to the forces in the market. It is important to have some knowledge of the relationship between the quantity of a commodity that producers have available for sale and the quantity that the consumers are willing and able to buy.

Demand depends on the price of the commodity, the process of related commodities, and the consumers' income and tastes.

Supply depends not only on the price obtainable for the commodity but also on the prices of similar products, techniques of production, and the availability and costs of inputs.

It is the function of the market to equalize demand and supply through the price mechanism. If buyers want to purchase more of a commodity than is available on the market, they will tend to bid the price up. If more a commodity is available than the buyers care to purchase, suppliers will bid prices down.

Thus, there is a tendency toward an equilibrium price at which the quantity demanded equals the quantity supplied. The measure of the responsiveness of supply and demand to changes in price is their elasticity.

CAREERS IN AGRICULTURE

This section briefly discusses the potential career opportunities in agriculture. From what you have discovered so far, it is clear that agriculture embraces a large number of activities in many different areas and in several related fields. The lessons to date has illustrated that agriculture requires knowledge of food safety and nutrition, economics, environment, production systems for crops and livestock, post-harvest handling, processing, marketing, research, extension, education.

Careers exist in the agriculture sector and many professionals and technicians are required in the different part of the industry. Each of these professionals and technicians require different levels and types of training. Some examples of different careers are described in the table below.

DISCIPLINE	CAREER	DESCRIPTION	LEVEL
Environment	Soil Microbiologist	Studies microorganisms involved in soil processes	Professional
	Agro-Meteorologist	Forecasts weather conditions and their likely effects on activities such as crop production, or disease incidence	Professional
	Laboratory Technician	Collects technical information using appropriate instruments	Vocational
Livestock	Veterinarian	Studies diseases of animals and treats sick animals	Professional
	Poultry Farmer	Rears poultry animals for sale	Vocational
Crop	Crop breeder	Studies the genetic composition of crops and develops new cultivars	Professional
Engineering	Agricultural Engineer	Designs machinery to improve efficiency in any area of agricultural activity	Professional
Food Processing	Food Processor	Transforms agricultural raw materials to new forms for easier consumption and longer storage	Vocational/ Professional
Banking and Finance	Agricultural Loans Officer	Evaluates proposals and monitors performance of agricultural loans	Professional

DISCIPLINE	CAREER	DESCRIPTION	LEVEL
Extension	Agricultural Extension Officer	Act as facilitators between research and government policy makers to help producers and processors make the best decisions for successful operations	Vocational/ Professional
Business - Sales	Vegetable Retailer	Advertises and sells vegetables to consumers	Vocational/ Professional

Additional Resources. Below are links that describe the different careers in agriculture. If you have an Internet connection explore these sites and find a career that may interest you.

Agricareer (http://www.agcareers.com/)

IFC Global Agribusiness - Business Opportunities (http://www.ifc.org/ifcext/agribusiness.nsf/Content/BusinessOpportunities)

CARICOM Opportunities in Agri-business: Sector Success Stories (http://www.caricom.org/jsp/community/regional_issues/agribusiness_forum/sector_success_stories.pdf)

SUMMARY

You are now familiar with the organization of the agribusiness and the potential careers that you could pursue as an agricultural professional. As you have discovered the agriculture sector requires a wide range of professional and vocational skills and knowledge. For every farmer there are dozens of other professionals required to support the agriculture industry in your country.

Lesson Discussion: You should now participate in the Lesson 1.3 discussion with your peers. Before you begin the discussion with your peers you should investigate at least two different careers (other than farmer or farm owner) that you would potentially pursue. Identify the education and training required to pursue these career streams and what institutions in your country would support the achievement of your career goals.

Once you have completed that activity then you should participate in a small group discussion where you describe the two careers you have selected and then explore the careers presented by your peers.

UNIT ONE DISCUSSION

You are nearing the end of this unit before we finish it is hoped that you can participate in another discussion with your peers.

Discussion Preparation: Before beginning the small group discussion you should re-read the CARICOM success stories (which were part of Lesson 1.3 - http://www.caricom.org/jsp/community/regional_issues/agribusiness_forum/sector_success_stories.pdf).

1. Consider the lessons learned from the different agribusiness examples discussed in the manual.
2. Consider your own country and list at least three lessons learned that would apply to your own country's agribusiness environment.
3. The lessons should be from three different countries.

Discussion: The instructor will break you into small groups. You must be prepared to present the results of your investigation and the lessons learned you have identified. Be prepared to provide feedback to your peers during the discussion. Specifically critique the lessons learned of others.

UNIT ONE SUMMARY

In this unit you have been introduced to agriculture. We have looked at the nature and scope of agriculture; starting first with its origins and shown how it has changed over time. Food security was defined, causes of food insecurity outlined and the current and potential contribution of agriculture to food security was discussed.

UNIT TWO – SOIL AND ITS IMPACT ON AGRICULTURE

INTRODUCTION

Soil is the life blood of agriculture. Rich, healthy soil in combination with the appropriate amount of water and sun will ensure that an agribusiness can thrive and that local farms can support the food requirements of its own population. As a person involved in the agriculture industry you must understand the different types of soils and how judge its quality. You must understand the language of soil and its biological make-up. This unit will provide an overview of soil and its impact on the agriculture industry.

GOALS AND OBJECTIVES

Upon completion of this unit you will be able to:

1. Classify and type soil.
2. Assess the physical characteristics of soil.
3. Assess and measure the chemical characteristics of soil.
4. Produce a soil analysis report.

LESSON 2.1 – SOIL – AN OVERVIEW

OVERVIEW

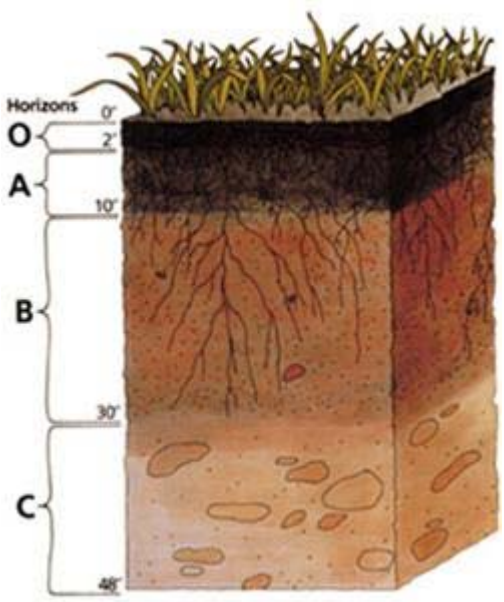
Soil refers to the upper layers of sediment on the Earth that support plant growth. As a medium for plants' growth, it plays an important role in determining which agricultural activity can be supported. Soil in general exists in horizons as shown in the diagram.

Layer O in the diagram is composed mainly of organic matters,

Layer A - the topsoil - Layer of mineral soil with most organic matter accumulation and soil life.

Layer B – subsoil – accumulates most of the leached material from horizon A, composed mainly of clay.

Layer C – Parent material – composed of rocks which weather to form the soil above it.



OBJECTIVES

Upon completion of this lesson learners will be able to:

1. Describe the organic and inorganic composition of soil.
2. Explain what impacts the quality of the soil.
3. Classify soil and soil types.

SOIL COMPONENTS

Soil is composed of organic matters, inorganic matters, organisms, and water and air.

ORGANIC MATTER

Organic component of the soil originates from the remains of plants and animals. When soil conditions are favourable (appropriate temperature and moisture), soil organisms such as earthworms, insects, bacteria, fungi, and other types of plants and animals use the organic matter as food, breaking it down into *humus* and soluble nutrients. This is the *decomposition process*. Through decomposition, plant nutrients are recycled, making it available for use by growing plants.

HUMUS

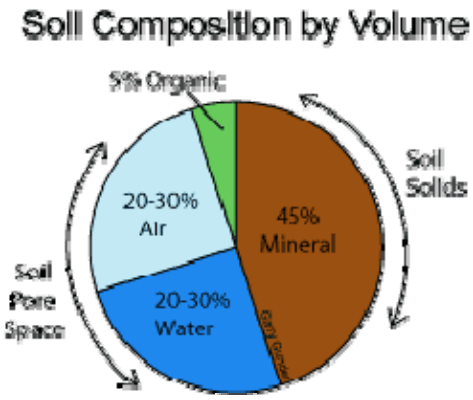
Organic materials assist the nutrients retention in plant-available form. It also helps the aggregation of soil, allowing better soil air-water relationship.

Organic matter content depends on the kinds of plants that are present in the area. Soils that have grass cover for long periods have relatively high organic matter content in the surface area. Those that have desert or native forest cover usually have relatively low organic matter content. In either case, if the plants are grown on a soil that is poorly drained, the organic matter content is usually higher than where the same plants are grown on a well-drained soil. This is due to differences in the availability of oxygen which is needed by the organisms to be able to decompose the organic material. Soils in a cooler climate area have more organic matter than those in the tropical areas where the climate is much hotter.

INORGANIC MATTER

Inorganic component of the soil are the mineral particles which are derived from rocks, sand, silt and clay. Eighteen of these mineral elements are essential for normal plant growth. These are; Carbon, hydrogen, and oxygen which are found in air and water. Nitrogen is a major plant constituent.

The other fourteen essential elements are iron, calcium, phosphorus, potassium, copper, sulphur, magnesium, manganese, zinc, boron, chlorine, cobalt, nickel and molybdenum. The composition of these elements in the soil depends on the parent materials they originate from. Soils that originate from coral limestone will have more calcium in it compared to that from volcanic rocks.



WATER AND AIR

Water and air occupies the same space in the soil. Water in the soil comes from precipitation or (rain, snow, hail, or sleet), and irrigation, entering the soil through cracks, holes, and openings between the soil particles. As the water enters, it pushes the air out. Oxygen is taken up by roots for respiration. If air is unavailable for too long, the roots will die.

Plants use some water, some is lost by evaporation, and some moves so deep into the soil that plant roots cannot reach it. If it rains very hard or for a long time, some of it is lost through surface run-off.

When organic matter decomposes in the soil, it gives off carbon dioxide. This carbon dioxide replaces some of the oxygen in the soil pores. As a result, soil air contains less oxygen and more carbon dioxide than the air above the soil surface. Carbon dioxide is dissolved by water in the soil to form a weak acid, carbonic acid. This then reacts with the minerals in the soil to form compounds that can be taken up and used as foods by the plants.

SOIL ORGANISMS

Soil organisms are composed of macro-organism and micro-organisms. Both these groups of organisms are either harmful or helpful.

Helpful macro-organisms are such as earthworms, which they help in the decomposition of organic matters and tunnelling through the soil leaving more spaces for air and water. The harmful organisms become pests in agriculture like rodents.

Harmful micro-organisms are those that cause diseases to other living organisms. Helpful micro-organisms are helpful in recycling of essential minerals through decomposition and nutrient cycles, such as nitrogen fixation.

SOIL ORGANISMS

We will now move on to discuss the characteristics of soil that distinguishes one from the other, such as classification, soil types, the physical, chemical, and biological characteristics of soil. The combination of these components and characteristics will play a vital role in determining what agricultural activity to practice in a particular area.

SOIL CLASSIFICATION

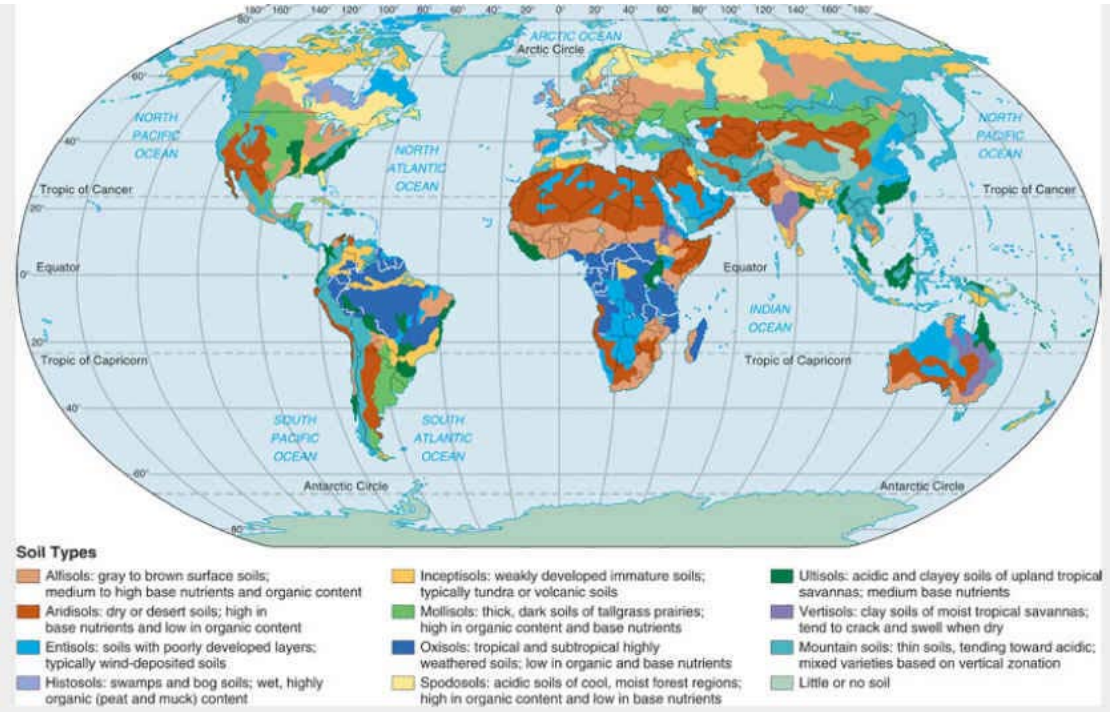
Soil classification considers the genetic origins of soils and defines categories by measurable soil features. Soil is classified into orders to understand the relationships between different

soils and to determine the usefulness of a soil for a particular use. It basically examines the parent material of that soil.

There are a number of different soil classification systems depending on the country of origin. Typically soils are divided into twelve soil orders based on soil characteristics that indicate major soil-forming processes, as given below. Orders are the highest category of soil classification. Order types end in the letters ***sol***.

Order	**General nature of soils**
Alfisols	Gray to brown surface horizons, medium to high base supply, with horizons of clay accumulation; usually moist, but may be dry during summer.
Entisol	Recently formed soils that lack well-developed horizons. Commonly found on unconsolidated sediments like sand, some have an A horizon on top of bedrock.
Vertisol	Inverted soils. They tend to swell when wet and shrink upon drying, often forming deep cracks that surface layers can fall into.
Inceptisol	Young soils. They have subsurface horizon formation but show little eluviation and illuviation.
Aridisol	Dry soils forming under desert conditions. They include nearly 20% of soils on Earth. Soil formation is slow, and accumulated organic matter is scarce. They may have subsurface zones (calcic horizons) where calcium carbonates have accumulated from percolating water. Many aridisol soils have well-developed Bt horizons showing clay movement from past periods of greater moisture.
Mollisol	Soft soils with very thick A horizons.
Spodosol	Soils produced by podsolization. They are typical soils of coniferous and deciduous forests in cooler climates.
Ultisol	Soils that are heavily leached.
Oxisol	Soil with heavy oxide content.
Histosol	Organic soils.
Andisols	Volcanic soils, which tend to be high in silica content.
Gelisols	Organic soils.

Below is a map that illustrates the distribution of soil by geographic region.

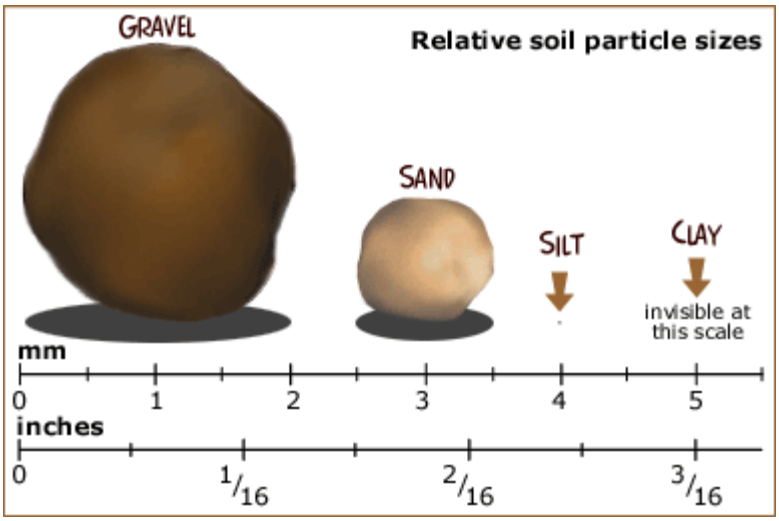


SOIL TYPES

The soil types are mainly determined by the size of soil particles, which are composed mainly of ***sand***, ***silt*** and ***clay***. Sand, silt, and clay are the basic types of soil.

Understanding the basic soil types and their characteristics, can give us a fair idea of which agriculture produce to produce in that particular area. The table below list the characteristics of the three basic soil types.

Characteristics	**Sand**	**Silt**	**Clay**
Particle Size	0.05 – 2.0 mm	0.002 – 0.05 mm	< 0.002 mm
Drainage	High	Moderate	Low
Water holding Capacity	limited	medium	very large
Permeability	rapid	low to moderate	slow
Pore space	Large	Small	Fine
Moisture retention	Low	Moderate	High
Ability to hold minerals	Low	Moderate	High
Tillage	Easy	Moderate	Hard
Texture by Feel	Gritty	Smooth and floury	Extremely Smooth
Soil particle surface area	Small	Medium	Large



Most soils are made up of a combination of the three basic soil particles. The texture of the soil, that is how it looks and feels, depends upon the proportion of each one in that particular soil particle. The texture of a soil, affects the physical behaviour of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification. The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb minerals and to retain moisture as illustrated on the table above.

The type of soil varies from place to place, and even varies from one place to another in your own backyard. During field work, we can determine the soil type by using the table below (observable soil types and their characteristics):

Type Of Soil		Texture	Feel	Structural Stability	Moisture Holding	Drains	Ease Of Digging
Light	Sand Based	Course	Gritty	Weak	Poor	Fast	Easy
Light	Peat Based	Fibrous	Crumbly	Weak	Fair	Slowly	Easy
Medium	Silt Based	Fine	Silky	Weak	Fair	Slowly	Fair
Medium	Loam Based	Mixed	Crumbly	Good	Good	Well	Good
Medium	Chalk/ Limestone Based	Mixed	Crumbly	Good	Good	Well	Fair-Good
Heavy	Clay Based	Fine	Smooth	Strong	Good/ Water Logs	Slowly	Hard

LESSON SUMMARY

During completion of this lesson you explored the composition of soil and how important soil health is to the cultivation of plants. You learned how to classify and soil and how to determine the soil's composition. In future lessons you will learn how to nurture the soil and ensure it can support your crops and the success of your farm.

LESSON 2.2 – SOIL CHARACTERISTICS

OVERVIEW

Soil physical properties are those characteristics which can be seen with the eye or can be felt. These are the result of soil parent materials being acted upon by climatic factors (such as rainfall and temperature), and affected by topography (slope and direction, or aspect) and life forms (kind and amount, such as forest, grass, or soil animals) over a period of time. A change in any one of these influences usually results in a difference in the type of soil formed. Important physical properties of a soil that will be discussed in this lesson are texture, structure, permeability, drainage, depth, infiltration rates, moisture retention, and erodability.

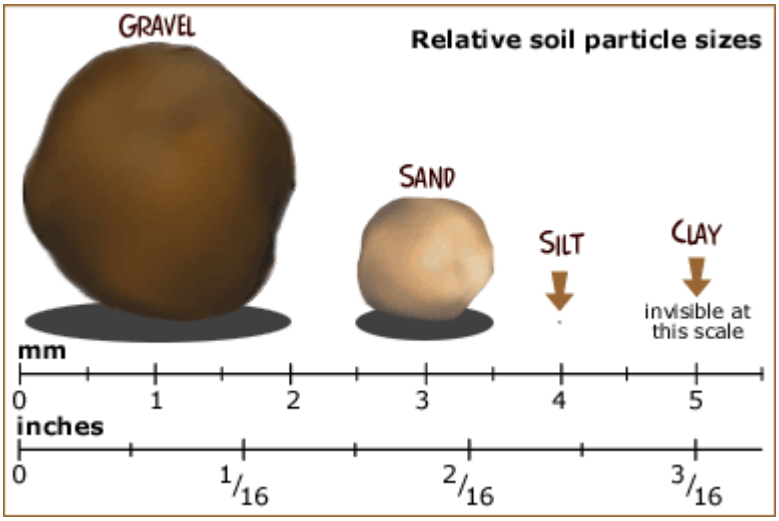
OBJECTIVES

Upon completion of this lesson you will be able to identify the physical characteristics of soil. Specifically you be able to discuss the concepts of:

1. texture,
2. structure,
3. permeability,
4. drainage,
5. depth,
6. infiltration rates,
7. moisture retention, and
8. erodability of soil.

SOIL TEXTURE

Soil texture refers to the proportion or relative composition of different soil particles in a soil. Soil texture depends on the relative amounts of sand, silt, and clay. In each texture class, there is a range in the amount of sand, silt, and clay that class contains. The picture below demonstrates the range of sizes.



Each soil has a mixture of these soil particles, and their proportion (in percentage %) determines the textural class. Observation and the use of feeling method are widely used in the field to quickly determine the texture.

An estimation of texture can be made in the field by using the following method:

1. Place about a tablespoon of soil in the palm of your hand.

2. Mix it with water and form a moist ball. The soil is at the correct consistency when the ball does not leave soil on the palm of your hands when it is rolled around (the consistency of modeling clay.)

3. Press the moistened soil ball between the thumb and forefinger in an attempt to form a ribbon with the soil. As the thumb and forefinger are pressed together the soil will extrude forming the ribbon. The motion should be repeated several times to test the cohesiveness of the ribbon, attempting to form a continuous ribbon.

4. Ribbons can be classed into three broad categories:
    a. **Good Ribbon** —The ribbon does not break and has very little cracking along the sides.
    b. **Medium Ribbon** —The sides of the ribbon crack deeply and eventually the ribbon will break and fall off.
    c. **Poor Ribbon** —No ribbon formed (no cohesiveness) or the ribbon breaks with the first applied pressure and does not cohere.

5. The sample is then further wetted and mashed between the thumb and forefinger. This is to determine the amount of grittiness or smoothness. The soil should be wet

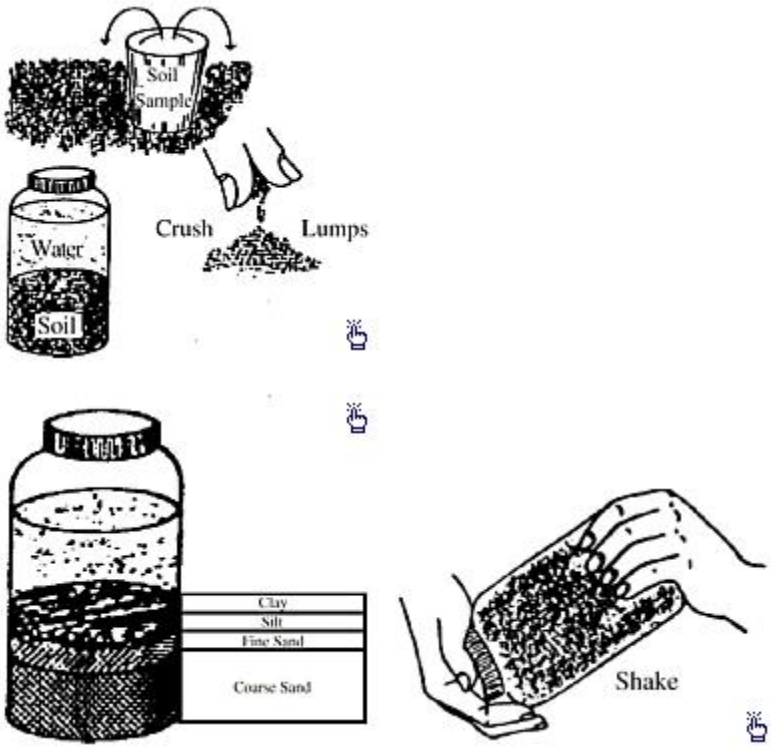
enough to feel individual particles. If the soil feels like sand, then it is called "gritty." If it feels like flour then it is called "smooth." There is a category between the two that is both smooth and gritty but no descriptive term is used.

DETERMINING SOIL TEXTURE

Your challenge now is to complete an individual experiment to determine the soil texture in your backyard or own personal garden. Try the two experiments described below and then be prepared to discuss the results or your experiment with your peers. It is recommended that you keep a journal to capture the results of your experiment.

Follow the guidelines below and be prepared to answer the questions are the end of each experiment.

Determining Soil Texture - Personal Exercise



Soil Texture

Objectives:

Students will be able to:

1. determine soil composition
2. identify the 3 soil particle sizes.

Activity:

1. Collect soil from 2 different areas in the outdoor classroom.
2. Fill two quart jars 2/3 full of water. Label them soil 1 and soil 2.
3. Pour 1 cup of finely crushed soil from area 1 into the jar labeled soil 1.
4. Pour 1 cup of finely crushed soil from area 2 into the jar labeled soil 2.
5. Add 3 tablespoons of non-sudsing detergent (dish washer detergent) to each jar.
6. Cover the jars tightly and shake hard, at intervals, for at least 5 to 10 minutes or until the soil particles are broken apart.
7. Place the jars where they will not be disturbed for 24 hours.

8. After 24 hours of settling, place an index card alongside each jar and carefully make a mark to show the thickness of each layer of settled soil. Label each layer of soil as illustrated. Coarsest particles (sand) will settle first: finest particles (clay) will settle out last.

Questions:

1. Which jar has the clearest water?
2. What is the approximate thickness of the layer of sand from the area 1 soil sample?
3. What is the approximate thickness of the layer of sand from the area 2 soil sample?
4. Which soils have the most sand? silt? clay?
5. What are the percentages sand, silt, and clay for each soil?
6. Can you explain why some soils have different proportions of sand, silt, and clay than the others?

Use the table given below to classify the soil samples you worked on.

Other textural designations of surface soils are sands, loamy sands, sandy clay loams, silty clay, silts, and clays. In each textural class there is a range in the amount of sand, silt, or clay that class may contain. These ranges can be expressed as a percentage for each soil texture. The percentages converge on the soil triangle to determine soil textural classes. The composition of each textural class does not allow for overlap from one class to another.

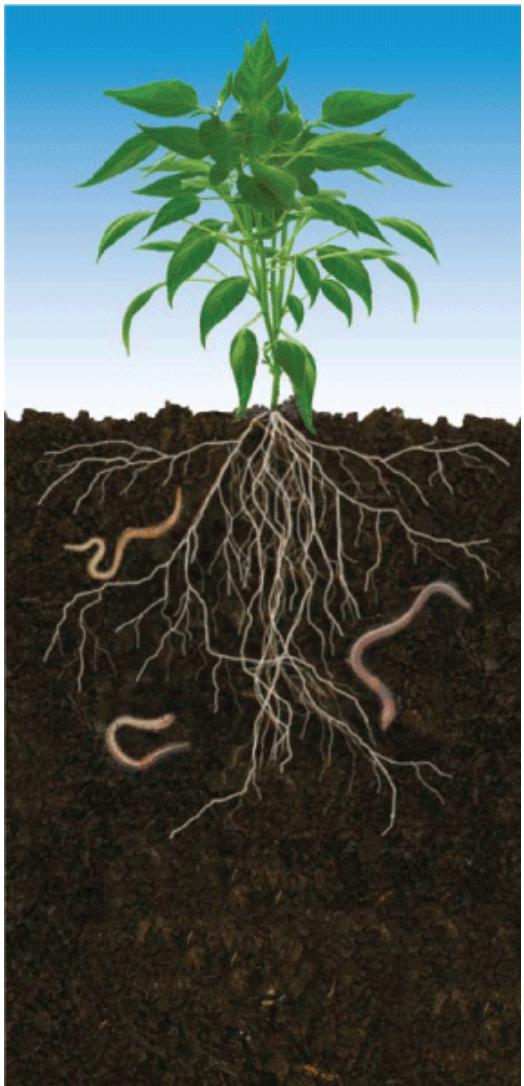
Textural Group		**Textural Classes**
Sandy	Coarse	• Sand • Loamy Sand
Loamy	Moderately Coarse	• Sandy Loam
	Medium	• Loam • Silt Loam • Silt
	Moderately Fine	• Clay Loam • Sandy Clay Loam • Silty Clay Loam
Clayey	Fine	• Sandy Clay • Silty Clay • Clay

SOIL STRUCTURE

Soil structure refers to the aggregation of the soil particles in the soil. Most soil particles are grouped together to form structural pieces called peds or aggregates. In the soil, the structure usually will be granular unless it is very sandy. The soil aggregates will be rounded and vary in size from very small to a large one. If organic matter content is low and the soil has been under continuous cultivation, the soil structure may be quite indistinct. If the soil is fine-textured with high organic content, it may have a blocky surface structure. Substance aggregate types are platy, blocky, prismatic, and massive. Refer to the diagram below for the comparison of these structure types.

Type	Single Grain	Granular	Blocky	Platy	Prismatic	Massive
Characteristics	Individual grains not held together often referred to as structure less.	Porous granules held together by organic matter and some clay. Found in *A* horizons with some organic matter.	Roughly equidimentional PEDS higher in clay than other structural aggregates.	Aggregates have a thin vertical dimension. Found in compact thin layers.	Aggregates that have a much greater vertical than lateral dimension.	No definite structure or shape, and is usually hard. Compact, and usually found in horizon C.

To learn more about soil structure and to view examples of the different types it is recommended you go to: Get Down and Dirty: How Does Soil Change with Depth? (http://www.sciencebuddies.org/science-fair-projects/project_ideas/EnvSci_p011.shtml)



Air and water movement within the soil is closely related to its structure. Good structure allows rapid movement of air and water, while poor structure slows down this movement. Other things being equal, water can enter a surface soil that has granular structure more rapidly than one that has little structure. Soil compaction due to excessive vehicle or foot traffic or excessive tillage can greatly reduce soil aggregation and water infiltration. Since plant roots move through the same channels in the soil as air and water, good structure allows extensive root development whereas poor structure discourages it. Water, air, and plant roots move more freely through subsoil that has blocky structure than those with a flaky

horizontal structure. Good structure of the surface soil is promoted by an adequate supply of organic matter. Soil structure can be protected, by working the soil only when moisture conditions are correct.

Growing plants also change the soil structure as they send their roots into the soil for mechanical support and to gather water and nutrients. The roots of plants, as they grow, tend to enlarge the openings in the soil. When they die and decay, they leave channels for movement of air and water. In addition to the plants that we see, there are bacteria, fungi, nematodes, and other very small organisms growing in the soil which can be seen only with the aid of a microscope.

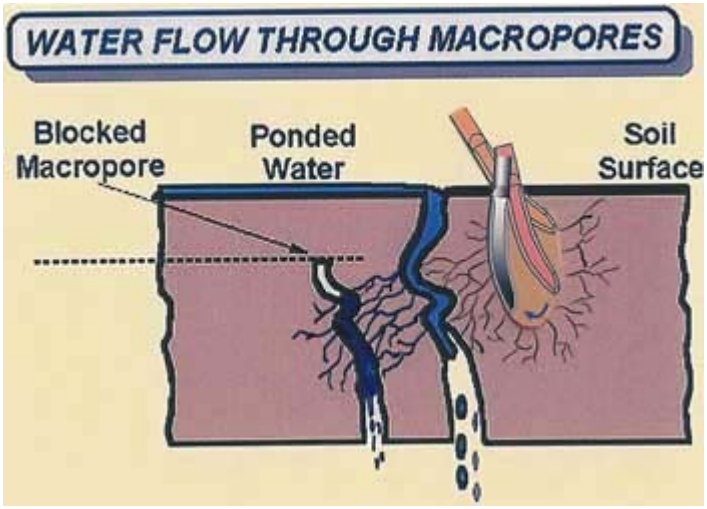
SOIL PERMEABILITY

Permeability refers to the rate at which water moves through the soil, and Water-Holding Capacity (WHC); the ability of a soil's microspores to hold water for plant use, are affected by:

- the amount, size and arrangement of pores, (determined by texture and structure of a soil);
- macrospores, which control a soil's permeability and aeration; and
- microspores, which are responsible for a soil's water holding capacity.

Porosity (ability of a material to transport water vertically or horizontally through a material) is affected by:

- soil texture;
- soil structure;
- compaction; and
- organic matter.



SOIL DEPTH

The effective depth of a soil for plant growth is the vertical distance into the soil from the surface to a layer that essentially stops the downward growth of plant roots. The barrier layer may be rock, sand, gravel, heavy clay, or a cemented layer (e.g. caliche). Terms that are used to express effective depth of soil are:

Very Shallow — surface is less than 25 cm from a layer that retards root development.

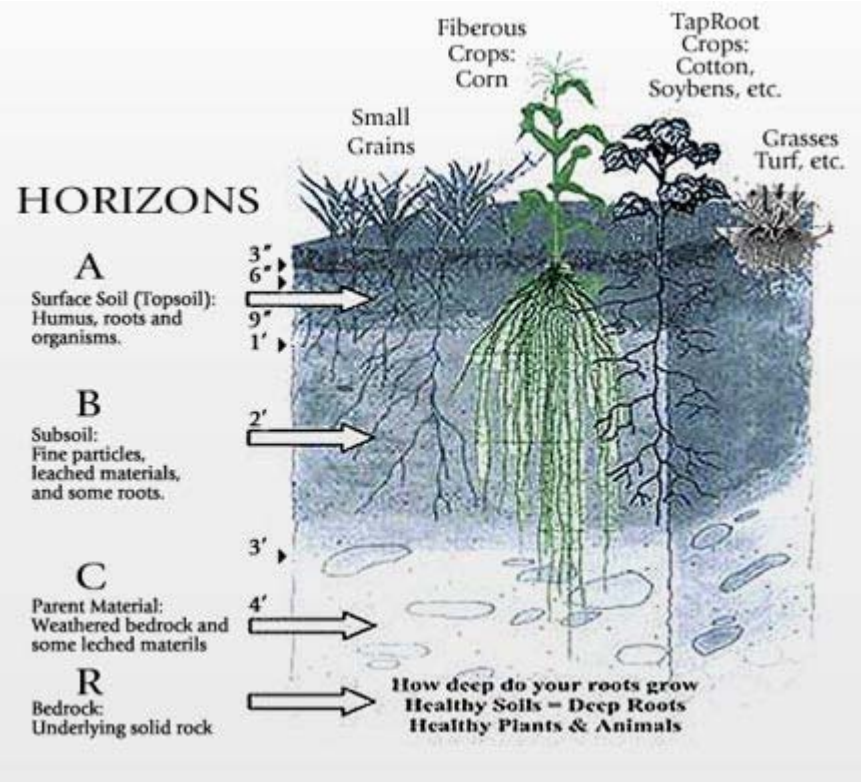
Shallow — Soil surface is 25 to 50 cm from a layer that retards root development.

Moderately Deep — Soil surface is 50 to 90 cm from a layer that retards root development.

Deep — Soil surface is 90 to 152 cm from a layer that retards root development.

Very Deep — Soil surface is 152 cm or more from a layer that retards root development.

Soils that are deep, well-drained, and have desirable texture and structure are suitable for the production of most garden or landscape plants. Deep soils can hold more plant nutrients and water than can shallow soils with similar textures. Depth of soil and its capacity for nutrients and water frequently determine the yield from a crop, particularly annual crops that are grown with little or no irrigation. Plants growing on shallow soils also have less mechanical support than those growing in deep soils. Trees growing in shallow soils are more easily blown over by wind than are those growing in deep soils.



INFILTRATION RATES

The **infiltration rate** is the velocity or speed at which water enters into the soil. It is usually measured by the depth (in mm) of the water layer that can enter the soil in one hour. An infiltration rate of 15 mm/hour means that a water layer of 15 mm on the soil surface, will take one hour to infiltrate.

In dry soil, water infiltrates rapidly. This is called the initial infiltration rate. As more water replaces the air in the pores, the water from the soil surface infiltrates more slowly and eventually reaches a steady rate. This is called the basic infiltration rate.

The infiltration rate depends on soil texture (the size of the soil particles) and soil structure (the arrangement of the soil particles. This is a useful way of categorizing soils from an irrigation point of view. The larger the soil pores, more water can to move in, the higher infiltration rate. Very high or very low infiltration rate, will not be appropriate for most farm enterprises to be produced in.

Knowing the infiltration rate of your piece of land to use is handy in deciding a farm enterprise to operate. To learn how to calculate the infiltration rate click here: How to Calculate Infiltration Rate (http://www.ehow.com/how_6586723_calculate-infiltration-rate.html).

Activity: Go into your backyard or into one of your fields and based on the article above calculate the infiltration rate for your own soil. Note that infiltration rate in your journal and be prepared to discuss it the next time you are in class.

SOIL MOISTURE RETENTION

The capacity of the soil to hold water and its availability to plants directly affects productive potential of that particular soil. The ability of a soil to store or retain water and nutrients, depend on the number and size of pores, 'storage sites' in the soil and the amount of clay and organic matter it contain. Bear in mind that clay soil (more microspores) tend to retain water better than sand, as well as organic matters, which help in preserving water in the soil.

Measuring the '*cation exchange capacity*' of the soil can assess the storage capacity for a range of nutrients. The availability of nutrients from this store can be assessed by standard soil and tissue tests.

Supplementary Readings. To learn more about cation exchange capacity it recommended you read the following article:

Micro Soil (http://www.microsoil.com/CEC.htm)

ERODABILTY

Soil erodibility is a measure of the likelihood of soil erosion, based on the physical characteristics of each soil. Generally, soils with faster infiltration rates (better drainage), higher levels of organic matter and improved soil structure have a greater resistance to erosion, thus soil erodability is lower. Sand, sandy loam and loam textured soils tend to be less erodible than silt, very fine sand, and certain clay textured soils.

Tillage and cropping practices which lower soil organic matter levels, cause poor soil structure, and the result of compaction contribute to increases in soil erodibility. Decreased infiltration and increased runoff can be a result of compacted subsurface soil layers. An increase in use of heavy machinery in the field will lead to soil compaction, thus increasing the chance for more water runoff, which contribute to greater soil erosion problems.

The steeper a piece of land slopes, the more susceptible it is to soil erosion. Plant and residue (organic matter) cover, on the other hand, protects the soil from raindrop impact and splash, tends to slow down the movement of surface runoff and allows excess surface water to infiltrate.

Past erosion has an effect on a soil's erodibility for a number of reasons. Many exposed subsurface soils on eroded sites tend to be more erodible than the original soils were, because of their poorer structure and lower organic matter. The lower nutrient levels often associated with sub-soils contribute to lower crop yields and generally poorer crop cover, which in turn provides less crop protection for the soil.

Supplementary Reading. To learn more about soil erosion it is recommended you review:

Soil Erosion - Causes and Effect (http://www.omafra.gov.on.ca/english/engineer/facts/87-040.htm)

LESSON SUMMARY

During completion of this lesson you completed some personal experiments to gauge your soil's texture and infiltration rate. You explored the characteristics of soil and the structure of soil. In the next lesson you will explore the chemical characteristics of soil and the impact of chemicals on the health of the soil.

LESSON 2.3 – CHEMICAL CHARACTERISTICS OF SOIL

OVERVIEW

Soil chemical characteristics can be described based on their pH level, the salinity (EC) of the soil, the cation exchange capacity (CEC) and the organic matter it contains. This lesson will explore the concepts underlying these characteristics and explore how to measure the chemical composition of your soil to determine its health and safety.

OBJECTIVES

Upon completion of this lesson you will be able to:

1. Explain and measure soil pH levels.
2. Explain and measure soil salinity.
3. Explain the cation exchange capacity of your soil.
4. Describe the impact of organic matter on the chemical composition of soil.

MEASURING SOIL PH

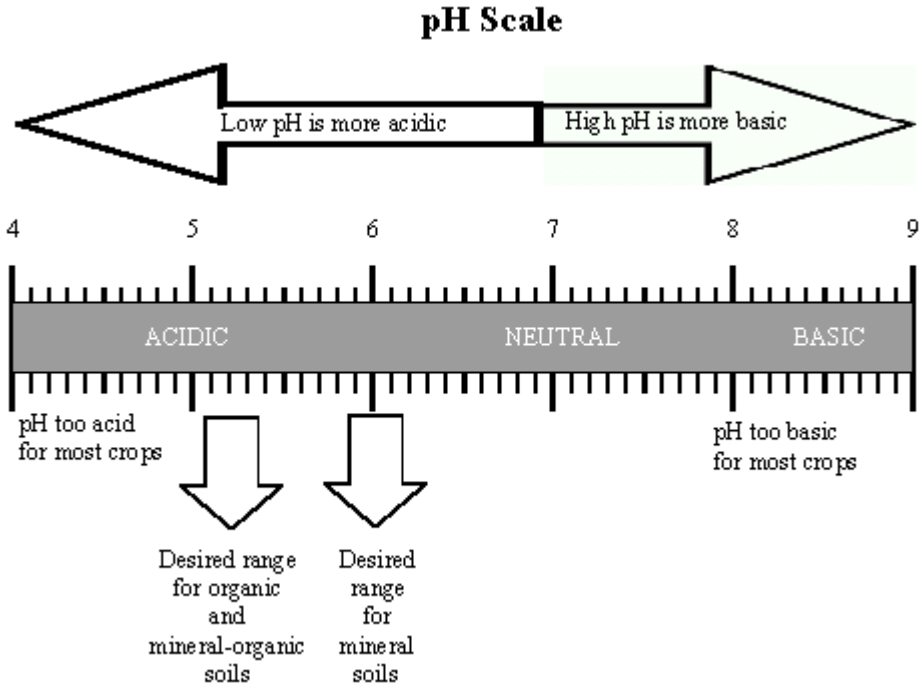
A pH (**p**otential **H**ydrogen ion) is a chemical measure that is taken with a meter that has a scale that measures the hydrogen (acid-forming) ion activity of soil or growth media. The reading expresses the degree of acidity or alkalinity in terms of pH values. It is a Logarithmic scale which means that a 1-unit drop in pH is a 10-fold increase in acidity.

The scale of measuring acidity or alkalinity contains 14 divisions known as pH units. It is centered around pH 7 which is neutral. Values below 7 constitute the acid range of the scale and values above 7 make up the alkaline range

The measurement scale is not a linear scale but a logarithmic scale. That is, a soil with a pH of 8.5 is ten times more alkaline than a soil with a pH of 7.5 and a soil with a pH of 6.5 is a hundred times more acid than a soil with a pH of 8.5

The pH condition of soil is one of a number of environmental conditions that affect the quality of plant growth. A near-neutral or slightly acidic soil is generally considered ideal for most plants. Some types of plant growth can occur anywhere in a 3.5 to 10.0 range. With some notable exceptions, a soil pH of 6.0 to 7.0 requires no special cultural practices to improve plant growth.

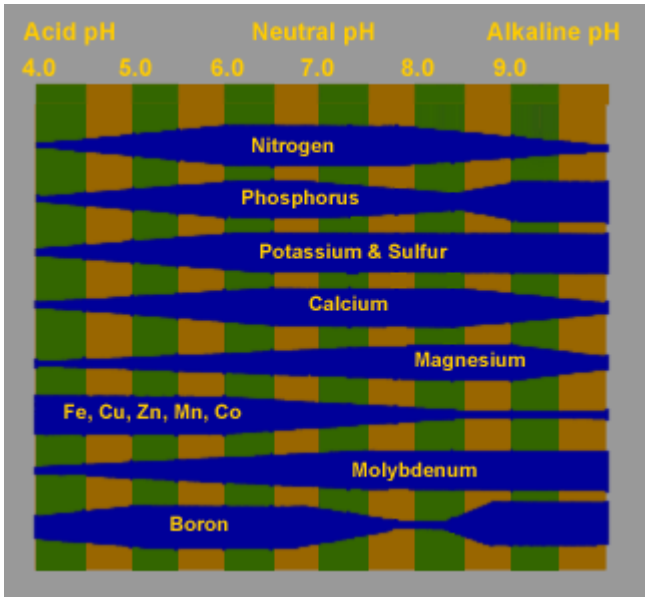
An example of pH scale is provided below.



Soil pH affects availability of plant nutrients (in general, optimal pH is between 5.5 - 7.0). The low pH soils (<5.0) results in an increase in aluminum is toxic to plants as well as other ions that often react with others forming insoluble salts, that locked it from being available to plants, such as Iron fixing Phosphate (making it unavailable). Calcium on the other hand fixes Phosphorus when soil is alkaline.

NUTRIENT STATUS

The chart on the next page shows how pH, the alkalinity or acidity of soil, affects availability of nutrients. Notice that most of the coloured bands are widest, indicating more of the nutrient is available, at pH range 6-7.



As this indicates, most nutrients are more available, chemically, in the soil at this optimum growth range for most plants. Where soils are more acid or alkaline, a nutrient deficiency symptom is more likely to appear even if the nutrient is present in the soil, because the plants cannot chemically extract it.

Supplementary Readings: To learn more about soil nutrients it is recommended you should review the following online articles:

Soil pH and Plant Nutrients
(http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex6607)

Tree Fruit Soil and Nutrition (http://soils.tfrec.wsu.edu/mg/chemical.htm)

SALINITY

Soil salinity describes the situation when a soil contains high levels of salt. Plants and soil organisms' are productivity is severely limited or killed on affected soil. Plants absorb essential nutrients in the form of soluble salts, but excessive accumulation of soluble salts, suppresses plants' growth. Salts in the soil exist as ions (electrically charge forms of atoms or compounds).

The sources of these salts are; weathered minerals in the soil, irrigation or the upward movement from shallow water table, and fertilizers.

Poor drainage is the most common cause of soil salinity, as well as poor irrigation water often contributes to soil salinity. When water are absorbed by plants or evaporates from the soil, increases the risk of soil salinity. To prevent this salinity built up, enough water must pass through to the root zone to leach salts from the soil. Keeping in mind, some of these salts are essential to plants' growth, such as Nitrate, and some may become

pollutants if leached to the underground water. Below is a picture of a field with high salinity (white on top of the soil).

The effect of salts on plants is its osmotic effect. It increases the energy that plant roots uses to absorb water from the soil particles. Water is then to be in adequate amount to dissolve these salts, to make water absorption of roots easier.

The other effect of salinity is its toxicity of certain salts to nutritional imbalances. Some elements such as boron, chlorine and sodium, have specific toxic effects on plants. These have to be kept in low level, as plants are so sensitive to their level in the soil. Some of the salts are essential plant nutrients; the high levels of salts will upset the nutrient balance in the plants, or interfere with the uptake of some nutrients.

Supplementary Reading - To learn more about soil salinity it is recommended you review the following article:

Wikipedia - Soil Salinity (http://en.wikipedia.org/wiki/Soil_salinity)

CATION EXCHANGE CAPACITY

The ability of the soil to hold on to cations is **cation exchange capacity** (CEC). It is a measure of the quantity of cations that can be adsorbed and held by a soil. Cations are positively charged ions. Most nutrients are cations: Ca^{2+}, Mg^{2+}, K^{+}, NH_4^{+}, Zn^{2+}, Cu^{2+}, and Mn^{2+}. These cations are in the soil solution and are in dynamic equilibrium with the cations adsorbed on the surface of clay and organic matter**.**

Clay particles are composed of minerals that, in general, possess a negative electrical charge. In some mineral particles this charge is built in to the clay crystals, and is unaffected by changing soil conditions. In other clay minerals, and in organic particles, the charge is

altered by changes in soil acidity. This charge is called **variable charge.** Variable charge is greatest under alkaline conditions, and least under acidic conditions.

The negative charges of clay particles give them the ability to attract and hold positively-charged molecules (cation). Nutrients retained by CEC are prevented from leaching out of the rooting zone, yet are held loosely enough to be available to growing plants.

The soil properties most closely related to CEC are *soil texture* and *organic matter* content. Fine textured soils have more CEC than coarse-textured soils, and soils high in organic matter have more CEC than low organic matter soils. Also, non-acidic soils have more CEC than acidic soils.

Some soil particles have a small positive electrical charge, and can attract **anions** (negatively-charged molecules.) Anion exchange capacity is usually insignificant in Arizona soils.

Supplementary Reading: To learn more about CEC review the following online article:

Cation Exchange Capacity in Soils, Simplified
(http://www.soilminerals.com/Cation_Exchange_Simplified.htm)

SOIL MICROBIOLOGY

Microorganisms constitute < 0.5% (w/w) of the soil mass yet they have a major impact on soil properties and processes. 60-80 % of the total soil metabolism is due to the microflora. In numbers, soil microorganisms beat out all other organisms. One gram of topsoil may contain; as many as one billion bacteria, up to 100 million actinomycetes, one million fungi, and 100 nematodes. Not all the microorganisms in the soil are beneficial, bear in mind that a lot are harmful to plans' growth.

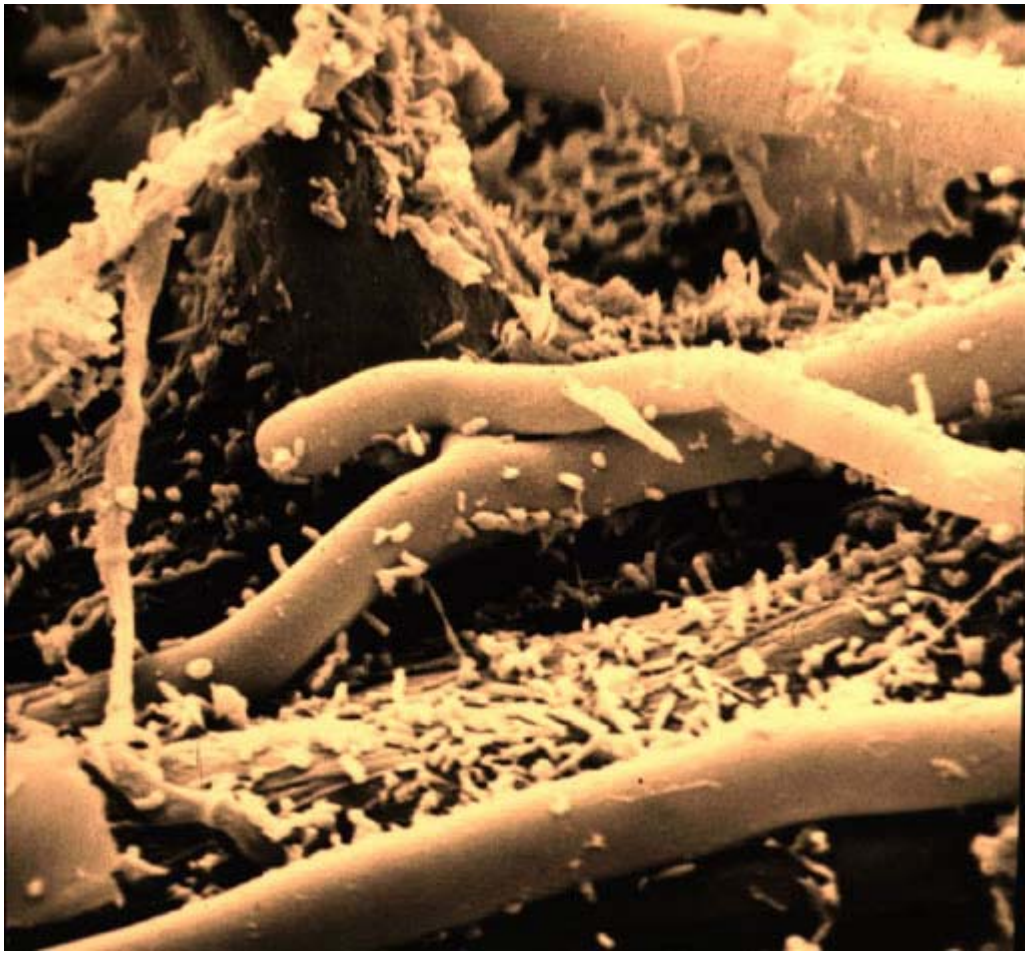
IMPORTANCE OF SOIL ORGANISMS

Microorganisms are beneficial in soil because they:

- are responsible for cycling of C, N and other nutrients, by decomposing organic matters, and their involvement in fixing nitrogen in the nitrogen cycle;
- enhance soil structure, through decomposition of organic matter, which its product (humus), helps in soil aggregation;
- increase soil aeration and penetrability, by helping soil structure formation, which allows more space for aeration and root penetration; and
- involved in disease transmission and control.

The narrow region of soil directly around roots, crowded with bacteria that feed on sloughed-off plant cells and the proteins and sugars released by roots. Protozoa and nematodes graze on bacteria also concentrated near roots.

Soil Bacteria



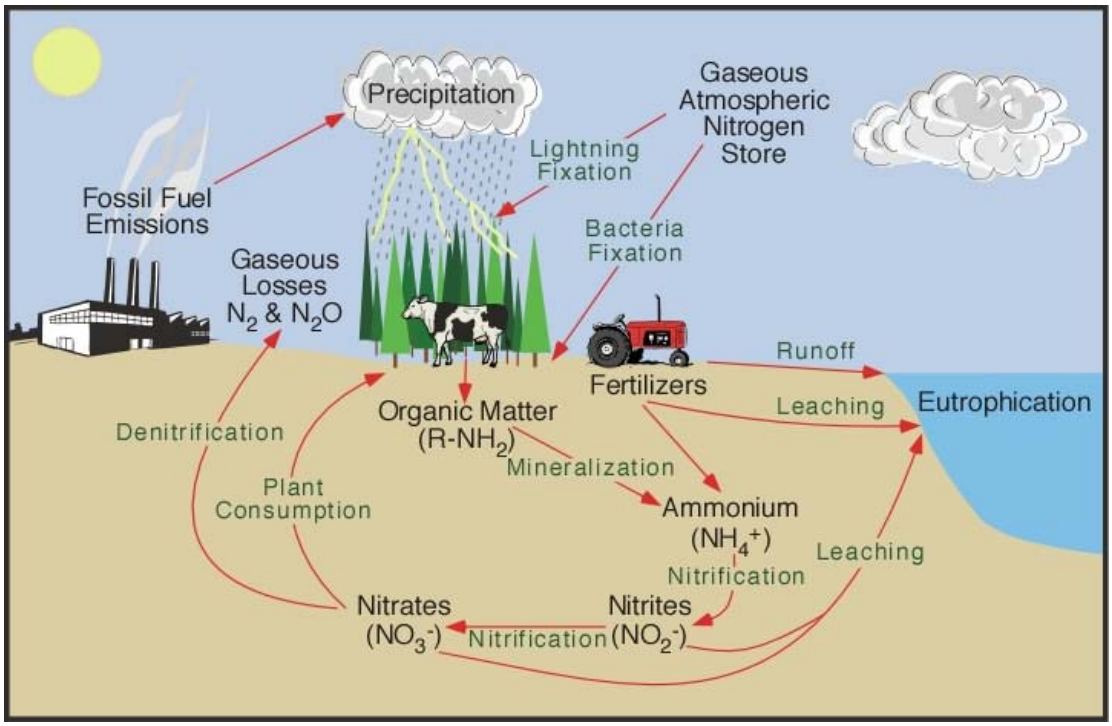
NITROGEN FIXATION

Micro organisms play a significant role in nutrient recycling, as well as getting involved in some important soil nutrient's recycles. Its involvement in the Nitrogen cycle is vital, for without these microbes this recycling of nitrogen, will be impossible.

Some bacteria such as Rhizobum and Azotobactor converts N_2 into ammonia by the process termed **nitrogen fixation**; these bacteria are either free-living or form symbiotic associations with plants or other organisms (e.g. legume's root nodules, termites, protozoa). Other bacteria bring about transformations of ammonia to nitrate, and of nitrate to N_2 or other nitrogen gases. Many bacteria and fungi degrade organic matter, releasing fixed nitrogen for reuse by other organisms.

All these processes contribute to the **nitrogen cycle** (see diagram below)**.** In most ecosystems nitrogen is primarily stored in living and dead organic matter. This organic nitrogen is converted into inorganic forms when it re-enters the biogeochemical cycle via decomposition. Decomposers, found in the upper soil layer, chemically modify the nitrogen

found in organic matter from ammonia (NH_3) to ammonium salts (NH_4^+). This process is known as mineralization and it is carried out by a variety of bacteria, actinomycetes, and fungi.



Nitrogen in the form of ammonium can be absorbed onto the surfaces of clay particles in the soil. The ion of ammonium has a positive molecular charge is normally held by soil colloids. Ammonium can be used by plants, but is often chemically altered by a specific type of autotrophic bacteria (Nitrosomonas bacteria) into nitrite (NO_2). Further modification by another type of bacteria (Nitrobacter) converts the nitrite to nitrate (NO_3). Both of these processes involve chemical oxidation and are known as nitrification. However, nitrate is very soluble and it is easily lost from the soil system by leaching. Some of this leached nitrate flows through the hydrologic system until it reaches the oceans where it can be returned to the atmosphere by denitrification. Denitrification is also common in anaerobic soils and is carried out by heterotrophic bacteria. The process of denitrification involves the metabolic reduction of nitrate (NO_3) into nitrogen (N_2) or nitrous oxide (N_2O) gas. Both of these gases then diffuse into the atmosphere. refer to the nitrogen cycle (figure 2.6 for illustration

Almost all of the nitrogen found in any terrestrial ecosystem originally came from the atmosphere. Significant amounts enter the soil in rainfall or through the effects of lightning. The majority, however, biochemically fixed within the soil by specialized micro-organisms like bacteria, actinomycetes, and cyanobacteria. Members of the bean family (legumes) and some other kinds of plants form mutualistic symbiotic relationships with nitrogen fixing bacteria. In exchange for some nitrogen, the bacteria receive from the plants carbohydrates

and special structures (nodules) in roots where they can exist in a moist environment. Scientists estimate that biological fixation globally adds approximately 140 million metric tons of nitrogen to ecosystems every year.

Nitrogen is the nutrient needed in largest amounts by plants and is the most commonly applied fertilizer. Excess N can have negative effects on plant growth and crop quality harming the environment, especially water quality.

Nitrogen is present in one of five forms in soil:

1. Organic N: 90% of N is in organic form. It must be mineralized to become available.
2. Ammonium N (NH_4^+): Inorganic, soluble form
3. Nitrate (NO_3^-): Inorganic, soluble form
4. Atmospheric N (N_2): 80% of atmosphere but unavailable to most plants except N-fixers
5. Nitrite (NO_2^-): only under anaerobic conditions. This form is toxic to plants and normally will not be present in significant amounts in soil.

MINERALIZATION AND IMMOBLIZATION

Mineralization - the release of organically bound nutrients in an inorganic form usable to organisms and/or plants.

Immobilization - the conversion of an element from the inorganic to the organic form unavailable to plants.

Mineralisation and Immobilization are based on C:N (carbon to nitrogen) ratios. That is when there is a:

Low C:N ratios (<25:1) indicates that mineralization and rates of decomposition will be fast.

High C:N ratios (>25:1) indicates an immobilization and slower decomposition rates.

Low C:N materials (high N values) is caused by, undiluted manure and blood meal, grass clippings (can get high), vegetable wastes and so forth.

Intermediate C:N materials, are found in most composts, leaf mulches and cover crop residues.

High C:N materials are in straw, bark, wood chips, sawdust, paper, cornstalks, foliage.

Supplementary Reading. To better understand the C:N ratios and their impact on your crops it is recommended your review the following online article.

Miller, C. (2000). Understanding the carbon to nitrogen ratio. Acres. (http://www.rockymtnbioproducts.com/pdf/Understanding%20the%20Carbon-Nitrogen%20Ratio.pdf)

ORGANIC MATTER DECOMPOSITION

Organic matter in soil consists of the remains of plants and animals. Organic matter is the storehouse for soil nutrients, which are only released for plant's use by soil organisms. When temperature and moisture conditions are favourable in the soil, soil organisms such as earthworms, insects, bacteria, fungi, and other types of plants and animals use the organic matter as food, breaking it down into humus (the portion of organic matter that remains after most decomposition has taken place) and soluble nutrients. Through this process, essential nutrients are made available for use by growing plants. In addition, organic material has a very high cation exchange capacity, so nutrients are retained in plant-available form. The digested and decomposing organic material also helps develop good soil-air-water relationships.

In sandy soil, organic material occupies some of the space between the sand grains, thus binding these particles together and increasing its water-holding capacity. In a finely textured or clay soil, organic material on and around soil particles creates aggregates of the fine soil particles, allowing water to move more rapidly around these larger particles. This grouping of the soil particles into aggregates or PEDS makes soil soft and easier to work.

Organic matter content depends primarily on the kinds of plants that have been growing in a soil, the long-term management practices, temperature, and drainage. Soils that have native grass cover for long periods usually have relatively high organic matter content in the surface area. Those that have desert or native forest cover usually have relatively low organic matter content. In either case, if the plants are grown on a soil that is poorly drained, the organic matter content is usually higher than where the same plants are grown on a well-drained soil. This is due to differences in available oxygen which is needed by the organisms that attack and decompose the organic material. The activity of soil microorganisms is temperature dependent, where too hot and too cold limits their activity.

Beneficial impacts of soil organic matters on soil properties are:

Physical - stabilizes soil structure, improves water holding characteristics, lowers bulk density, dark color may alter thermal properties

Chemical - higher CEC, acts as a pH buffer, ties up metals.

Biological - supplies energy and body-building constituents for soil organisms, increases microbial populations and their activities, source and sink for nutrients, ecosystem resilience, affects soil enzymes

Each year, about 1 to 4% of nutrients in the soil organic matter are released through microbial transformations to become available to plants. Release is highest under warm, moist conditions and slowest in cool dry climates. Microorganisms are the driving force for nutrient release to plants.

SUMMARY

The location of land area, where it is located geography, climates of that particular area, as well as the type of parent materials, will contribute to the physical and chemical characteristics of that particular land area. Any agricultural activity to be put up in such area, one has to look at these important factors, before deciding on what to produce in that area.

Any farming practice to take place in these areas, has to be within the capacity of this area. In doing so, there will be less disturbance to the natural environment, thus more sustainable, and more environmental friendly.

In later units we wil discuss the impact of geography and climate on the soil and what crops to grow.

You have now completed the lessons in Unit Two. You should be prepared to complete the following activities. Your instructor will provide additional guidance.

UNIT TWO – DISCUSSION

Your challenge is to identify and share two journal articles, newspaper articles, sector reports, government reports, web sites or other sources that an agribusiness professional could use to assess the quality of the soil in his or her country. Once you have identified the sources be prepared to share these resources (as a handout) to your peers. Also be prepared to provide a brief explanation on why you view these resources as a good tool to support local agriculture professionals.

Your instructor will provide a time and guidance on how to prepare for this discussion.

UNIT TWO – ASSIGNMENT

Directions: You are to produce a short (two or three pages) report that describes the quality of your soil. You are to identify a plot of land around a plantation or livestock in your area, then complete the following activites.

1. Obtain a soil sample from the selected area; name the component of this soil as you can observe. Explain how you identify the components named.
2. Determine the texture of this soil using the feeling method. Describe how each was felt, then name its textural class.
3. Suggest two farming activities for this area, based on the physical characteristics observed. Give the reasons for each activity that led you to select them.
4. (Tip: Observe the plant distribution and growth in this area.)
5. Obtain from your local Agricultural Extension Officer or from the appropriate agribusiness web site, the chemical characteristics of your area, then answer the questions that follows.
6. Compare what your land area can provide with the requirement of the farm activity you suggested in 3 above.
7. Explain what you can do to improve the land area, to meet the farm activity suggested.

Submission: Once you have collected the appropriate data you should submit the report to your course instructor for review, feedback and grading.

UNIT TWO – SUMMARY

During this unit we learned that soil fertility, refers to "The quality of a soil that enables it to provide essential chemical elements in quantities and proportions for the growth of specified plants." (Brady and Weil, 1999, The Nature and Properties of Soils). Different agriculture enterprises, have different requirements, and can do better or worse in

different places. Knowing the combinations of the appropriate factors will provide the basis for the selection of what and how to produce.

Environmental and soil characteristics and properties required for each farming enterprise will be different. It is then significant to select the appropriate farming activity suitable to environment and soil characteristics of a particular area.

Growing rice in Asia will be different as its grown in the Pacific Islands, due to their different environmental requirements. If a Pacific Islander is willing to plant rice in its environment, it will not be as good as it is in Asia. If we force a crop in a new environment, a lot of inputs has to be put in, which is not environmental friendly.

It will be more appropriate to select an enterprise that performs best in that particular area, where minimal input will be added.

In the next few units we will explore climate, geographical and other issues that impact agricultural production.

Before moving on to the next unit you should complete and submit the Unit 2 Assignment.

UNIT THREE – CLIMATE AND AGRICULTURE

OVERVIEW

If soil is the life blood of agriculture, then climate provides the energy to nurture the blood. Climate delivers water, sunlight, heat and wind to the soil. The amount of perception, the amount of daily sunlight and the intensity of the temperature all impact the ability to continuously grow products or support livestock. Weather extremes can cause severe damage to the agriculture system. Understanding climate and climate change are essential to the success of all agriculture professionals. This unit will provide an introduction to climate, the types of climate throughout the globe and the impact that climate change has on the future of the agricultural industry.

GOALS AND OBJECTIVES

Upon completion of this unit you will be able to:

1. Explain the concepts of temperature, latitude and longitude, and precipitation.
2. Explain the impact of solar radiation on agriculture products.
3. Identify the prevailing wind systems in your country.
4. Classify climate and describe the characteristics of each category.
5. Describe the impact of topography on agriculture.
6. Examine the impact of client change.

LESSON 3.1 – CLIMATE

OVERVIEW

Climate is the characteristic condition of the atmosphere near the earth's surface at a certain place on earth. It is the long-term weather of that area (at least 30 years). This includes the region's general pattern of weather conditions, seasons and weather extremes like hurricanes, droughts, or rainy periods. Two of the most important factors determining an area's climate are air temperature and precipitation. World biomes are controlled by climate. The climate of a region will determine what plants will grow there, and what animals will inhabit it. All three components, climate, plants and animals are interwoven to create the fabric of a biome. Weather is a set of all the phenomena occurring in a given atmosphere at a given time. Weather refers, generally, to day-to-day temperature and precipitation activity.

OBJECTIVES

Upon completion of this lesson you will be able to:

1. Explain the concepts of temperature, latitude and longitude, and precipitation.
2. Explain the impact of solar radiation on agriculture products.
3. Identify the prevailing wind systems in your country.
4. Classify climate and describe the characteristics of each category.
5. Describe the impact of topography on agriculture.
6. Examine the impact of client change.

TEMPERATURE

Temperature is a measure of the average energy of motion, or kinetic energy, of particles in matter. When particles of matter, whether in solids, liquids, gases, or elementary plasmas, move faster or have greater mass, they carry more kinetic energy, and the material appears warmer than a material with slower or less massive particles. Kinetic energy, a concept of mechanics, is the product of mass and the square of a particle's velocity. In the context of thermodynamics, it is also referred to as *thermal energy* and the transfer of thermal energy is commonly referred to as heat. Heat always flows from regions of higher temperature to regions of lower temperature. Temperature is a physical property that underlies the common notions of hot and cold. Something that feels hotter generally has a higher temperature, though temperature is not a direct measurement of heat. Temperature is one of the principal parameters of thermodynamics. If no net heat flow occurs between two objects, the objects have the same temperature; otherwise, heat flows from the object with the higher temperature to the object with the lower one. This is a consequence of the laws of thermodynamics.

Temperature is measured with thermometers that may be calibrated to a variety of temperature scales. In most of the world the Celsius scale is used for most temperature measuring purposes. Thermodynamic temperature is measured using the Kelvin scale, which the Celsius scale shifted downwards so that 0 K= −273.15 °C, or absolute zero.

The temperature of the air generally decreases as altitude increases. The rate at which the temperature decreases is called the lapse rate. The average environmental lapse rate is a drop of about 6.5 °C for every 1 km (1000 meters) increase in height.

It is also important to understand that the soil temperature also has an impact on the ability of the soil to germinate crops. Therefore there is a direct relationship to air temperature to soil temperature.

Supplementary Readings

To learn more about the impact of soil temperature on crop germination you should review the following article: Alberta Agriculture: Soil Temperature for Germination. (http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex1203).

To learn more about the concept of temperature review the following online articles:

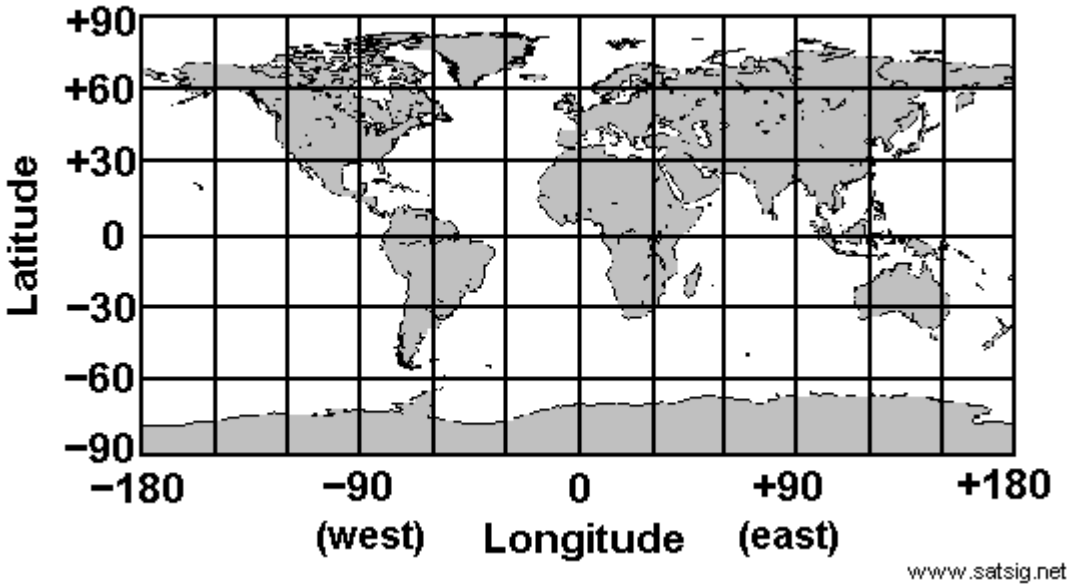
Introduction to the Atmosphere. The Concept of Temperature. (http://www.physicalgeography.net/fundamentals/7k.html)

LATITUDE AND LONGITUDE

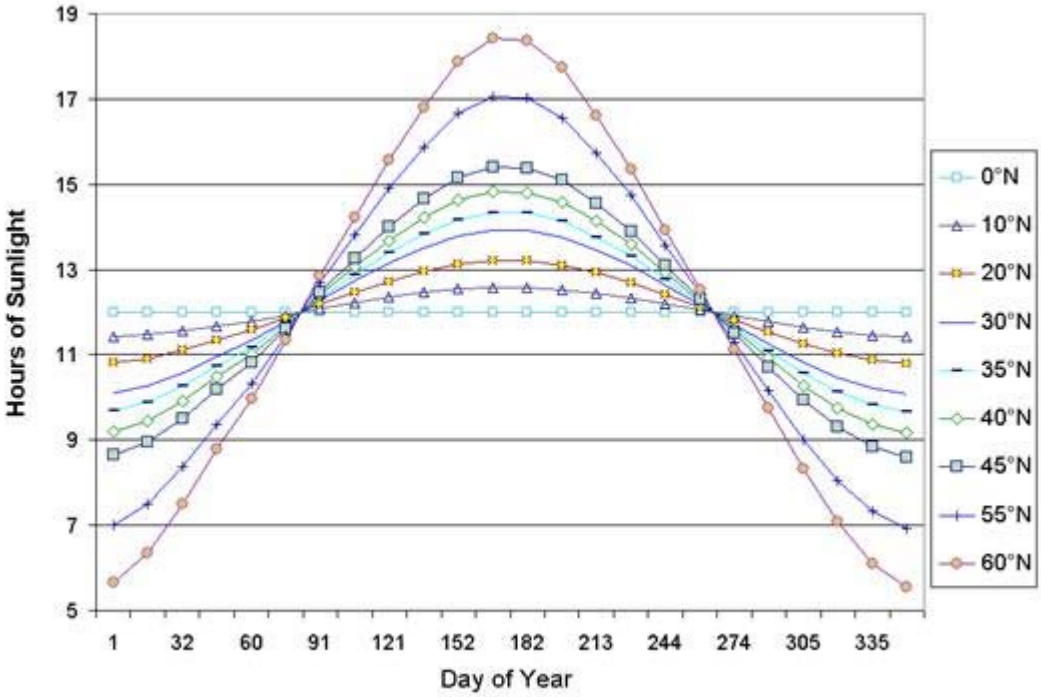
Where you are located on the earth impacts the agriculture industry and the type of products it can grow and the length of the growing cycle. As you move further north or south depending on your latitude the growing cycle gets longer or shorter. Therefore you must understand the concept of latitude and longitude and where you are on the globe.

Latitude is the angle from a point on the Earth's surface to the equatorial plane, measured from the center of the sphere. Lines joining points of the same latitude are called parallels, which trace concentric circles on the surface of the Earth, parallel to the equator. The north pole is 90° N; the south pole is 90° S. The 0° parallel of latitude is designated the equator, the fundamental plane of all geographic coordinate systems.

The equator divides the globe into Northern and Southern Hemispheres. Longitude on the other hand is the angle east or west of a reference meridian between the two geographical poles to another meridian that passes through an arbitrary point. All meridians are halves of great circles, and are not parallel. They converge at the north and south poles. The figure below shows major latitudes and longitudes overlaid on a map of the world.



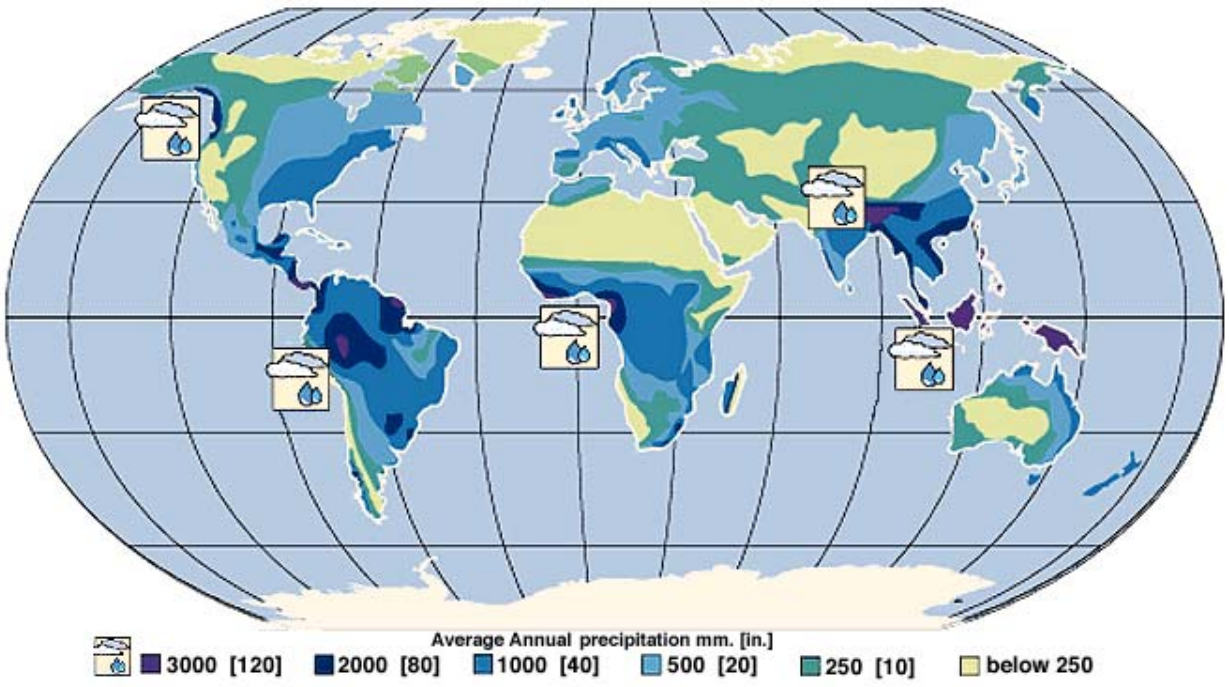
The chart below illustrates the impact of latitude on the amount of sunlight based on latitude. As you can see the closer you get to the poles, the less sunlight you have consistently over the year. When at the equator you have an average of 12 hours of sunlight per day for almost 365 days of the year. This obviously will have an impact on your growing cycle and the type of crops you grow.



PRECIPITATION

Precipitation is any product of the condensation of atmospheric water vapor that is pulled down by gravity and deposited on the Earth's surface. The main forms of precipitation include rain, snow and ice pellets. It occurs when the atmosphere, a large gaseous solution, becomes saturated with water vapour and the water condenses, falling out of solution (i.e., precipitates). Two processes, possibly acting together, can lead to air becoming saturated: cooling the air or adding water vapour to the air. Rain occurs when tiny cloud droplets collide to form bigger droplets. This keeps happening until the droplet is too heavy for the air to support it. The droplet then begins to fall, colliding with more cloud droplets as it gains in size. If the liquid water does not encounter a deep layer of sub-freezing air, it will remain liquid and fall to the ground as rain. Hail is a product of very intense thunderstorms. Hail is rarely seen when the surface air temperature is below freezing. It forms as a byproduct of strong updrafts that exist in thunderstorms. The clouds that are associated with thunderstorms can grow to heights where the temperature is below freezing. Drops of water will rise up with the upward directed wind as they collide with other droplets and grow larger. This will eventually result in the droplet freezing into a hailstone. The size of hailstones varies with the intensity of the thunderstorm. The stronger the thunderstorm, the stronger the updraft and the longer the hailstone will have to grow in size. Hail size is often described using common spherical objects. Sizes can range from pea-sized to golf-ball sized, but have even been seen as big as a softball or even larger. Sleet occurs when there is a warm layer of air above a relatively deep sub-freezing layer at the surface. Sleet usually doesn't last long and mainly occurs ahead of warm fronts during winter months.

The map below illustrates the average rainfall in different parts of the globe.



SOLAR RADIATION

The electromagnetic waves emitted by the sun, varying in wavelength from long-wave radio waves, through infra-red waves and visible light, to ultraviolet waves, X-rays, and gamma radiation. Earth gets only 0.0005% of the sun's radiation. Most solar radiation passes straight through the atmosphere without warming it, but it is received and absorbed by the earth. The earth receives energy from the Sun in the form of radiation. The Earth reflects about 30% of the incoming solar radiation. The remaining 70% is absorbed, warming the land, atmosphere and oceans. For the Earth's temperature to be in steady state so that the Earth does not rapidly heat or cool, this absorbed *solar radiation* must be very nearly balanced by energy radiated back to space in the infrared wavelengths. Since the intensity of infrared radiation increases with increasing temperature, one can think of the Earth's temperature as being determined by the infrared flux needed to balance the absorbed solar flux.

If you wish to learn more about the impact of the sun and solar radiation on the earth it is recommended you view this YouTube video:

http://www.youtube.com/v/ajQ3hm5JidU?fs=1&hl=en_US

WIND

Wind is the movement of air relative to the surface of the Earth. Wind is an important factor in determining and controlling climate and weather. It is also the generating force of most ocean and freshwater waves. The general pattern of winds over the Earth is known as the general circulation, and specific winds are named for the direction from which they originate (e.g., a wind blowing from west to east is a westerly). Wind speeds are often classified according to the Beaufort scale.

The direction of wind is usually indicated by a thin strip of wood, metal, or plastic (often in the shape of an arrow or a rooster) called a weather vane or weathercock (but more appropriately called a wind vane) that is free to rotate in a horizontal plane. When mounted on an elevated shaft or spire, the vane rotates under the influence of the wind such that its center of pressure rotates to leeward and the vane points into the wind.

Wind velocity is measured by means of an anemometer or radar. The oldest of these is the cup anemometer, an instrument with three or four small hollow metal hemispheres set so that they catch the wind and revolve about a vertical rod; an electrical device records the revolutions of the cups and thus the wind velocity.

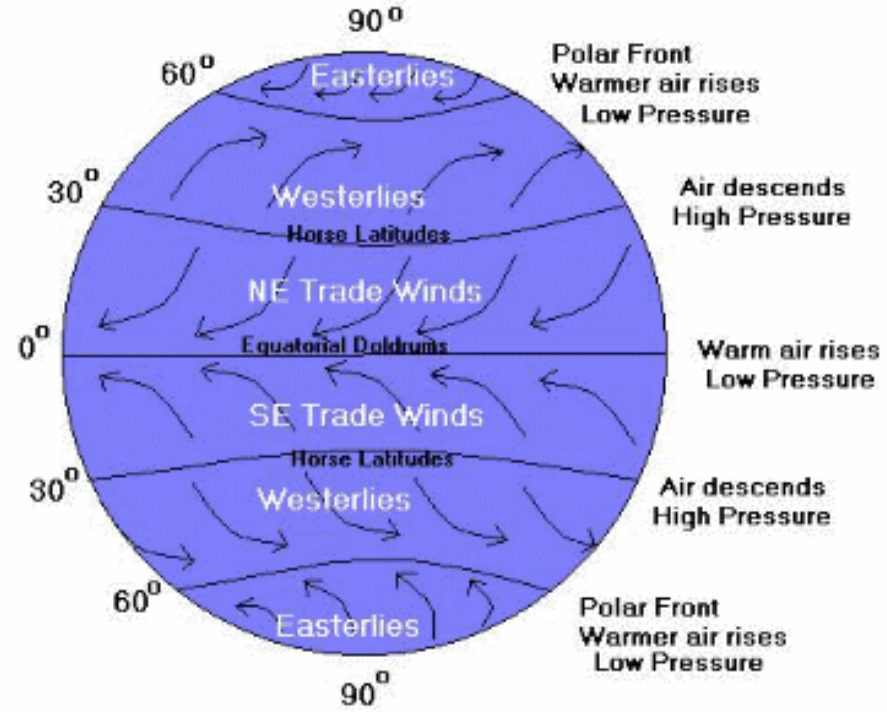
Over some zones around the earth, winds blow predominantly in one direction throughout the year and are usually associated with the rotation of the earth; over other areas, the prevailing direction changes with the seasons; winds over most areas also are variable from day to day so that no prevailing direction is evident, such as, for example, the day-to-day changes in local winds associated with storms or clearing skies. Around the equator there is

a belt of relatively low pressure known as the doldrums, where the heated air is expanding and rising; at about lat. 30°N and S there are belts of high pressure known as the horse latitudes, regions of descending air; farther poleward, near lat. 60°N and S, are belts of low pressure, where the polar front is located and cyclonic activity is at a maximum; finally there are the polar caps of high pressure.

The prevailing wind systems of the earth blow from the several belts of high pressure toward adjacent low-pressure belts. Because of the earth's rotation the winds do not blow directly northward or southward to the area of lower pressure, but are deflected to the right in the Northern Hemisphere and to the left in the Southern Hemisphere. The wind systems comprise the trade winds; the prevailing westerlies, moving outward from the poleward sides of the horse-latitude belts toward the 60° latitude belts of low pressure (from the southwest in the Northern Hemisphere and from the northwest in the Southern Hemisphere); and the polar easterlies, blowing outward from the polar caps of high pressure and toward the 60° latitude belts of low pressure. The video below illustrates the global wind patterns.

Other concepts that relate to global wind patterns are the coriolis affect and the trade winds.

The coriolis effect results in the creation of the trade winds and the westerly winds as illustrated in the diagram below.



HURRICANES/CYCLONES

Hurricanes are tropical cyclones with winds that exceed 64 knots (74 mi/hr) and circulate counter-clockwise about their centers in the Northern Hemisphere (clockwise in the Southern Hemisphere).

A tropical cyclone is a storm system characterized by numerous thunderstorms that produce strong winds and heavy rain. Tropical cyclones feed on heat released when moist air rises, resulting in condensation of water vapour contained in the moist air. Strong winds combined with rainstorms produce cyclones and hurricanes, especially in the tropical regions. Island states are most affected by the cyclones and hurricanes. Depending on its location and strength, a tropical cyclone is referred to by names such as hurricane , typhoon , tropical storm , cyclonic storm , tropical depression , and simply cyclone .

If you wish to learn more about the concepts underlying hurricane and tropical cyclone formations you should view the following YouTube video:

http://www.youtube.com/v/HJydFJORWf4?fs=1&hl=en_US

SUMMARY

This lesson introduced you to climate and its potential impact on agriculture. The next lesson will provide a way of classifying weather. At the end of this unit you will be required to produce a report on the type of climate that exists in your community.

LESSON 3.2 – CLASSIFICATION OF CLIMATE

OVERVIEW

There are a number of different climate classification models based on variety of variables. In general climate is classified based on the latitude you live in, the amount of perception you receive annually and the average temperature you experience. The three major climate classifications include:

- Low-Latitude Climates.
- Mid-Latitude Climates.
- High-Latitude Climates.

Each of these three major classifications can in turn be broken down further. As you explore climate you should understand what type of region you live in. Where you live and operate your agribusiness will be impacted by the type of climate you experience. This lesson will explore the three major classification systems and their sub-classifications.

OBJECTIVES

Upon completion of this lesson you will be able to:

1. Describe how to classify climate.
2. Describe the characteristics of low-latitude climate.
3. Describe the characteristics of mid-latitude climate.
4. Describe the characteristics of high-latitude climate.

LOW LATITUDE CLIMATES

These climates are controlled by equatorial tropical air masses. They can further be divided into Tropical-Dry Climates, Wet-Dry tropical Climates, and Dry-Tropical Climates.

Tropical Moist Climates

Rainfall is heavy in all months. The total annual rainfall is often more than 2500 mm. There are seasonal differences in monthly rainfall but temperatures of 27°C mostly stay the same. Humidity is between 77 and 88%.

High surface heat and humidity cause cumulus clouds to form early in the afternoons almost every day. The climate on eastern sides of continents is influenced by maritime tropical air masses. These air masses flow out from the moist western sides of oceanic high-pressure cells, and bring lots of summer rainfall. The summers are warm and very humid. It also rains a lot in the winter.

Farm in the Rainforest

- Average temperature: 18 °C.
- Annual Precipitation: 2620 mm.
- Latitude Range: 10° S to 25 ° N.
- Global Position: Amazon Basin; Congo Basin of equatorial Africa; East Indies, from Sumatra to New Guinea.
- The biome of the region is rainforest.

Wet-Dry Tropical Climates

A seasonal change occurs between wet tropical air masses and dry tropical air masses. As a result, there is a very wet season and a very dry season. Trade winds dominate during the dry season. It gets a little cooler during this dry season but will become very hot just before the wet season.

Farm in the Savannah

- Average temperature: 16 °C.
- Annual Precipitation: 850 mm.
- Latitude Range: 15 ° to 25 ° N and S.
- Global Range: India, Indochina, West Africa, southern Africa, South America and the north coast of Australia.
- The biome of the region is savannah.

Dry Tropical Climates

These desert climates are found in low-latitude deserts approximately between 18° to 28° in both hemispheres. These latitude belts are centered on the tropics of Cancer and Capricorn, which lie just north and south of the equator. They coincide with the edge of the equatorial subtropical high pressure belt and trade winds. Winds are light, which allows for the evaporation of moisture in the intense heat. They generally flow downward so the area is seldom penetrated by air masses that produce rain. This makes for a very dry heat. The dry arid desert is a true desert climate, and covers 12 % of the Earth's land surface.

Farm in the Desert

- Average temperature: 16° C.
- Annual Precipitation: 250 mm.
- Latitude Range: 15° - 25° N and S.
- Global Range: South-Western United States and northern Mexico; Argentina; north Africa; South Africa; central part of Australia.
- The region is predominantly desert.

MID LATITUDE CLIMATE

Climates in this zone are affected by two different air-masses. The tropical air-masses are moving towards the poles and the polar air-masses are moving towards the equator. These two air masses are in constant conflict. Either air mass may dominate the area, but neither has exclusive control. The mid-latitude climates are divided into Dry Mid-latitude Climates (Steppe), Mediterranean Climates, Dry Mid-latitude Climates and Moist Continental Climates.

Dry Mid-Latitude Climates

Characterized by grasslands, this is a semiarid climate. If it received less rain, the steppe would be classified as an arid desert. With more rain, it would be classified as a tall grass prairie. This dry climate exists in the interior regions of the North American and Eurasian continents. Moist ocean air masses are blocked by mountain ranges to the west and south. These mountain ranges also trap polar air in winter, making winters very cold. Summers are warm to hot.

Farm on the Steppes

- Average temperature: 24° C
- Annual Precipitation: less than 100 mm in the driest regions to 500 mm in the moister steppes.
- Latitude Range: 35° - 55° N.
- Global Range: Western North America (Great Basin, Columbia Plateau, Great Plains); Eurasian interior.
- The biome is referred to as steppe.

Mediterranean Climate

This is a wet-winter, dry-summer climate. Extremely dry summers are caused by the sinking air of the subtropical highs and may last for up to five months.

Plants have adapted to the extreme difference in rainfall and temperature between winter and summer seasons. Fires occur frequently in Mediterranean climate zones.

Farm in a Mediterranean climate.

- Average temperature: 7 °C
- Annual Precipitation: 420 mm
- Latitude Range: 30° - 50° N and S
- Global Position: central and southern California; coastal zones bordering the Mediterranean Sea; coastal Western Australia and South Australia; Chilean coast; Cape Town region of South Africa.
- The biome is referred to as chaparral.

Dry Mid-Latitude Climates

These dry climates are limited to the interiors of North America and Eurasia.

Ocean air masses are blocked by mountain ranges to the west and south. This allows polar air masses to dominate in winter months. In the summer, a local continental air mass is dominant. A small amount of rain falls during this season. Annual temperatures range widely. Summers are warm to hot, but winters are cold.

Farm on the grasslands.

- Annual Precipitation: 810 mm
- Latitude Range: 30° - 55° N and S
- Global Position: western North America (Great Basin, Columbia).
- The biome is grasslands.

Moist Continental Climate

This climate is in the polar front zone. Seasonal changes between summer and winter are very large. Daily temperatures also change often. Abundant precipitation falls throughout the year. It is increased in the summer season by invading tropical air masses. Cold winters are caused by polar and arctic masses moving south.

Japanese Farm in a Deciduous Forest

- Average Annual Precipitation: 810 mm
- Latitude Range: 30° - 55° N and S (Europe: 45° - 60° N).
- Global Position: eastern parts of the United States and southern Canada; northern China; Korea; Japan; central and eastern Europe Plateau, Great Plains); Eurasian interior.
- The biome is deciduous forest.

HIGH LATITUDE CLIMATES

Polar and arctic air masses dominate these regions. Canada and Siberia are two air-mass sources which fall into this group. A southern hemisphere counterpart to these continental centers does not exist. Air masses of arctic origin meet polar continental air masses along the 60th and 70th parallels.

Boreal Forest Climate

This is a continental climate with long, very cold winters, and short, cool summers. This climate is found in the polar air mass region. Very cold air masses from the arctic often move in. The temperature range is larger than any other climate. Precipitation increases during summer months, although annual precipitation is still small.

Much of the boreal forest climate is considered humid. However, large areas in western Canada and Siberia receive very little precipitation and fall into the subhumid or semiarid climate type.

The Boreal Forest

- Temperature Range: -25 °C to16 °C
- Average Annual Precipitation: 310 mm.
- Latitude Range: 50° - 70° N and S.
- Global Position: central and western Alaska; Canada, from the Yukon Territory to Labrador; Eurasia, from northern Europe across all of Siberia to the Pacific Ocean.
- The biome is Taiga.

Tundra Climate

The tundra climate is found along arctic coastal areas. Polar and arctic air masses dominate the tundra climate. The winter season is long and severe. A short, mild season exists, but not a true summer season. Moderating ocean winds keep the temperatures from being as severe as interior regions.

Arctic Tundra

- Temperature Range: -22 °C to 6 °C
- Average Annual Precipitation: 200 mm.
- Latitude Range: 60° - 75° N.
- Global Position: arctic zone of North America; Hudson Bay region; Greenland coast; northern Siberia bordering the Arctic Ocean.
- The biome is referred to as Tundra.

Highland Climate

Highland climates are cool to cold, found in mountains and high plateaus. Climates change rapidly on mountains, becoming colder the higher the altitude gets. The climate of a highland area is closely related to the climate of the surrounding biome. The highlands have the same seasons and wet and dry periods as the biome they are in.

Mountain climates are very important to mid-latitude biomes. They work as water storage areas. Snow is kept back until spring and summer when it is released slowly as water through melting.

The Highlands

- Temperature Range: -18 °C to 10 °C
- Average Annual Precipitation: 230 mm.
- Latitude Range: found all over the world
- Global Position: Rocky Mountain Range in North America, the Andean mountain range in South America, the Alps in Europe, Mt. Kilimanjaro in Africa, the Himalayans in Tibet, Mt. Fuji in Japan.
- The biome is referred to as Alpine.

TOPOGRAPHY

Topography and various landforms also impact climate and agriculture. You should be familiar with the following topographical terms.

Altitude

Altitude or height is defined based on the context in which it is used (aviation, geometry, geographical survey, sport, and more). As a general definition, altitude is a distance measurement, usually in the vertical or "up" direction, between sea level and a point or object. The reference datum also often varies according to the context. In the earth sciences and geology sub-fields, a landform or physical feature comprises a geomorphological unit, and is largely defined by its surface form and location in the landscape, as part of the terrain, and as such, is typically an element of topography. Landform elements include mountains, river valleys, plains, deltas and atolls.

Mountain

A **mountain** is a large landform that stretches above the surrounding land in a limited area usually in the form of a peak. A mountain is generally steeper than a hill.

River Valley

A valley formed by flowing water, or *river valley*, is usually V-shaped. The exact shape will depend on the characteristics of the stream flowing through it. Rivers with steep gradients, as in mountain ranges, produce steep walls and a narrow bottom. Shallower slopes may produce broader and gentler valleys, but in the lowest stretch of a river, where it approaches its base level, it begins to deposit sediment and the valley bottom becomes a floodplain.

Plain

A **plain** is land with relatively low relief that is flat or gently rolling. Plains occur as lowlands and at the bottoms of valleys but also on plateaus at high elevations. In a valley, a plain is enclosed on two sides but in other cases a plain may be delineated by a complete or partial ring of hills, by mountains or cliffs. Plains in many areas are important for agriculture, because where the soils were deposited as sediments they may be deep and fertile, and the flatness facilitates mechanization of crop production; or because they support grasslands which provide good grazing for livestock.

Delta

A **delta** is a landform that is created at the mouth of a river where that river flows into an ocean, sea, estuary, lake, reservoir, flat arid area, or another river. Deltas are formed from the deposition of the sediment carried by the river as the flow leaves the mouth of the river. Over long periods of time, this deposition builds the characteristic geographic pattern of a river delta. River deltas are often provide rich soil that supports agricultural production.

Atoll

An **atoll** is a type of low, coral island found in tropical oceans and consisting of a coral-algal reef surrounding a central depression. The depression may be part of the emergent island, but more typically is a part of the sea (that is, a lagoon), or very rarely is an enclosed body of fresh, brackish, or highly saline water. Atolls are surrounded by deep ocean water and range in diameter from about 1 km to over 100 km. They are especially common in the western and central Pacific Ocean and are believed to form along the fringes of underwater volcanoes. The Maldives is formed from a number of atolls.

IMPACT OF CLIMATE AND TOPOGRAPHY

The agricultural enterprises and activities found in a country are influenced by its climate and topography. The majority of small states are found in tropical climates. The main horticultural crops are papaya, rubber trees, coconuts, bananas and palms. The common agricultural crops are cassava, maize, rice, sorghum, sweet potato, taro and yam. A number

of cash crops are grown in the tropics, and they include sugarcane, tobacco, tea, cotton, coffee and cocoa. The dominant livestock in the tropics are cattle, sheep, goats, camels, chicken and pigs. The large stock such as cattle and camels are not dominant in island states. Temperate crops are grown to a small extent in high altitudes within the tropics, where temperatures are low. Such crops include peaches, apples, wheat and potatoes. Adverse effects of climate and weather conditions to agricultural enterprises at localized level are shown in the Table below.

Table: Examples of Climate and Weather Situations and Their Adverse Effects on Agricultural Industries

Too Little	Pastures	• Plants become stressed and may die.
	Livestock	• Lack of moisture reduces pasture quality. • Reduced protein, unpalatable, leading to poor nutrition and poor health.
Too Much	Horticulture, grain crops, pastures, soil resources	• Plants become stressed and may reduce yield and die. • Waterlogging can cause nutrient stress. If too much rain occurs at harvest, quality is downgraded for wheat. • Water erosion and subsequent physical and chemical soil decline and water deterioration downstream.
Wrong Timing	Cherries	• Suffer from splitting if occurs at harvest.
	Pastures	• Possible weed germination eg. Barley grass.
	Dried fruits	• Spoilt crop, increased labour charges to move products quickly.
Too Hot	Plants	• Heat stress reduces yield, increased amounts of moisture needed or wilting occurs.
	Animals	• Heat stress reduces production, requires increased uptake of water, in severe cases may lead to death.
Too Cold	Plants	• Cold stress reduces yield eg. wheat with frosts at flowering.
	Animals	• Cold stress reduces production, requiring increased uptake of food to maintain body weight.
Too Much	Animals	• Possible wind chill if cold wind, heat stress if hot wind.
	Pastures	• Increased evapotranspiration and possible moisture stress, non target chemical damage if sprays are used.
	Crops, horticulture	• Lodging of crops; wind damage to fruit trees; non target chemical damage if sprays are used.
	Bare soil	• Wind erosion and dust storms down wind, reducing soil fertility on site.
	People & buildings	• Damage, threat to life.
Not Enough	Animals	• Heat stress in hot conditions.
	Plants	• Possible humid, non target chemical damage if sprays are used.

LAND SIZE AND CLIMATE

Due to large size and wide range of geographic features, continental states have considerable variation in climate as opposed to insular states (such as island states). Continental states tend to have extremes in terms of temperature and rainfall. The variation in temperature and rainfall for insular states tend to be not large. Insular states are prone to cyclones and hurricanes. Continental climates are often found to be relatively dry, as most of the moisture carried by air masses originating over ocean regions is lost as rainfall earlier in its journey.

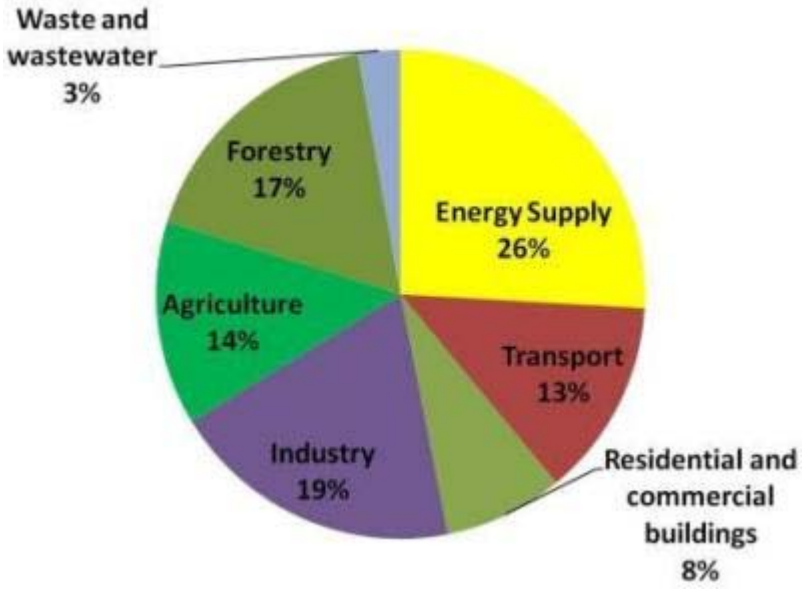
SUMMARY

This lesson provided an introduction to climate and its impact in different parts of the world. You examined how topography and impacts climate and explored the causes of major climate systems like hurricanes and drought. In the next lesson we will explore the impact of climate change on the agri-business.

LESSON 3.3 – CLIMATE CHANGE

OVERVIEW

Scientists and to some degree politicians now agree that our climate is changing because of population growth, industrialization and national and regional environmental practices. The cause of climate change is the increasing production of greenhouse gases which allow the atmosphere to heat up, thus impacting climate throughout the world. The OECD reports that in 2004, the Intergovernmental Panel on Climate Change noted that agricultural production and the agri-business represented 14% of the globe's carbon emissions.



The Intergovernmental Panel on Climate Change noted that agriculture is particularly vulnerable to climate change. This lesson will explore the issue of climate change and its impact on agriculture.

OBJECTIVES

Upon completion of this lesson you will be able to:

1. Define climate change.
2. Explain the impact of climate change on agriculture.
3. Explore some potential measures that can be taken to address the impact of climate change.
4. Assess the potential impact of climate change on your own community.

WHAT IS CLIMATE CHANGE?

Wikipedia.org describes climate change as "a change in the statistical distribution of weather over periods of time that range from decades to millions of years. It can be a change in the average weather or a change in the distribution of weather events around an average (for example, greater or fewer extreme weather events). Climate change may be limited to a specific region, or may occur across the whole Earth."

Climate change is taking place at a time of increasing demand for food, feed, fibre and fuel, has the potential to irreversibly damage the natural resource base on which agriculture depends. The relationship between climate change and agriculture is a two-way street; agriculture contributes to climate change in several major ways and climate change in general adversely affects agriculture.

Because so many systems are tied to climate, a change in climate can affect many related aspects of where and how people, plants and animals live, such as food production, availability and use of water, and health risks.

For example, a change in the usual timing of rains or temperatures can affect when plants bloom and set fruit, when insects hatch or when streams are their fullest. This can affect historically synchronized pollination of crops, food for migrating birds, spawning of fish, water supplies for drinking and irrigation, forest health, and more. When considered it has serious implications for agricultural production.

In some places, floods and/or drought could become more frequent and more severe. Even seemingly less dramatic local changes in temperature, precipitation and soil moisture could severely impact many things important to human life and all life around us, including natural ecosystems

The disruption or elimination of life in ecosystems. Example increases in sea water temperature affects the marine life in mangrove swamps. Marine life supports the growth of mangroves. If however this dependency is curtailed through the death of marine habitation the efficacy of mangrove will be lost.

With the onset of climate change in Small states a number of effects will occur.

- Flooding both salt and sea water.
- Decreased agriculture and food output.
- Increased precipitation etc.

THE GLOBAL TEMPERATURE PUZZLE

To understand the causes and impact of global warming and climate change it is recommended you review the following YouTube video.

http://www.youtube.com/v/Kambs1N7nIM?fs=1&hl=en_US

IMPACT OF CLIMATE CHANGE

In mid- to high latitude regions moderate local increases in temperature can have small beneficial impacts on crop yields; in low-latitude regions, such moderate temperature increases are likely to have negative yield effects. Some negative impacts are already visible in many parts of the world; additional warming will have increasingly negative impacts in all regions. Water scarcity and the timing of water availability will increasingly constrain production. Climate change will require a new look at water storage to cope with the impacts of more and extreme precipitation, higher intra- and inter-seasonal variations, and increased rates of evapotranspiration in all types of ecosystems. Extreme climate events (floods and droughts) are increasing and expected to amplify in frequency and severity and there are likely to be significant consequences in all regions for food and forestry production and food insecurity. There is a serious potential for future conflicts over habitable land and natural resources such as freshwater. Climate change is affecting the distribution of plants, invasive species, pests and disease vectors and the geographic range and incidence of many human, animal and plant diseases is likely to increase.

As the chart below illustrates, the OECD predicts that a change of just one to five degrees in our global temperature will have considerable impact on our agricultural production.

Temperature change	Impact
+1° to +2°	Some increase in yield Cold limitation alleviated Yield reduction in some latitudes (without adaptation) Seasonal increase in heat-stress for livestock
+2° to +3°	Potential increase in yield due to CO_2 fertilisation (but likely offset by other factors) Moderate production losses of pigs and confined cattle Increased heat stress Yields of all crops fall in low latitudes (without adaptation)
+3° to +5°	Maize and wheat yields fall regardless of adaptation in low latitudes High production losses of pigs and confined cattle Increased heat stress and mortality in livestock

Source: Adapted from IPCC AR4 Working Group II.

As the table notes the success or failure of agricultural production is tied to climate. A change in climate can affect many related aspects of where and how people, plants and animals live, such as food production, availability and use of water, and health risks.

For example, a change in the usual timing of rains or temperatures can affect when plants bloom and set fruit, when insects hatch or when streams are their fullest. This can affect historically synchronized pollination of crops, food for migrating birds, spawning of fish, water supplies for drinking and irrigation, forest health, and more. When considered it has serious implications for agricultural production.

In some places, floods and/or drought could become more frequent and more severe. Even seemingly less dramatic local changes in temperature, precipitation and soil moisture could severely impact many things important to human life and all life around us, including: natural ecosystems.

The disruption or elimination of life in ecosystems. Example increases in sea water temperature affects the marine life in mangrove swamps. Marine life supports the growth of mangroves. If however this dependency is curtailed through the death of marine habitation the efficacy of mangrove will be lost.

A healthy mangrove forest can also prevent salt water intrusion preventing damage of freshwater ecosystems and agricultural areas. The growing threat of climate change in small states can result in flooding, both salt and sea water, increased precipitation and other catastrophic events.

ECONOMIC EFFECTS OF CLIMATE CHANGE

When the change of weather affects agricultural production output there are effects of price fluctuations. A simplistic model of the economic effect of climate change is discussed below.

SHORT TERM IMPACT

In the short term there will be less produce on the market. Farmers producing a given crop will be unable to switch crops in response to short run variation in weather. If product is inelastic, the target population in the market will seek out other available supplies. Since there will be less to serve the market consumers will be willing to pay more for the available product and the producers will call for increased prices.

This is true since there if there is a reduction in the short run supply. Farmers at this time cannot switch quickly or react to this market force since there is a lag between planting and harvests.

The increase in prices will help mitigate the representative farmer's losses due to the lower production. However, if the product is elastic, consumers of the produce in the market may switch to purchasing substitutes and there may be little or no increase in prices.

LONG TERM IMPACT

Over the long term market forces coupled with market intelligence of both the producers and consumers will cause a stabilization of prices. Prices will eventually fall as more farmers would have switched to the production of a more appropriate crop for the climate. However, the supply of agricultural goods is more elastic in the long run as other farmers (or even new farmers) will respond to the price change by increasing output.

It must be noted that some of these production problems can be bypassed through the use of alternative forms of agricultural production and through improved technology and the use of more tolerant/resistant crops (to drought, salt water, flooding, insect/pests) nullifying the effects of negative weather conditions. This will take a concerted effort by everyone in the industry.

GOVERNMENT ROLE

Governments at all levels must produce land use plans and zoning laws guiding agricultural production. They must create new policy directives addressing the impacts of global warming. Governments and universities need to support the agricultural sector particularly in the form of agricultural extension education and research and development.

MEASURES TO COUNTERACT CLIMATE CHANGE

In the case of agriculture and food supplies, the following measures will have to be implemented. Some of these measures are:

- Erosion control.
    - Soil conservation practices to be improved.
    - Dam construction.
    - To control for Irrigation and drainage control.
- Changes in fertilizer application.
    - Strategies to be implemented to be able to target plants and eliminate wastage of fertilizer.
    - Use of hydroponic strategies.
    - Use of Drip Irrigation strategies.

Introduction of new crops or switching to different cultivars. Introduction of a diversity of crops with adaptability to following conditions:

- Flooding.
- Salt intrusion.
- High soil moisture.
- Low soil moisture.
- Shorter day lengths owing to increased cloud cover.
- Development of plants that have shorter maturity periods.
- Development of Genetically Modified Plants for increased production.
- Soil fertility maintenance.
    - Utilization of organic fertilizers to maintain/enhance soil structure, nutrient availability and fertility.
- Changes in planting and harvesting times.
    - Planting and harvesting crops during periods of lesser climatic stress as related to seasonal changes in rainfall patterns.
- Educational and outreach programmes on conservation and management of soil and water.

Human Resource Capacity Building in Agricultural Extension Systems in Small States will become essential as more information will have to be disseminated to farmers who will need this information to survive the effects of climate change.

Further, there is also a number of anticipatory measures that should be put in place. Some of these are:

- The development of tolerant/resistant crops (to drought, salt water, flooding, insect/pests);
- Research and development;
- Soil water management;
- Diversification and intensification of food and plantation crops;
- Policy measures, tax incentives/subsidies, free market; and
- Development of early warning systems.

The effects of climate change will affect agriculture. The vulnerability of Agricultural production will require change to adaptation measures. These measures will have economic effects on agriculture.

CLIMATE RELATED RISKS

Planning for climate change must involve consideration of climate related risks including those which have a slow onset, such as changes in temperature and precipitation leading to agricultural losses and drought and biodiversity losses, and those which happen more suddenly such as tropical storms and floods. It is now recognized that climate related risks are already happening and past and current experiences in dealing with climate variability and extreme events provide valuable information for reducing vulnerability and enhancing resilience to future climate related adverse impacts.

Human Health: A number of health risks as a result of climate change can indirectly affect agricultural productivity due to the limitation of the provision of adequate labour as required.

Forestry: Since forests are natural carbon sinks, it is necessary to as much as is possible have little or no destruction of forests. Economies that rely on forest based income will have to plan alternate strategies for income generation. Guyana has implemented a Low Carbon Development Strategy.

Water Resources and Availability: With the anticipated flooding from sea water or as a result of increased precipitation there will be contamination of water resources. On the other hand aridity will have to be addressed since in some areas drought conditions will prevail. Thus it will be critical to protect ground water resources through improved management and maintenance of existing water supply systems. Further, fresh water catchment areas should be protected.

Energy Use: Every day we burn large amounts of gasoline, oil, coal and natural gas. These important sources of energy power our cars, run our businesses and provide electricity. But burning these fossil fuels also produces harmful greenhouse gas emissions.

Like the glass in a greenhouse, these gases collect in the atmosphere and create a barrier that prevents the earth's excess heat from escaping. As the barrier grows, the earth's temperature increases. This is magnifying the natural greenhouse effect and the result is climate change.

Transportation: Climate change may be the most significant issue facing transportation today. It is imperative that we reduce mobile sources greenhouse gas emissions to avert future climate disruption. The reduction of fossil fuel use, both seeks to ensure energy security and to contribute toward efforts to reduce greenhouse gas emissions. Strategies to achieve this include:

- Advanced, energy-efficient technologies,
  - shifts to non-carbon based fuels and energy sources,
  - system management, and
  - demand management strategies will be required to reduce transportation's contribution to greenhouse gases.

Transportation in countries like Guyana where there are interior agricultural production swollen rivers and creeks may make some routes inaccessible and interfere farm to market transportation and distribution routes.

SUMMARY

After completing this lesson you should realize that climate change is a major threat to the success of the agri-industry and the ability of farms to feed their constituents. The agriculture industry is a one the major contributors to global warming and each agri-professional must seek ways to reduce their organization's and the industry's impact on global warming.

UNIT THREE – DISCUSSION

Climate change is of major concern today. Many scientists believe it will have a major impact on the world and agriculture. Others say that the impact will not be that bad and that man will be able to adapt.

Explain your position on climate change. Find at least two articles that defend your position. Once you have made your initial posting review the articles and postings of some of your peers and enter into a dialogue about the impact of climate change.

UNIT THREE – ASSIGNMENT

Description: Under the guidance of your instructor you should produce a two to three page paper that examines the climate your community or nation. The paper needs to be supported by specific evidence from web sites, articles or other agricultural sources. The paper should address or describe the following.

1. The type of climate (by classification and sub-classification) that your community experiences.
2. A brief topographical description of your community.
3. A chart of the annual average temperature and precipitation for your community.
4. The types of agriculture products that have proven successful in your community.
5. Analyze the potential impact of climate change on your community. Describe the impact of climate change on the agricultural industry in your community, region and country.

Instructions: Once you have completed the report, submit it to your instructor for review, feedback and grading.

UNIT THREE – SUMMARY

While completing this unit you learned about climate in different parts of the world and the impact that climate and climatic conditions have on the types of crops that you can grow. Climatic changes and global warming are issues that many agri-professionals must consider when planning and managing their agri-businesses. Knowing about climate and its impact on agriculture is essential for all agriculture professionals.

UNIT FOUR – FACTORS AFFECTING AGRICULTURE

OVERVIEW

In this unit we will look at a range of factors that make up the environment within which agriculture is conducted. This environment is made up of physical factors such as climate and soils and the relationships between them. The environment also consists of biological factors which are discussed first within context of ecosystems that consider the interactions between the physical environment and living things, or organisms that make up the biodiversity in specific environments. Biological organisms are discussed both within the context of pests, the benefits of biodiversity and implications for biodiversity loss. Major social, economic factors and available support systems are also shown to be a part of the environment. Most of these factors pertain especially to the local environment, but global influences are also important. Consequently, global issues including global markets and trade, energy and climate change are also outlined. The impact of all factors, local and global, on agriculture in small states, is discussed.

GOALS AND OBJECTIVES

Upon completion of this unit you will be able to:

1. Explain how the agricultural sector is affected by physical, biological and socio-economic factors.
2. Discuss the influences of trade policies in the export of agricultural produce and commodities in small states in the global market

LESSON 4.1 – BIOLOGICAL FACTORS

OVERVIEW

An ecosystem is a biological environment that exists in a specific location (on land or under the water). The ecosystem consists of all living biological organisms (animal and vegetation) and those non-living entities (such as decaying materials) that interacts with the air, water, soil and sunlight. In a complex ecosystem a change in one factor can impact the entire system and the biological organisms it supports. This lesson will examine the impact of biology on the agriculture industry.

OBJECTIVES

Upon completion of this lesson you will be able to:

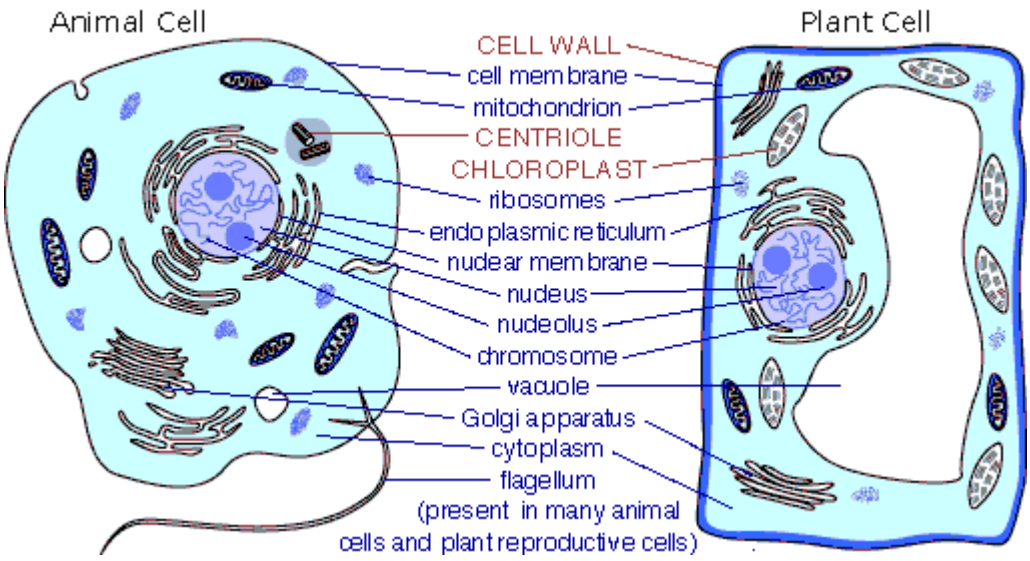
1. Explain the different types of ecosystems.
2. Discuss the impact of population on ecosystems.
3. Describe and classify different biological organisms.
4. Examine the impact of ecosystems change on the existing environment.
5. Explain biodiversity and its impact on agriculture.

BIOLOGICAL ORGANISMS

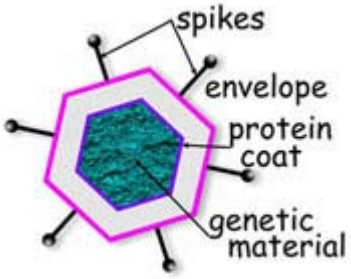
Biological factors are also referred to as biotic factors. These are the living organisms that are present naturally in any given environment or, as in cultivated ecosystems, occur there because of human intervention. These living organisms are classified into three broad groups according to the type of cells of which they are composed and the mechanism by which they reproduce themselves. Cells are the basic units that make up the structure of organisms. Some organisms are made up of many cells which may be specialized for different functions, while others may consist of only one cell. Organisms are classified according to the types of cells of which they consist:

Complex cells surrounded by a cell membrane and containing at least a nucleus. The nucleus contains the genes (genetic material) which allow the organism to reproduce offspring like itself. Examples of such organisms include plants, animals, fungi (fungus is the singular term), blue-green algae

Simple cells surrounding by a cell membrane but there is no well-defined organelle such as a nucleus. However, they contain their own genetic material that allows them to reproduce themselves. Bacteria are in this group.



Viruses are unlike other living organisms because they have no cells and are unable to carry out any of the processes of living things on their own. They consist only of nucleic acid material. Therefore, they need to invade other living organisms and attach themselves to the genetic material of those organisms in order to reproduce.

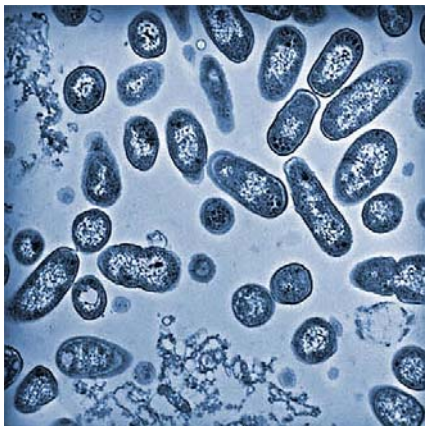


ORGANISM CLASSIFICATION

Scientists called taxonomists study the relationships among organisms and classify them further into groups according to similarities in their structure and how they conduct the processes of living organisms Fig. 2. One important outcome of taxonomy (the science of classification of organisms) is that organisms are given scientific names. Usually, the name consists of two parts, the name of the genus and the name of the species. The following are some of examples of the scientific names of some familiar organisms:

Solanum lycopersicum
(Tomato)

Gallus domesticus
(Chicken)



Salmonella enterocolitis
(Bacteria)

Salmonella bacteria is one of the most common causes of food poisoning.

Another important way in which taxonomy is useful is that it allows us to identify organisms that are related. For example, the white or Irish potato (*Solanum tuberosum*) and the eggplant, brinjal or aubergine (*Solanum melongena*) are close relatives of tomato because they belong to the same genus, *Solanum*. This also demonstrates genetic variation within one genus, because there are different species. This type of information about living organisms is very useful in agriculture and will be discussed further below and in later units.

PESTS

A pest is any organism that causes harm to plants or animals so that they grow and perform below their potential or may even die. Pest is a broad term that includes:

Pathogens - are disease-causing organisms and include fungi, bacteria, viruses. Some examples of these are:

- **Fungi** - *Mycosphaerella fijiensis* causes the Black Sigatoka disease in bananas; *Rhizoctonia* spp. causes Root Rot in seedlings.
- **Bacteria** – *Pseudomonas syringae* causes brown spots in beans and many other crops and *Xantomonas campestris* causes blight diseases on many crops.
- **Viruses** – A virus cause's foot and mouth disease in cattle. Common plant viruses are the Bunchy Top Virus that affect papaya and the Swollen Shoot Virus that affects cacao. The Avian Flu that affects poultry is caused by a virus.

Insect pests - Insect pests damage crops directly e.g by eating the leaves or indirectly e.g by being vectors (transmitters of pathogens). Fruit flies invade the fruits of many fruit crops, mites attack coconut fruits and beetles are pests of the aubergine plant. Ticks are not insects, because they have eight legs. They are a major pest of cattle and other large livestock.

Nematodes - These are microscopic worms that usually penetrate the roots of plants to feed on the plant tissues and disrupt the ability of the plant to take up water and nutrients. *Meloidgyne incognita* causes Root Knot disease in many crops including carrots. In livestock many worms are internal parasites, e.g. tapeworms, long worms and round worms.

Weeds – These are plants that harm crops plants mainly by direct competition for ware, nutrients and light. The nutgrass (*Cyperus rotundus*) is a major weed as is White Top (Parthenium *hysterophorus*). Some weeds also serve as alternate hosts for pathogens or insect pests, while others are parasites.

Many pests and diseases are unique to a specific region and agricultural departments in most countries take specific measures to prevent the transfer of diseases from other countries into their own agricultural environment. With global trade and growing transportation between countries this is becoming more and more difficult.

Supplementary Readings: To familiarize yourself about agricultural pests and diseases it is recommended you review the following online articles:

Common Agriculture Pests and Diseases - Identification Guide (Senegal) (http://pcsenegal.org/)

Australian Centre for International Agriculture Research - Books Online (http://aciar.gov.au/publication/term/13) Identify a booklet that you might be interested in reading and download it.

ECOSYSTEMS

Ecosystems examine the relationship between the environment and biological systems that exist within the environment. The concept of an ecosystem is important because it allow us to understand how the biological or biotic factors that will be discussed in this section, interact with the physical environment which was discussed above. Ecosystems are complex systems consisting of communities of plants and animals, including microorganisms, and their interactions with one another and their environment in ecological units which may occupy very small to very large areas. Therefore, an ecological unit may be a pond, water shed or an entire region. There are different types of ecosystems and the major types that occur in small states include:

Dryland systems - crop cultivation are limited by inadequate water. These systems differ in the level of aridity and may be totally uncultivated, or used for seasonal crops depending on water availability. The major agricultural activity tends to be livestock production as in Namibia.

Inland water systems - these are based on permanent bodies of water away from the coast such as lakes. There is usually flooding for some period of the year.

Mountain systems - these develop in steep, highland areas, for example in the mountainous areas of Lesotho.

Coastal systems - in these systems the sea has a strong influence on adjacent land. Only those small states that are land-locked such as Lesotho and Swaziland do not have coastal systems.

Island systems - land surrounded by water with a high ratio of coast to land. Countries in the Pacific, the Caribbean and in the Indian Ocean.

Forest systems - these systems are dominated by trees which may be used for lumber, non-wood products and firewood as in Guyana and the Seychelles and some Pacific countries such as Samoa and the Solomon Islands.

Cultivated systems - these are man-made systems in which domesticated species predominate. Most crop production occurs in these systems which are present in all small states.

Supplementary Readings: To learn more about ecosystems it is recommended your read the following online article:

Wikipedia.org - Ecosystem (http://en.wikipedia.org/wiki/Ecosystem)

ECOSYSTEM CHANGE

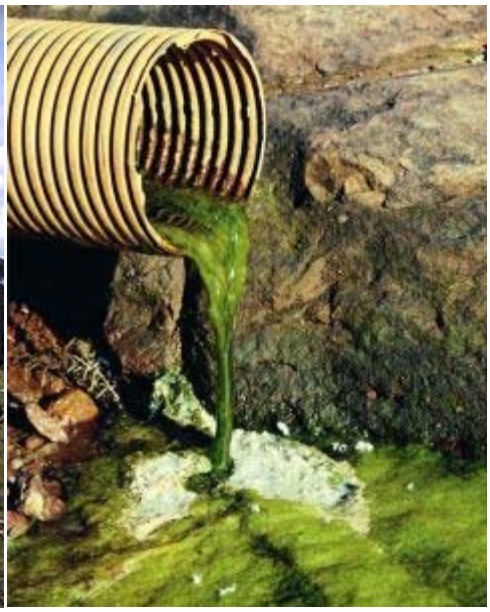
Ecosystems provide many benefits which are derived from the natural processes and cycles such as the water, nitrogen and carbon cycle that occur in them. These benefits are referred to as ecosystem services and include the maintenance of environmental conditions that are necessary for life on Earth, provision of food and water, flood and disease control and non-tangible benefits which may be cultural, recreational or psychological.

Ecosystem change is a matter of serious concern because it means that many of these services will be available to a lesser extent than in previous years. Human activities are the main reason for these changes, and among these activities, agriculture is a major contributor especially the highly intensive systems that developed during the last 60 years. Ecosystem change results in a loss of balance or equilibrium in the environment that manifest in problems that have far-reaching consequences for all life on earth and, even for agriculture directly. With respect to agriculture, one example of this loss of equilibrium is the development of disease and pest infestations. Disease requires three important conditions to be available simultaneously. These are:

- a pathogen or disease-causing organisms;
- environmental conditions that facilitate the growth and development of the pathogen; and
- a susceptible host which may be a plant or an animal.

Human activities, such as land clearing, can cause disequilibrium to the ecosystem and result in the development of disease situations. The same is true for the invasive species that can become serious pests in environments in which organisms that would naturally control their populations are absent.

Deforestation



Pollution of Water Systems

The examples above are major reasons for embracing sustainable agriculture, in which the aim is to develop systems of production that mimic natural systems, for example, organic farming. In sustainable agriculture, practices are used that will impose minimal or no damage to the physical environment and the biological components that inhabit it. We will now look at these biological components.

BIODIVERSITY

A key concept associated with biological organisms and ecosystems is that of biological diversity, which is usually contracted to the term, biodiversity.

Definition: Biodiversity is the total number of organisms, including the full range of genetic variation that occurs between and within species within an ecosystem or in larger areas including a geographic region.

Importance of Biodiversity

The importance of biodiversity is that many ecosystem services that are critical for life, including human life, on Earth, are derived from the activities and interactions of organisms with one another and the physical environment. Some of the most important services include:

1. **Food** – It is estimated that of 50,000 plant species are edible, however, only about 30 species are predominant in human diets worldwide at present. Plants also provide all livestock feeds. All carbohydrates, some protein and fat, as well as vitamin and minerals are provided by plants to human and livestock diets. Terrestrial and marine animals are major sources of protein / fat.
2. **Medicine** – Thousands of plant species are used in traditional and conventional medicine. *Penicillim chrysogenum*, a fungus, is the natural source from which penicillium, the first antibiotic was produced. Medicines are also derived from animal sources.
3. **Soil nutrient status** – Plants, soil animals, including earthworms, and soil microorganisms are critical to the maintenance of the nutrient cycles mentioned previously.
4. **Air quality** - Plants are very important sources of oxygen and prevent build-up of carbon dioxide in the atmosphere by absorbing it to produce carbohydrates through the process of photosynthesis which will be described in more detail in Unit 4.
5. **Erosion and flood control** – Plant roots stabilize soils thereby reducing erosion. They also reduce rainfall runoff from steep slopes lower the risk of flooding in low-lying areas.
6. **Pollination and seed dispersal** – Many plant species depend on pollination by insects for the reproductive process and also for their distribution and survival by animals and birds.

LOSS OF BIODIVERSITY

Given the benefits that are derived from the activities of organisms in ecosystems, loss of biodiversity is a very serious concern that is engaging the attention of many organizations worldwide at the national and international level and strong measures including international agreements such as the Convention on Biodiversity, are being made to encourage biodiversity conservation. Biodiversity loss is due primarily to human activities. Climate change has also become a major factor. Agriculture is one human activity, among others, that contributes to biodiversity loss.

Agricultural activities that contribute to biodiversity loss:

1. **Deforestation –** Removal of forests to make land available for farming causes loss of habitat to wildlife and destroys the genetic resources of many organisms. Large-scale livestock production and plantation systems, as well as, small-scale production by farmers who practice slash and burn agriculture are direct contributors to biodiversity loss.
2. **Water use** – Water use of irrigation, intensive livestock production, post-harvest handling and processing of agricultural commodities are all significant users of water. Competition for water supplies depletes the availability of this resource for biological organisms in natural ecosystems.

3. **Pollution –** Indirectly, agriculture can influence biodiversity loss at the location in which it is being practiced as well as in locations far away. Leaching of nitrogen fertilizers and pesticides from crops, animal waste, antibiotics and hormones from livestock operations, and chemicals and processing wastes from processing plants, contaminate water sources and even the sea, with deleterious effects on biodiversity.

Therefore, sustainable agriculture can contribute to biodiversity conservation through adoption of safer practices.

BIODIVERSITY IN AGRICULTURE

The services that organisms in ecosystems provide through the role in nutrient cycles, soil fertility, erosion control and pollination among others mentioned above, are very important benefits that agriculture derives from biodiversity. In addition, there are others are directly used in the practice of agriculture. We will discuss each of these separately.

GENETIC DIVERSITY

The genetic variability that exists within species is used in to select desirable types of plants and animals and to breed new types that better suit the requirements of producers and consumers. For example, a livestock farmer may prefer a certain breed of goats because it is better adapted to the local temperatures or because they produce more offspring than another breed. Similarly, a mango grower may chose a variety with low fibre-content in the flesh, or that has a tough skin that is not easily damaged because they are important to consumers.

Genetic diversity is also used in propagation of tree cops and ornamental species using grafting techniques. Grafting involves joining two pieces of plant, from different parent sources together to obtain the desirable characteristics of both parents. Grafting is most successful when used on plants types that are closely related, such as plants of the same species, or sometimes, the same genus. Commercially produced citrus trees are commonly grafted.

A more recent technique that makes use of biodiversity is genetic engineering in which a desirable gene from one organism is added to the DNA of another organism to produce a genetically modified organism (GMO). Several crops such soybeans have been genetically modified for several reasons e.g. for herbicide resistance in order to produce higher yields, or prolonged post-harvest life to facilitate longer but cheaper transport to market.

Intercropping systems and agroforestry that use a mixture of crops, and the use of mixtures of different cultivars of the same crops are important traditional and sustainable strategies for minimizing the risk of crop loss due to adverse physical or biological factors e.g. drought or pest. This is based on variation among cultivars and species in the ability to tolerate or resist attacks from such factors.

CROP PROTECTION

Weed Control

As has been mentioned biodiversity can be used to enhance the ability of a crop to withstand herbicides that are applied for weeds.

Insect Control

Several newer pesticides that are safer for the environment and for consumers have been developed using biological organisms, such as bacteria that are parasites of certain insects and are applied as a spray. These are called biopesticides. Another strategy is to use predators of crop insect pests for their control, for example, the Lady Bird beetle is a natural predators of aphids that are crop pests. Insect parasitoids have used to control the Pink Hibiscus Mealy Bug that attacks many crops in the Caribbean. Plant extracts can also replace harmful synthetic chemical pesticides. Neem and marigold are two examples of plants used in agriculture for their insecticidal properties.

Composting

The activity of soil organisms in the decomposition of organic wastes from plant parts, animal manures and other sources is very important in the process of composting which is the main method by which the organic matter is added to soils. Composting requires the activity of different types of bacteria at different stages of the process until the final stable product is ready. Compost is safe to use to improve the properties of soils or can be used directly as a growing medium for seedling and ornamental plants.

Among the benefits of compost to agriculture are:

- Suppression of pests including disease.
- Reduction in the need for inorganic fertilizers and other synthetic agricultural inputs.
- Reduction in soil, water and air pollution.
- Remediation of soils contaminated with heavy metals, oil and grease
- Cost-effectively increase yield.

SUMMARY

All the benefits of biological agents to human well-being and to agriculture provide support for the need to adopt more environmentally-friendly approaches in agriculture that will conserve natural ecosystems and also ensure that agriculture itself can be sustained over a long period. This approach to agriculture will protect human health and contribute to more productive life as a whole on Earth.

LESSON 4.2 – SOCIAL AND HUMAN FACTORS

OVERVIEW

So far we have considered environmental factors affecting agriculture in terms of the physical and the natural environment. However, as we have seen, human beings are also a significant part of this environment and influence both the physical and biological components through their activities, with agriculture being a major activity. The manner in which human beings conduct agriculture and affect the environment is determined not merely by decisions made by individual persons, but by human societies and the relationships within and among them, therefore, their influence has a strong social basis. This means that generally in most societies, agricultural decision-making is guided by what individuals perceive as being acceptable and beneficial to their society as a whole and not only by what benefits the individual solely.

OBJECTIVES

Upon completion of this lesson you will be able to:

1. Describe the impact of culture and local traditions on agriculture.
2. Discuss the role of gender and youth in the agricultural business.
3. Reflect upon the health issues impacting agricultural workers.
4. Discuss the education needs of agricultural professionals.
5. Determine the social capital within agricultural communities.

CULTURE AND TRADITIONS

The culture of a society which includes the beliefs, world view, norms, and practices or behaviours, influence how that society organizes its life and its traditions. The culture is manifested in the language, religion, food, relationship with the environment and the economic activities. During early human civilization, individual human groups or societies had unique cultures shaped to a large extent by their peculiar physical environment and natural resources, but with travel and trade, most societies have now gained influences from other societies. Nevertheless, some specific distinctions still persist.

The choice of plant and animal species used for food is a major cultural factor. For example, in Tonga, yams, kava and pigs are such highly prized items, that they are essential components in the gifts to their king. The status of yams in this society is based on the fact that of all the root crops consumed by this society, it is the most difficult to cultivate, and since men are the ones who undertake its cultivation, good yam yields are a testimony of manhood. In other societies, these commodities might not be valued, for example, pigs which are regarded as unclean animals by Muslims, for example, the Maldivian people. These examples show how beliefs can influence the choice of species for farming.

Slash and burn agriculture was developed as a traditional farming system in several parts of the world. It was based on meeting subsistence needs and was practiced extensively on land that was communally owned, so that after cultivating one plot of land for a few years, farmers cleared and moved to a new plot, when the former lost its fertility and yields began to decline. This plot regained fertility by being left uncultivated or fallow for several years during which period the original vegetation was re-established on it. In this context, slash and burn agriculture was sustainable. However, changes such as individual land ownership, commercial agriculture and the absence of a fallow period caused by larger populations and increased demand for food, have made this system of food production unsustainable. Where it is still practiced by small farmers, as in parts of Africa, very limited access to land is now a major factor. Another example of traditional farming systems is the r ice/fish farming in Asia in which fish ponds are integrated with flooded rice production. In this system there is nutrient recycling between the rice plants and the fish, the rice provide shade, while the fish oxygenate the water, control insect pest and are a valuable source of protein.

GENDER

The term “gender” is used to refer to not only to the sex of a person as determined biologically, but also to the roles that they are ascribed by their societies. In many societies, women are responsible for provision of the household food needs and consequently, undertake most of the farming activity. They tend to dominate the domestic markets also. Where men are involved in agricultural activity, their crops may differ as well as the cultural operations that they undertake, for example, land preparation, whereas weeding is women’s work. The men are also more involved in the marketing of export crops such as cocoa.

Gender roles can sometimes create inequalities between men and women with respect to access to resources necessary to improve agricultural output and increase income. One such area is the inheritance of land; in some societies, women cannot inherit land. Other areas of inequity include access to education, extension services and credit. This leads to the differences among male and female producers in the ability to develop their production systems. This can have serious consequences for food security where women are the major food crop producers. For example, if a woman does not own land, she is hardly likely to be access loans, even if she can out take loans on her name, because she lack collateral. Another area of inequality is in technological improvements which usually are developed for those operations such as tillage for which men are responsible. Even in conservation tillage, whenever no tillage or reduced tillage is the practice that receives most emphasis, the work of women who may be responsible for weeding increases, since tillage as method of weed control has been removed.

GENDER CASE STUDY - MALDIVES

Gender Roles and Biodiversity Management in the Maldives

Due to their small population and widely dispersed islands, the Maldivians have developed a socio-cultural pattern characterised by close-knit homogenous communities. Frequent divorces and remarriages have enlarged the family and diluted its influence on children. Traditions favouring segregation of women, common in many Islamic countries, are conspicuously absent in the Maldives. There is free mixing between the sexes and restrictions on female education or employment are absent. Women work alongside men in a number of occupations. Thus gender roles reflect the unique culture that has been fashioned from an amalgamation of the best components of various influencing cultures.

Nevertheless, the traditional gender division of labour is well defined and continues to prevail even today. The islands are dependent upon a seafaring economy. Fishing has provided the main occupation for men on the atolls. According to tradition, men go to sea to fish for tuna during the day, while women tend the home, care for children and produce food and articles for subsistence. Women on the atolls have also traditionally been involved in boiling, drying and salting fish, as well as in various local fibre-based handicrafts, including the production of coir rope and twine, matting, producing palm frond panels and basketry.

In general, two major constraints inhibit the ability of women to participate in economic activities:

1. Obligations to care for the family, more demanding in the Maldives as a result of the large family size (7.2 persons per on average).

2. Mobility constraints imposed by the island geography, as well as the fact that women cannot migrate with or follow their husbands at will to the place of their new and more lucrative jobs, such as the Gulf States.

Outsides Male', on the outer islands, people's lifestyles is very different. In particular, there is a greater dependency on local resources among atoll communities. Given the large-scale migration of men aged between 15-40 years to Male' or the resort islands in search of employment, the availability of male labour is in scarce supply on the atolls. This has attendant effects on agricultural production, particularly in male-dominated production activities such as coconut harvesting. In general, there is a larger proportion of men on the fishing islands, than on islands where agriculture is the main occupation.

Source: H. S. Kanvinde (1999). Maldivian Gender Roles in Bio-resource Management. RAP Publication 1999/15, FAO Regional Office for Asia and the Pacific, Bangkok, Thailand.

YOUTH

One of the factors that is affecting agricultural output and activity in several small states is the relatively high percentage of aging farmers because fewer young persons are opting for careers in agriculture. There are many reasons for this including lack of land ownership and capital. However, a major factor is the perception that most youth have of agriculture being strenuous but low-paying work usually undertaken by persons whose social status or level of educational achievement is too low to allow them access to better paying jobs.

It is critical that this impression of agriculture be eradicated, since as we have discussed so far in this course, there are many challenges confronting agriculture which makes it a dynamic and exiting field that require the boldness, innovativeness and energy of youth. Furthermore, as the recent food crisis, consumer demands and the need for adoption of sustainable approaches show, many countries are now looking to agriculture as a major growth area in the national economy and in that scenario, increased incomes for those involved in the sector are expected to increase significantly. Consequently, many efforts are being made in several small states to encourage youth involvement in agriculture. One example is the "Young Leaders in Agriculture" programme which is conducted by the Inter-American Institute for Cooperation in Agriculture, for young people in the Americas. After participating in one of the recently mounted programmes, a young leader commented,

"One of the key things that I learned over the last week is that the problems we are facing in agriculture are almost universal from top to bottom of the Americas and so it is important to have young, educated leaders helping to resolve these problems for the future of MANKIND. One day the general population will realize just how important farmers are!"

(Source: Forum for Young Leaders in Agriculture of the Americas, 24 -29 March, 2008, Centre for Leadership in Agriculture, Inter-American Institute for Cooperation in Agriculture.)

HEALTH

Health is a very important consideration especially with respect to farm families and the agricultural labour force. Nutrition is a major determinant of health and it is determined by both the quantity and the quality of food consumed. Food security, therefore, has a direct impact on the nutritional status of a population and where there is an emphasis on improving this status, domestic agriculture is often expected to play a leading role. For example, in Trinidad and Tobago, an increasing percentage of the food used in school feeding programmes is being grown under contractual arrangements with local farmers.

Of all diseases, in recent times, HIV/AIDS has had the biggest impact on the availability of labour and the productivity of production systems. In some small states such as Botswana, Namibia and Swaziland where the incidence of the disease among youth in the 15 to 49 age

group which is the major working age group, is estimated between 20 to 26%. This has serious implications for the availability of labour for cropping systems which will affect their productivity and sustainability. The disease directly decimates the labour force as well, as sick members of the family that require care, detract from labour that would otherwise be employed in farming. A study conducted by FAO identified some of the following effects of loss of labour due to HIV/AIDS on small farmer production in sub-Saharan Africa:

Declining crop yields – This is due to several factors including neglected or untimely performance of practices such as land preparation and weeding, loss of soil fertility, increase in pests and disease. The net effect is the reduction on farm income.

Decline in the range of crops grown – This has serious consequences such as limited nutrient intake in household diets and biodiversity reduction The impact of HIV/AIDS on livestock production.

Changes in livestock production – These include reductions in the herd size especially of cattle and change to smaller livestock which require less management.

Change in the level and nature of extension services – Less service may be available to farmers due to reduction of the number of extension officers and loss of extension time due to increase time being spent by extension officers at funerals. Because less labour was available, recommendations for certain practices had to be amended.

Loss of agricultural heritage - in terms of knowledge of specific plants and their uses, and loss of management skills.

EDUCATION

Access to education, both informal and formal is a critical factor influencing agriculture. Informal education consists of the traditional knowledge that is acquired through interaction with other farmers, especially the older ones. Unfortunately, much traditional knowledge gained over sometimes centuries of experience has been lost because its value in the management of fragile environments and indigenous species was not recognized until recently. The FAO recently mounted an agricultural heritage programme to preserve such knowledge where it still exists. One project in Peru, using an ancient farming technique called waru-waru that had been forgotten in modern times, was revived and is being practiced on over 7000 ha and higher yields and farm incomes are being achieved than before.

Formal education also has an important role to play since a wide range of knowledge and skills are important for any successful agricultural enterprise in the 21st century. Education provides access to information, new ideas and technologies, and the ability to communicate with wider range of persons with diverse knowledge and skills necessary for tackling complex problems. Most small states provide educational opportunities up to tertiary level, and compulsory and free education at least to the primary level. However, rural

populations in many states have limited access to education to acquire basic literacy and numeracy skills. Availability of training in agriculture at different levels is less widespread, which can result in fewer researchers and extension officers to service the agricultural sector. There are now many programmes in primary schools, secondary schools and post-secondary level to address this deficiency. This includes distance training programmes such as this one. Besides, the technical training, various programmes are available for personal development such as the training in leadership mentioned above.

SOCIAL CAPITAL

Social capital is the capacity provided by the relationships that exist within a group of people such as a community or a society, whether by kinship, shared culture, geographical location or common interests. Within an agricultural community, social capital is the enhanced capacity for decision–making and pursing set goals and objectives for the benefit of individuals and the community as a whole, because it is based on collective instead of individual action. Such collective action is based on trust. Social capital is a powerful mechanism that allows a group to transmit knowledge and skills, to interpret changes in the environment and their implications for the well-being of the group, to articulate positions and respond to challenges. These relationships can be expressed as local associations, institutions or networks.

Several studies of agricultural communities have shown that social capital allows indigenous groups, farmers, women, youth and other actors in agriculture to derive benefits such as:

- Access to credit.
- Access to inputs.
- Better biodiversity management.
- Access to support services from government.
- Better market arrangements.
- Greater influence on government policies affecting agriculture.
- Improved food security.
- Empowerment for self-help projects.

More detail and practical advice for building social capital will be discussed later in the course.

SUMMARY

Our discussion of human and social factors are not intended to suggest that all farmers from any given society or country behave in identical ways. On the contrary hopefully they illustrate that the background against which individuals who are engaged in agriculture make decisions. Everyone should realize that individual considerations such as gender, age, social standing within a community, will affect access to education and both economic and

social capital. These in turn will determine the chances of successful engagement in agricultural activity.

Lesson Discussion: Before proceeding to the next lesson you should participate in a class discussion organized by your instructor. You are to consider the following question:

What social considerations and human factors must an agricultural professional working in your local community must consider? Provide an example of how these factors can impact your success in agricultural activities.

L

ESSON 4.3 – ECONOMIC FACTORS

OVERVIEW

Farms and farm production is a business be it a small business, corporate entity or international company. No matter the size of the business all are impacted by various local, national and international economic factors. Since you are running a business an understanding of economics and business markets is essential to any agricultural professional.

OBJECTIVES

Upon completion of this lesson you will be able to:

1. Discuss the issues surrounding land tenure.
2. Examine the impact of farm size.
3. Examine different production systems and products.
4. Explore the costs of farm operations.
5. Explore different agriculture markets and their impact on the economy.

LAND TENURE

Land tenure is the name given, to the legal regime in which the land is owned by an individual, who is said to "hold" the land. The term "tenure" is used to signify the relationship of how the lands are occupied if by ownership, lease or other. Since production of agricultural products require land of different forms, agribusiness professionals must be familiar with land tenure and the regulations and laws governing tenure.

Common forms of land tenure are owner-occupied farms which range from large farms using hired labour to peasant plots and tenancies which vary very widely but basically involve payment, in one form or another, to the landlord from the tenant. Another form is leased farm land from another owner.

Ownership is established if farmers have legal documentation (as dictated by the local or national laws) that demonstrates that the farmer has legal ownership of the land and thus ha all of the rights (as established in law) to sell or otherwise dispose of the land. Sale and use of the land may be dictated by zoning regulations, local land use guidelines and other rules established by the appropriate governing body.

Many farmers do not own the land they cultivate. In these cases they will lease the land from the titled owner. A legal contract normally exists for the lease of the land. The lease contains an agreement that the lessee is obligated to pay rent each year for the use of the land for the duration of the contract. If the lessee builds on the land the buildings so

constructed would normally be turned over to the land's owner at the termination of the contract.

Landless farming (or free range farming) is a method of land use which is particularly popular with range farming of livestock. Animals: cows, goats or sheep are allowed to roam freely grazing on the natural sward of grasslands. This is a feature of small farm agriculture which continues to provide livelihoods and basic food for many rural farmers. These farmers experience difficulty when, and if they approach lending institutions for credit since they have no fixed collateral to be used as security. Often the land is owned by the government or an agency of government or is uncultivated land that has not been claimed by others.

The type of land tenure can affect agriculture investment. This is particularly important, especially when farmers seek investment funds from developmental banks. To prove commitment, the financial institution seeks a fixed immovable asset as collateral, this is usually land. Thus farmers without formal documentation of ownership of land maybe denied credit. Credit may be needed for capital investment activities.

FARM SIZE

There is a definite distinction between farm land and farm size. The distinction comes from the fact that the farmer/operator may have access to land but not economically cultivating or utilizing all of his land. A tract of land area cultivated for the purpose of agricultural production has varying dimensions depending on the scope of the resources available to the operator. A tract of useable land can also be patterned for livestock production.

Farm size can also be judged based on the number of animal units present, scope of operations or nature of the production.

Scale of Operations

Farm size influences agriculture especially reference to the scale of operations. This influences both for livestock and crop production. Some of the examples include:

- A farm that has five milking cows produce less revenue from milk production than another farm that has fifteen milking cows once the cows are of similar genetic material..
- A crop farm that has more arable land cultivated will have the potential to have greater harvests that farms with less land cultivated.
- Large scale operations require larger initial investment funds, they utilize similar management but output owing to size is bigger thus realizing greater profits. Operationally, these under larger scales of operation there is the potential for higher efficiency of labour use.

NATURE OF PRODUCTION

There are a number of production systems that can influence farm size**.**

Extensive System

Cropping patterns that utilize farm areas for field crops where there is low input can be termed extensive. Livestock farming when animals are free to range and forage over large little inputs crop is also considered an extensive system.

Intensive System

Intensive systems exist in crop production. Systems of cultivation where there is intensive use of space relative to production are included in this classification.

Hydroponics

Hydroponic gardening uses less land but require more resources and infrastructure to support greenhouse cultivation.

Inter Cropping Systems

Inter cropping occurs where a different varieties of crops is produced on the same land. This is a system where more animals are reared per unit area of location. Broiler production using the deep litter system with tunnel ventilation or poultry and cows are being kept under feed lots.

FACTORS IMPACTING FARM SIZE

Availability of Labour

Availability of labour is a critical element of the production function. If there are limitations in the availability there will be a direct effect on the productive capacity of the production unit, it may also constrain the increase in the productive capacity and development of farms.

Labour usually is divided into two categories. Household or farm family labour and hired labour. Farm family labour is usually associated with smaller holdings and peasant farming. It is particularly experienced in the small states. Labour determines and contributes to the productive capacity of farms. Unavailability of labour can constrain manual activities on farms affecting land preparation, sowing, maintenance and harvesting activities. Some farms may eve import labour for specific cultural activities.

Access to Credit

Access to credit is another critical element that can constrain farm size. Unavailability of credit may limit investment capacity for the purchase of capital investment items. Other short falls in cash may need credit, if however unavailable this can be detrimental to farm production. If the investor realizes that there are constraints, there may be stagnation of farm size.

Availability of Technology

Technology and farm mechanization allows the farmer to have an increased productive capacity. Technology can contribute to systems of intensive farming where there can be more production. Here farm size can be as a factor of the number of productive units per location. A larger number of productive units mean larger farms.

Issue of Tenure

The issue of tenure can influence the size of farms. If the lands cultivated are held under tenure conditions that farmer do not legal documentation for, the farmers may see the occupation of these lands as a risk to investment. As such he may not be able to easily acquire credit for the increase in farm size. His he will be risk averse since not possessing tenure documentation indicates him not having permanent rights which will curtail plans for investment and ultimately increase in farm size.

Fragmentation of Farms

Fragmentation is the division of a farmer's land into a collection of scattered lots. Fragmentation is usually the result of inheritance but may also reflect present processes like bush fallowing. Farms may be composed of up to twenty different plots, restricting mechanization and decreasing efficiency.

- A type of subsistence agriculture in which land is cultivated for a period of time and then left uncultivated for several years so that its fertility will be restored.
- Subsistence farming – in this case efficiency is not significant as the ratio of output of production to time spent on the farm is low. This is the case where more energy per unit time is spent traversing from one farm / plot to another. Usually the scale of production of each plot is low.
- There is also difficulty with accessibility to markets. Farm to market transportation difficulties may present cases of post-harvest spoilage of perishables.

COST FACTORS

Input Costs

Input costs affect agriculture in reference to costs of production and profit maximization. High input cost impinges upon profit. Thus the farmer may have to sell more units of produce to arrive at a break-even-point or on the other hand low input costs will contribute

to the farmer selling less units of his produce to arrive at a break-even point. A lower break-even-point means more profit all things being equal.

Capital Costs

Costs associated with the capital or investment expenditures on land, plant, equipment, and inventories. Unlike labour and operating costs, capital costs are independent of the level of output. However, capital costs are not limited to the initial construction of a factory or other business. For example, the purchase of a new machine that will increase production and last for years is a capital cost. Capital costs do not include labour costs except for the labour used for construction. Unlike operating costs, capital costs are one-time expenses, although payment may be spread out over many years in financial reports and tax returns. Capital costs are fixed and are therefore independent of the level of output. Returns on capital investment are not realised in one production period but have to be spread over the entire life of the resource that funds were expended on.

ENERGY AND ITS IMPACT

Agriculture necessitates the use of energy. As agriculture becomes more and more mechanised, technological influences require more energy use in the quest to achieve efficiency and increase scales of production. A number of energy sources are utilised. Energy is classified is renewable and non-renewable forms.

These sources can be categorised as either non-renewable or renewable energy.

Non Renewable Energy

Non-renewable energy relies on the use of fossil fuels. There are three major forms of fossil fuels: coal, oil and natural gas. All three were formed many hundreds of millions of years ago before the time of the dinosaurs- hence the name fossil fuels. The age they were formed is called the Carboniferous Period. It was part of the Paleozoic Era. “Carboniferous” gets its name from carbon, the basic element in coal and other fossil fuels.

The use of fossil fuels involves the use the conversion of these natural resources into petroleum based products. These fuels are used in tractors, water pumps, mowers, tillers, rotavators, etc. Fossil fuel is the most popular form of energy and its use has a direct impact on the cost of production.

Renewable Energy

Solar energy is derived from the sun with the use of solar panels, solar energy is trapped and stored in batteries and used for a number of activities. These pieces of equipment require little operational costs but relatively higher capital investment costs. These solar powered equipment is used as solar electrical fences as for rotational grazing in cattle production, as water heating equipment and a number of other functions.

Wind power forms the energy of active turbines for the production of electricity for various functionalities including the pumping of water farm use.

Bio Gas on farms is becoming a more popular form of renewable energy. Bio gas refers to a gas made from anaerobic digestion of agricultural and animal waster. The gas, a mixture of methane and Carbon dioxide, is used for direct combustion in cooking or lighting applications or to power combustion engines for motive power or electricity generation.

Water power is another renewable energy source that supports the production of electricity through the creation of dams and other types of generators that can harness the flow or wave action of water.

SUMMARY

Agricultural professional must understand there are a variety of factors that impact the industry and its ability to produce cost effective quality products. Not only must you know about soil, chemicals and the weather, you must also understand the legal aspects of farming operations, the use of land, the operational and capital costs of an agri-business and the impact of energy on the operation of the business.

LESSON 4.4 – MARKETING FACTORS

OVERVIEW

Markets and market accessibility influences the success or failure of an agricultural business. With the unavailability of markets there are no rewards for production. Agriculture production and output should be the a result of market demand. Thus it is necessary to synchronize agriculture technology in the production units to match the demands of the market segments that the agricultural businesses serve. This lesson will explore the local and international agricultural marketing.

OBJECTIVES

Upon completion of this lesson the learners will be able to discuss markets and their impact on the agriculture sector. Specifically you will be able to:

1. Discuss market criteria.
2. Explain how to promote your agri-business.
3. Examine global markets and trading blocks.
4. Examine trade agreements and economic partnerships.
5. Discuss the impact of trade barriers and trade policies.

MARKET CRITERIA

A market exists as a result of the ability of individuals to purchase and consume. Consumers of agricultural products are referred to as its markets. If there is an inability of individuals to pay for a product in a particular location there is no market. Thus if there is a demand, a market exists. If there is a demand there is an ability to pay. Markets can also be developed around the following criteria, price or product.

Price

Markets can be price sensitive. Owing to the competition of other products, the consumer seeks to maximize his utility by the purchase of more items at lower prices, while the producer seeks to produce more products at higher prices as to maximize their profitability. However, the invisible hand in the market stabilizes prices and an equilibrium price is achieved in the market. Knowledge of the market prices to all producers and consumers result in this phenomenon.

The price to which a product is sold can influence profit. The higher the price per unit can mean chances of higher revenues. If the market is controlled by one large farmer, there is monopoly and he sets the price. He can limit supply and create a demand so that he effectively keeps the price up. The consumers will then be price takers.

Premium prices can be obtained by providing niche products. Providing products in locations where there are small markets which are willing to pay and beneficially affect agriculture production by providing higher revenues.

Products

Type – Certain markets seek specific produce. As such only these products will be consumed in these markets. For example the sale of pork products will not be in demand in Muslim based market but beef products will be. Thus producers will have to be cognizant of the type of product and its sensitivity in the market.

Brand – Often consumers become loyal to particular brands owing to previous knowledge of the proprieties of the product and have developed a taste for it. The aim of marketing is to build brand loyalty.

Quality - Product quality influences the element of repeat buying. When a consumer experiences a quality product his or her chance of buying that product again is high. When there is repeat buying of produce a sustainable and strong market for agricultural production exists. When a poor product is experienced or is referenced in the media, product purchases will fall.

Consumer Preference - Some parts of the market are concerned about how they are perceived by others and thus may seek out products that illustrate their economic or social standing. Convenience shoppers may have more disposable income than other consumers and thus may be willing to make their purchases in more up-scale shops vice that that shop at the municipal vendors' market place. People may be purchase a particular product because they were satisfied with the service they received during the transaction. This can also be attributed to the purchase of exotic agricultural produce like rambutan or kiwi in some local markets.

MARKET PROMOTION

Market promotion is an important element of marketing as it presents to the consumer information on the product while enticing them to purchase. Increased purchase augers well for production. Producers aim on producing large quantities of products. Effective promotion has the potential of increasing the market share of the target population ie; the segment of the market targeted. Through promotion this segment can be increased.

MARKETING CONSIDERATIONS

Containers or wrappers for a consumer products serve a number of purposes including protection and description of the contents, theft deterrence, and product promotion. Innovative packaging may actually add value to the product if it meets a consumer need. Packaging can attract consumers while adding value which indicates that if more is produced more revenue can be realized for sales. It may also mean that more primary inputs and investment maybe required for the production.

Distance from area of production presents challenges especially if there is difficulty for transportation. Access routes are to markets are important considerations to be taken in planning a marketing strategy for agricultural products. Another aspect of place is the concentration of consumers and the intensity of demand. Places where population is high and demand is intensive presents lucrative markets. This consideration should be taken for both local and overseas markets.

Another consideration is the ease of entering and exiting markets. The investor needs to identify competitive forces that will aid or hinder his entrance in the specified market.

The tastes or preferences of your target market impacts your potential to sell into the market. If the market does not have a taste for the product (e.g. liver) sales will not be lucrative. You need to consider your customer and what they want and ideally can't get anywhere else.

GLOBAL MARKETS

Globalisation offers opportunities for growth and development in all parts of the world provided it goes with liberalisation of trade and finance. Without the liberalisation of trade and finance, small states will increasingly become marginalized, especially in agriculture.

Small states may face difficulties, both internal and external in their efforts to develop their agriculture and to achieve their objectives of improving food security and increasing export earnings. Internal difficulties include low productivity, low skill capacity, poor infrastructure and deficient institutional and policy frameworks. At the same time, with growing integration of markets due to globalization and liberalization, their economies face a more competitive external trading environment.

Today, farmers must be familiar with the global market place and the rules that govern it. Agribusiness professionals must become knowledge of trade policies, trade blocks and international trade agreements.

TRADING BLOCKS

Agriculture in small states has to operate within the context of globalization. States have trade policies to govern and direct their agricultural activities. Some of the small states have developed their specific national agriculture and trade policies, while others follow an open trade policy. All the states belong to regional trade blocks that aim to enhance cooperation between countries and represent their interests. The Pacific Islands Forum is an inter-governmental organization that includes small states such as Australia, New Zealand, Samoa, Solomon Islands, Tonga and Tuvalu.

The mission of Pacific Islands Forum is to work in support of Forum member governments, to enhance the economic and social well-being of the people of the South Pacific by fostering cooperation between governments and between international agencies, and by representing the interests of Forum members in ways agreed by the Forum.

On the other hand countries in southern Africa formed the **Southern African Development Community** (**SADC**) whose goal is to further socio-economic cooperation and integration as well as political and security cooperation among 15 southern African states. Small states that are members of the SADC are Botswana, Lesotho, Mauritius, Namibia, Seychelles and Swaziland.

The **Association of Caribbean States** **(ACS**) was formed with the aim of promoting consultation, cooperation, and concerted action among all countries of the Caribbean. Small states that are members of ACS are Antigua and Barbuda, Bahamas, Barbados, Dominica, Guyana, Jamaica, St. Lucia, and Trinidad and Tobago.

The region organisation representing West African countries is **the** **Economic Community of West African States (ECOWAS)** with a mission of promoting economic integration of the member countries. Gambia and Sierra Leone are two small states that are members of the ECOWAS.

TRADE AGREEMENTS

Small states have entered into bilateral, regional and international agreements to promote trade in different sectors, including agriculture. Development cooperation between the African, Caribbean and Pacific Group is States and the European Union is coordinated through the Treaty of Rome of 1957 which first established a collective European development and trade policy. Several agreements were signed between the European Union and ACP member states, and they include the Lome Convention of 1975 and the Cotonoua Agreement of 2000. The Cotonoua Agreement is designed to last for a period of 20 years and is based on four main principles: partnership, participation, dialogue and mutual obligations, and differentiation and regionalisation.

The **World Trade Organization (WTO)** is an international organization designed to supervise and liberalize international trade. The organization officially commenced on January 1, 1995 under the Marrakech Agreement, replacing the General Agreement on Tariffs and Trade (GATT), which commenced in 1947. The World Trade Organization deals with regulation of trade between participating countries; it provides a framework for negotiating and formalising trade agreements, and a dispute resolution process aimed at enforcing participants' adherence to WTO agreements which are signed by representatives of member governments and ratified by their parliaments.

The **Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS)** is an international agreement administered by the World Trade Organization (WTO) that sets down minimum standards for many forms of intellectual property (IP) regulation as applied to nationals of other WTO Members. It was negotiated at the end of the Uruguay Round of the General Agreement on Tariffs and Trade (GATT) in 1994. Specifically, TRIPS contains requirements that nations' laws must meet for: copyright rights, including the rights of performers, producers of sound recordings and broadcasting organizations; geographical indications, including appellations of origin; industrial designs; integrated circuit layout-designs; patents; monopolies for the developers of new plant varieties; trademarks; trade dress; and undisclosed or confidential information.

The **Agreement on the Application of Sanitary and Phytosanitary Measures** - also known as the **SPS Agreement** is an international treaty of the World Trade Organization. It was negotiated during the Uruguay Round of the General Agreement on Tariffs and Trade, and entered into force with the establishment of the WTO at the beginning of 1995.

Under the SPS agreement, the WTO sets constraints on member-states' policies relating to food safety (bacterial contaminants, pesticides, inspection and labelling) as well as animal and plant health (phytosanitary) about imported pests and diseases.

ECONOMIC PARTNERSHIPS

Economic Partnership Agreements (EPAs) are a scheme to create free trade areas (FTA) between the European Commission of the European Union and different groups of African, Caribbean and Pacific (ACP) countries. The EPAs' key feature is their reciprocity and their non-discriminatory nature. They involve the phased out removal of all trade preferences which have been established between the EU and the ACP countries since 1975 as well as the progressive removal of trade barriers between the partners. In order to fulfil the criterion of being a non-discriminatory agreement, the EPAs are open to all developing countries, thereby effectively terminating the ACP group as the main development partner of the EU. The Cotonou agreement encourages developing countries to enter into the EPAs in regional groupings. So far the ACP countries have formed six regional groupings in which they intend to enter into EPAs with the European Union. These regional groupings are:

- The Economic Community of West African States
- la Communauté économique et monétaire de l'Afrique centrale
- The Southern African Development Community
- The East African Community
- The Caribbean Community + Dominican Republic (CARIFORUM)
- The Pacific Region.

Supplementary Reading: To learn more about the EPAs and reciprocity it is recommended you read the following online article:

Stevens, C. & Keenan, J. (2005). EU–ACP Economic Partnership Agreements: The Effects of Reciprocity. Institute of Development Studies, Sussex, UK.

(http://www.sarpn.org.za/documents/d0001254/EPA_reciprocity_BP2.pdf)

TRADE BARRIERS & COMPETITIVENESS

Free Trade

Free trade establishes a system of trade policies that allow traders to act and transact without interference from government. According to the law of comparative advantage the policy permits trading partners mutual gains from trade of goods and services.

Under a free trade policy, prices are a reflection of true supply and demand, and are the sole determinant of resource allocation. Free trade differs from other forms of trade policy where the allocation of goods and services amongst trading countries are determined by artificial prices that may or may not reflect the true nature of supply and demand. These artificial prices are the result of protectionist trade policies, whereby governments intervene in the market through price adjustments and supply restrictions. Such

government interventions can increase as well as decrease the cost of goods and services to both consumers and producers.

Interventions include subsidies, taxes and tariffs, non-tariff barriers, such as regulatory legislation and quotas, and even inter-government managed trade agreements such as the North American Free Trade Agreement (NAFTA) and Central America Free Trade Agreement (CAFTA) (contrary to their formal titles) and any governmental market intervention resulting in artificial prices.

Most states conduct trade policies that are to a lesser or greater degree protectionist. One ubiquitous protectionist policy employed by states comes in the form of agricultural subsidies whereby countries attempt to protect their agricultural industries from outside competition by creating artificial low prices for their agricultural goods.

Free trade agreements are a key element of customs unions and free trade areas. The details and differences of these agreements are covered in their respective articles.

Trade Barriers

Trade barriers are any government policy or regulation that restricts international trade. The barriers can take many forms, including tariffs, import licenses, export licenses, import quotas, subsidies, non-tariff barriers to trade, voluntary export restraints, local content requirement and embargo. Most trade barriers work on the same principle: the imposition of some sort of cost on trade that raises the price of the traded products.

Competitiveness

Competitiveness is a comparative concept of the ability and performance of a firm, sub-sector or country to sell and supply goods and/or services in a given markets. National competitiveness is important for small open economies like those of small states, which rely on trade, and typically foreign direct investment, to provide the scale necessary for productivity increases to drive increases in living standards.

TRADE POLICY INFLUENCES ON AGRICULTURE

Under ideal situations where there is free trade countries would produce and trade on agricultural commodities on which they have comparative advantage. The trade policies of different countries and global agreements however influence the agriculture in many countries. Countries that aim at food self-sufficiency tend to encourage production of food products (mainly staple food), as opposed to those that aim at food security. Under food security farmers are encouraged to produce cash crops for export with the intension of obtaining foreign exchange to be used for acquiring the required food. A number of small states fall under the ACP, and they depended on production and export of sugar for the EU as a result of the Lome Convention of 1975. The products of the ACP countries were given preferential prices. Some countries provide subsidies to protect their emerging local

producers. The WTO intends to liberalise international trade and abolish preferential prices and subsidises and other forms of trade barriers. The majority of small states do not have the scale necessary for productivity increases in order for them to be competitive in the world trade for agriculture products.

LESSON DISCUSSION

Now that you have completed the lesson four content you are asked to complete the following activities.

1. Identify and report on at least one national or international treaty, trading block or marketing policy that has either a positive or negative impact on your ability to do business in the agricultural sector in your country.

2. Once you have identified the information above your instructor should organize a small group discussion that allows you to discuss the following with your peers.

   Explain the impact and discuss with your peers their own observations about the marketing environment that currently exists in your country.

SUMMARY

Understanding global markets, trade agreements and trade associations is important to the agricultural professional since much of our fruits, vegetables and meat products are shipped to other parts of the developed and developing world. The impact of policy changes or trade barriers can have an impact on the success of your farm operations. It may cause you to change crops or seek out different markets.

LESSON 4.5 – OTHER FACTORS IMPACTING AGRICULTURE

OVERVIEW

So far in this unit we have discussed some of the major factors that impact agricultural production and their impact on the ability of agri-professionals to do business. Agriculture is a staple in almost all societies. We depend on it for our subsistence. We depend on it for our livelihoods.

This lesson will explore a number of other factors that could impact your ability to conduct an agricultural business. Each country and region will be impacted by some but not all of these factors. Take them into consideration when beginning your work as a agri-business professional.

OBJECTIVES

Upon completion of this lesson you will be able to:

1. Describe the impact of institutional and government support and policies on agri-business.
2. Describe the need for local and national commodity organizations.
3. Examine the impact of research and development on agricultural community.
4. Explain the impact of credit or lack of credit on the local farms.
5. Examine the impact of competition and industry rivalry.
6. Explore the external threats to your industry.

INSTITUTIONAL SUPPORT

Institutional and government support are essential to the success of the agricultural industry within your company. This should be a multi-organization push from organizations in the private sector, public sector and international agencies. Let's examine each sector.

The Private Sector

The private sector is instrumental in supporting the industry. Depending on the organization some private organizations will provide the following:

- Credit and financial support to help grow your business.
- Support for the distribution and sale of new or existing products.
- Provision of education about new products that can enhance production.
- Supply chain processes that can move your product to local, national and international markets.

The private sector, be it financial providers, transporters, wholesalers, retailers and others are essential to the success of your business. You must explore the private sector support available in your community.

The Public Sector

Government and government agencies are essential partners in the growth and sustainability of local and national agriculture. Ministries of Agriculture have a role to provide effective policies and appropriate funding to guide the agriculture industry. Governments have an obligation to provide where needed:

- Credit facilities to help finance the growth of the industry.
- Grants and subsidies to support the planting of specific products or the switch from one product to another product that is more in demand and economically viable.
- Provision of research and development facilities to support the health and growth of the industry.
- Creation of policies and regulations that will ensure the success of the industry.
- Provision of health and safety regulations and processes that will ensure the safety of the food chain.

Government policies should reflect the interests of the government and their constituents. The policies should reflect the development of specific areas in the industry where there is a common thrust or vision. Policy development and implementation means that the government is interested in the provision of services in support of agriculture production. Once the government commits to support the industry, the follow on support services will evolve to support the farm communities. Once support services are in place, for example, extension services, drainage and irrigation services, extension services, marketing services, grants and loans, allowances (duty free), subsidies etc. all serve the commonality for the improvement of production.

Professional Agencies

Farm and agricultural groups, farm cooperatives, community groups, marketing boards and other professional agencies support the collaboration of farmers to help them support their training and education, the marketing of agricultural products and the negotiation for funds through grants and loans.

You should become engaged with the different professional agencies within your community. You should join and learn from them.

International Sector

Governments collaborate with other governments and create agencies like the FAO, CARDI, IICA, IFAD, IDB, IDRC and the Agriculture Institute of Canada that provide services globally to the agriculture communities that are in need or require technical support. Many of these

international agencies, like the FAO are very active in supporting small states agriculture. Some of these institutions also provide human resource development and capacity building to both public and private institutions which in turn targets the productive sector of agriculture.

RESEARCH AND EXTENSION

Research and extension services are usually offered free by the state. Recently private sector institutions have entered this market and are providing these support services for a fee. In some cases a private institution will contract a farmer for to use his plot as a pilot farm and use it as an extension tool to disseminate the information and its suitability to the farming communities located there in.

Extension programs should include the following:

1. Conduct and dissemination of agricultural research that is relevant to the community.
2. Human resource development to assist the agricultural community in growing their knowledge and skill in production, distribution and food safety and other topics.
3. Access to consulting and advisory services.
4. Exchange and collaboration programmes across the different national and international communities.
5. Provision of educational support materials.

Extension service provides a methodology for the dissemination of agricultural related information that has been researched but scientists at the research institutions. The scientific data is converted into using simple language and appropriate examples that farmers will understand. However, some innovative farmers will also do research on their farms. This research is also fed back to the research institutions and extension agents. Research and extension are two important services that complement agricultural production. It serves provide new technologies for increased benefits to agricultural production.

ACCESS TO CREDIT

Access to credit is an important issue in the agricultural sector. The inability to access credit reduces the potential for development of farms and effectively can curtail expansion and production. Farmers' access to credit may be limited by their tenure relationships. On the other hand access to credit fulfils investment activities that have benefits that improve the standard of living of farm families. Increased investment can mean increased production, increased revenue and increased profits. Credit to farmers is usually rendered by agricultural development banks and similar formal lending institutions. However, there are situations where there are informal financial arrangements. The may be the village lender. An affluent member of the community may be approached who provides funds to

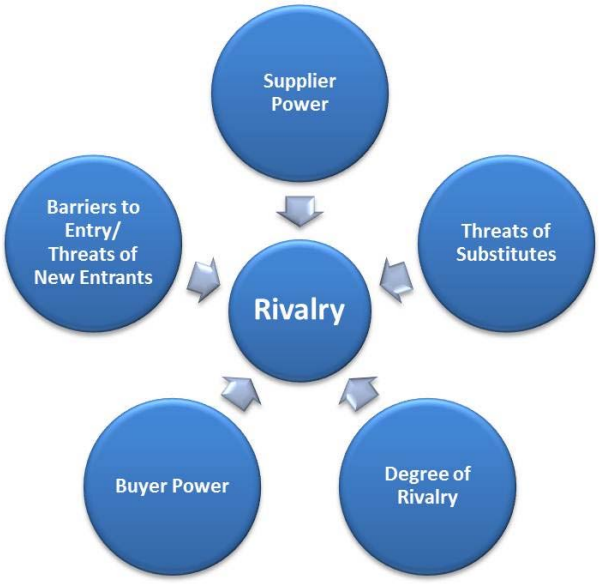
the rural farmer and serves similar functions of bank. In some cases commercial banks also offer loans to farmers, these tent to have higher interest rates. Commercial banks utilize similar interest rates to farmers and difficulties arise when there are losses in production resulting from natural causes. Agricultural production is fraught with a number risks. This fear can cause a risk adverse farmer to stay clear from credit and there may be the stagnation of agricultural production on his farm. This usually applies to peasant farmers and subsistence farming.

COMPETITIVENESS

The ability of a firm or a nation to offer products and services that meet the quality standards of the local and world markets at prices that are competitive and provide adequate returns on the resources employed or consumed in producing them. Competition implies that risk-adjusted rates of return should be constant across firms and industries. However, numerous economic studies have showed that different industries can keep up different levels of profitability; part of this difference is explained by industry structure. Thus the strategic agricultural business manager who seeks to have a competitive edge over other competitors in the industry can study the factors that influence how his business operates in the agriculture industry context in which his business operates.

As the diagram illustrates, there are several factors that influence competition:

- Industry Rivalry
- Degree of rivalry
- Supplier Power
- Buyer power
- Threat of New Entrants/Barriers to entry
- Threat of substitutes



Let's explore each one.

INDUSTRY RIVALRY

In each business there is a level of efficiency. Efficiency influences the levels of profits to be realized. However, competition among rival businesses in the industry drives the profits to zero. The most efficient business will be able to offer the lowest price thus other businesses that are less efficient are forced to reduce prices to compensate. Since price offered is a major determinant of profitability for businesses the equilibrium price in the market will satisfy consumer buying behaviour, since the consumers will seek out products that are of higher quality at lower prices. It is further seen that inefficient agribusiness are forced out of the sector owing to their in ability to compete. In addition to rivalry among agri-businesses in the form of efficiency, it can also occur with the scale of operation and also the products offered. Small States face physical disadvantages through the limitations of land areas, farm sizes, fragmentation of farms, allocation of resources to other industries (tourism), and the threat of the use of genetically modified foods among other influencing factors. In the relatively small populations of the Small States, competition for market share maybe influenced by efficiency. In the case where there is a high concentration of businesses in the market there is much competition. However competition is not perfect and firms are not unsophisticated price takers, rather, these businesses strive for a comparative advantage over their rivals. In a market where there is a high concentration of businesses the completion is great. However, competition is not perfect and firms are not unsophisticated price takers. Rather, these businesses strive for a comparative advantage.

The intensity of rivalry among businesses varies across industries. If there is a situation where in the industry there are few firms holding a large market share, the competitive landscape is less competitive (closer to that of a monopoly). On the other hand if there are many rivals, none of who has a significant market share. These fragmented markets are said to be competitive.

If rivalry among firms in the industry is low, the industry is considered to be disciplined. Explicit collusion generally is illegal and not an option. In low rival industries, competition moves must be constrained informally. However a Maverick firm seeking a competitive advantage can displace the otherwise disciplined market.

When a rival acts in a way that elicits a counter response to other firms actions, rivalry intensifies. The intensity of rivalry commonly being referred to as cutthroat, intense, moderate, or weak, based on the firms aggressiveness in attempting to gain an advantage.

In pursuing an advantage over its rivals a firm can choose from several competitive moves:

- Changing price: -raising or lowering prices to gain temporary advantage.

- Improving product differentiation: - improving features, implementing innovations in the manufacturing process and in the product itself.
- Creativity using channels of distribution – using vertical integration or using a distribution channel that is novel to the industry.
- Exploiting relationships with suppliers.

INTENSITY OF RIVALRY

The intensity of rivalry is influenced by the following industry characteristics:

1. **A large number of firms** cause an increase rivalry because more firms must compete for the same customers and resources. The rivalry intensifies if the firm have similar market share, leading to a struggle.

2. **Slow market Growth** causes firms to fight for for market share. In a growing market, firms are able to improve revenues simply because of the expanding market.

3. **High fixed costs** result in an economy of scale effect that increases rivalry. When total costs are mostly fixed costs, the firm must produce near capacity to attain the lowest unit costs. Since the firm must sell this large quantity of product, high levels of production lead to a fight for market share and results in increased rivalry.

4. **High storage costs or high perishable products** can cause a producer to sell goods as soon as possible. If other producers are attempting to upload at the same time, competition for customers intensifies**.**

5. **Low switching costs** increase rivalry**.** When a customer can freely switch from one product to anther there is a greater struggle to capture customers.

6. **Low levels of product differentiation** are associated with higher levels of rivalry. Brand identification, on the other hand, tends to constrain rivalry.

7. **Strategic Stakes are high** when a firm is losing market position or has potential for great gains. This intensifies rivalry.

8. **High exit barriers** place a high cost on abandoning the product. The firm must compete. High exit barriers cause a firm to remain in an industry, even when the venture is not profitable. A common exit barrier is asset specificity. When the plant and equipment required for manufacturing a producer is specialized, these assets cannot easily be sold to other buyers in another industry.

9. **Diversity of rivals** with different cultures, histories, and philosophies make an industry unstable. There is a greater possibility for mavericks and for misjudging rival's moves. Rivalry is volatile and can be intense.

10. **Industry shakeout is a** growing market and the potential for high profits induces new firms to enter a market and incumbent firms to increase production. A point is reached where the industry becomes crowded with competitors, and demand cannot support the new entrants and the resulting increased supply. The industry may become crowded if its growth rate slows and the market becomes saturated, creating a situation of excess capacity with too many goods chasing too few buyers. A shakeout ensues, with intense competition, price wars, and company failures.

The situation of rivalry in markets in the small states will vary. However similar may situations of rivalry exist both with reference to local and overseas markets.

THREAT OF SUBSTITUTES

The competition engendered by a **Threat of Substitute** comes from products outside the industry. While the threat of substitutes typically impacts an industry through price competition, there can be other concerns in assessing the threat of substitute**.** Products that may cost less that the products in the industry, these new products may be of a lower quality but they provide similar utility to the consumer. If these products are providing the satisfaction to the consuming target population, the competition of the new product can cause a shift in consumption for the original product. Further this situation can exist when cheaper imports flood a local market. This situation can be to the detriment of locally produced product especially if the scale of production is low cause. This situation has been to the detriment of the dairy industry in some territories in the Caribbean where cheaper dairy products in the form powdered milk imports compete with the imported dairy products. The local industry cannot compete with the foreign imports. To control this situation there may be the need for policy interventions of enacting tariffs or trade barriers.

BUYER & SUPPLIER POWER

Buyer Power

The power of buyers is the impact that customers have on a producing industry. In general, when buyer power is strong, the relationship to the producing industry is near to what an economist terms a monopsony – market in which there are many suppliers and one buyer. Under such market conditions, the buyer sets the price. In reality few pure monopsonies exist, but frequently there is some asymmetry between a producing industry and buyers.

Supplier Power

A producing industry requires raw materials – labour, components, and other supplies. This requirement leads to buyer-supplier relationships between the industry and the firms that provide it the raw materials used to create the products. Suppliers, if powerful, can exert an influence on the producing industry, such as selling raw materials at a high price to capture some of the industry's profits.

Barriers/Threats of Entry

It is not only incumbent rivals that pose a threat to firms in an industry; the possibility that new firms may enter the industry also affects competition. In theory, any firm should be able to enter and exit a market, and if free entry and exit exists, then profits always should be nominal. In reality, however, industries possess characteristics that protect the high profit levels of firms in the market and inhibit additional rivals from entering the market. These are *barriers to entry*.

Barriers to entry are more than the normal equilibrium adjustments that markets typically make. For example, when industry profits increase, we would expect additional firms to enter the market to take advantage of the high profit levels, over time driving down profits for all firms in the industry. When profits decrease, we would expect some firms to exit the market thus restoring a market equilibrium. Falling prices, or the expectation that future prices will fall, deters rivals from entering a market. Firms also may be reluctant to enter markets that are extremely uncertain, especially if entering involves expensive start-up costs. These are normal accommodations to market conditions. But if firms individually (collective action would be illegal collusion) keep prices artificially low as a strategy to prevent potential entrants from entering the market, such entry-deterring pricing establishes a barrier.

Barriers to entry are more than the normal equilibrium adjustments that markets typically make. For example, when industry profits increase, we would expect additional firms to enter the market to take advantage of the high profit levels, over time driving down profits for all firms in the industry. When profits decrease, we would expect some firms to exit the market thus restoring a market equilibrium. Falling prices, or the expectation that future prices will fall, deters rivals from entering a market. Firms also may be reluctant to enter markets that are extremely uncertain, especially if entering involves expensive start-up costs. These are normal accommodations to market conditions. But if firms individually (collective action would be illegal collusion) keep prices artificially low as a strategy to prevent potential entrants from entering the market, such entry-deterring pricing establishes a barrier.

SUMMARY

Competition is a dynamic factor that influences agriculture. Generally it is a market driven force in most cases. Without demand and the ability of consumers to rely on the goods and services provided there will be no competition. However competition will exist once there is trade of agricultural products. There is also competition in the value chain of production.

Government, the private sector and professional agencies also influence the local agricultural system. The agricultural system is a complex process that can be influenced by economics, policy, and other factors. As a professional you must become familiar with your surroundings and assess the factors that will impact on your success.

UNIT FOUR – ASSIGNMENT

Now that you have completed the readings and activities in Unit Four you should, under the guidance of your instructor, complete the following assignment.

Assignment Objective: Complete an analysis of all of the relevant factors that are impacting the agricultural industry in your community or small nation state.

Instructions: Based on the various factors discussed in Unit Four, you are to select a farming community that reflects your local agricultural environment and determine what factors impact on the success or failure of this community. You should view the current situation and make recommendations about how the community can become more successful by addressing the factors you have identified.

The specific areas that your analysis should address includes:

1. The current situation in the community or region. What products do you grow now? What is the state of the agriculture industry within your community or region?
2. What social and human factors impact on your farming community? What is the availability of labour to assist in production?
3. What types of diseases threaten your agricultural production? What is being done to counteract the biological threats to the local crops and farm animals?
4. What is the economic viability of your community or regional agricultural sector? Who is the primary target audience for your products? Is the market growing? What impact does the global market have on your ability to do business? How do you get your products to your local and global markets?
5. Who are your competitors? Do they try to undercut your prices?
6. What type of legislation or trade agreements impact your business?
7. What type of farmer cooperatives or professional associations exists within the local community or region to help you enhance your ability to do business?
8. What type of research and extension facilities and services exist in your local community or region?
9. Other factors that an agricultural professional should consider when establishing an agricultural business in your community or region?

The paper should be no more than ten double spaced pages. References should be provided to support your data or observations.

When you have completed your paper you should submit it to your instructor who will review it, provide feedback and assign a grade.

UNIT FOUR – SUMMARY

This unit has provided you with a comprehensive overview of the major factors in the physical, social and economic environment, on the local and global scales, that influence agriculture. While the natural factors determine what is potentially possible, social and economic factors also influence decision making in agriculture. All entrepreneurs have individual characteristics that impact on successful participation in this sector of the economy. However, these characteristics are determined to a significant extent by social factors such as culture, gender, age, access to education, health issues within the society and social capital. The immediate economic environment can is determined by land tenure arrangement, farm size, the availability of labour, capital and input costs and markets.

Agriculture worldwide is affected not only by local conditions but very largely by global factors also. Global markets and the related issues of trade arrangements and competitiveness are critical for the sustainability of agriculture in many small states that engaged in agriculture, especially for export. Since many agriculture related technologies use energy, alternative sources of energy have to be considered to reduce the current level of reliance on fossil fuel. This is also an important consideration in climate change which is already having serious direct and indirect impact on agriculture.

UNIT FIVE – AGRICULTURAL PRODUCTION SYSTEMS

OVERVIEW

This unit will expose you to the various types of agricultural production systems in use today. It starts with describing the two most common types of production systems; crop and livestock. This is followed by more complex agricultural systems like mixed farming and integrated farming systems. All will be discussed in the view point of small states and emphasising on the sustainability of that system. Agroforestry systems being quite common in the small states will be discussed in detailed in this unit. Also included are some examples of other production systems for agricultural diversification to open your eyes to possible opportunities for agribusiness in your state

GOALS AND OBJECTIVES

Upon completion of this unit you will be able to:

1. Understand the factors that influence the choice of production systems.
2. Compare the advantages and disadvantages of different production systems and technologies.
3. Describe the non-crop and non-livestock production systems.
4. Compare between Organic agriculture and Conventional agriculture.
5. Understand the various fields of diversification in agriculture

LESSON 5.1 – CROP PRODUCTION SYSTEMS

OVERVIEW

There are different kinds of farms in different regions of the world. It follows that the same kind or methods of farming cannot and are not practiced everywhere. It therefore means that different varieties of farming systems have been developed for growing crops in these different places. Every cropping system used has its own set of advantages and disadvantages, and are used for different reasons under different conditions. A number of these cropping systems will now be discussed to give an insight into how they work and under what conditions they may be used.

OBJECTIVES

Upon completion of this lesson you will be able to:

1. Compare monoculture and polyculture agriculture systems.
2. Discuss the benefits of crop rotation.
3. Examine conventional vs. organic agriculture.
4. Explore alternative crop production systems.

MONOCULTURE SYSTEMS

Under this system one type of crop is grown on the same piece of land year after year. The crop planted could either be an annual or perennial crop; usually grown over a wide area, and is widely used in modern commercial agriculture.

Monoculture is regarded by many as the normal way to produce crops and is a simple and convenient way of planting, cultivating and harvesting of any crop. To many people this is an added advantage for choosing this system. Another accepted advantage of the system, is that it encourages specialization. Farmers using the monoculture system become highly skilled at growing their one particular crop. This results in increased productivity and improved crop quality.

There are however, disadvantages that arise from using this system:

1. It provides the perfect opportunity for the spread of many crop pathogens carried by air borne spores. These disease causing spores would have a high chance of success even after a single spore infects one leaf. These spores would then spread disease more easily because they would land on identical susceptible leaves.

2. The system also exposes this crop to invasion of pests on a large scale. This is because the pest organism would easily spread when all the plants are the same.

3. The practice of monoculture gently increases the cost of production due to the cost associated with controlling disease. One must therefore either keep producing new crop varieties or develop new fungicides.

POLYCULTURE SYSTEMS

In this system the farmer grows multiple crops in his field. Crop rotation, multicropping and intercropping are all included in polyculture. This system is often more labour intensive than monoculture and is also believed to have several advantages over it as well.

One such advantage is that polyculture tends to give more stable yields over different environs than monoculture. This is because of the availability of excess nutrients not utilized by one crop species, which would be used by other crop species growing in the same soil, thus providing higher yields.

An example of polyculture is to grow lettuce after growing cabbage in the previous harvest. There are a number of different ways to implement a polyculture system on your farm. Below are the most common.

Multicropping

In this system farmers grow two or more crops in the same area during a single growing season. Multicropping is most common in small states and suits most farmers.

An example of multicropping is the growing of tomatoes and onions. Marigold may be used as an insect repellent to some pests of tomato.

Relay Cropping

In this system the crops are mixed but not planted at the same time. The main crop is planted first, then the second, and then sometimes afterwards the third crop is planted. When the first crop reaches maturity and is harvested it is then followed by the second, then the third crop.

Relay cropping is best used where the growing season for the second crop is slightly longer than that required for the first crop and similarly the third over the second. An advantage of relay cropping is more efficient utilization of land resulting in more crops being produced and more profitable farming operations.

Intercropping

In this system an additional crop is planted in available spaces left between the main crops in the field. Intercropping allows the farmer to grow more than one type of crop on the same piece of land at the same time. At least two types of crops are planted in an organized or unorganized method.

Organized method : Crops are planted in straight rows and are well spaced. E.g. A straight row of corn and a straight row of potatoes are grown simultaneously on the same piece of soil at the same time.

Unorganized method : No fixed rows are used and plants are not spaced. Two crops are grown together, but not in any particular proportions. This system is mostly used in small scale or subsistence farms and in backyards in Small States.

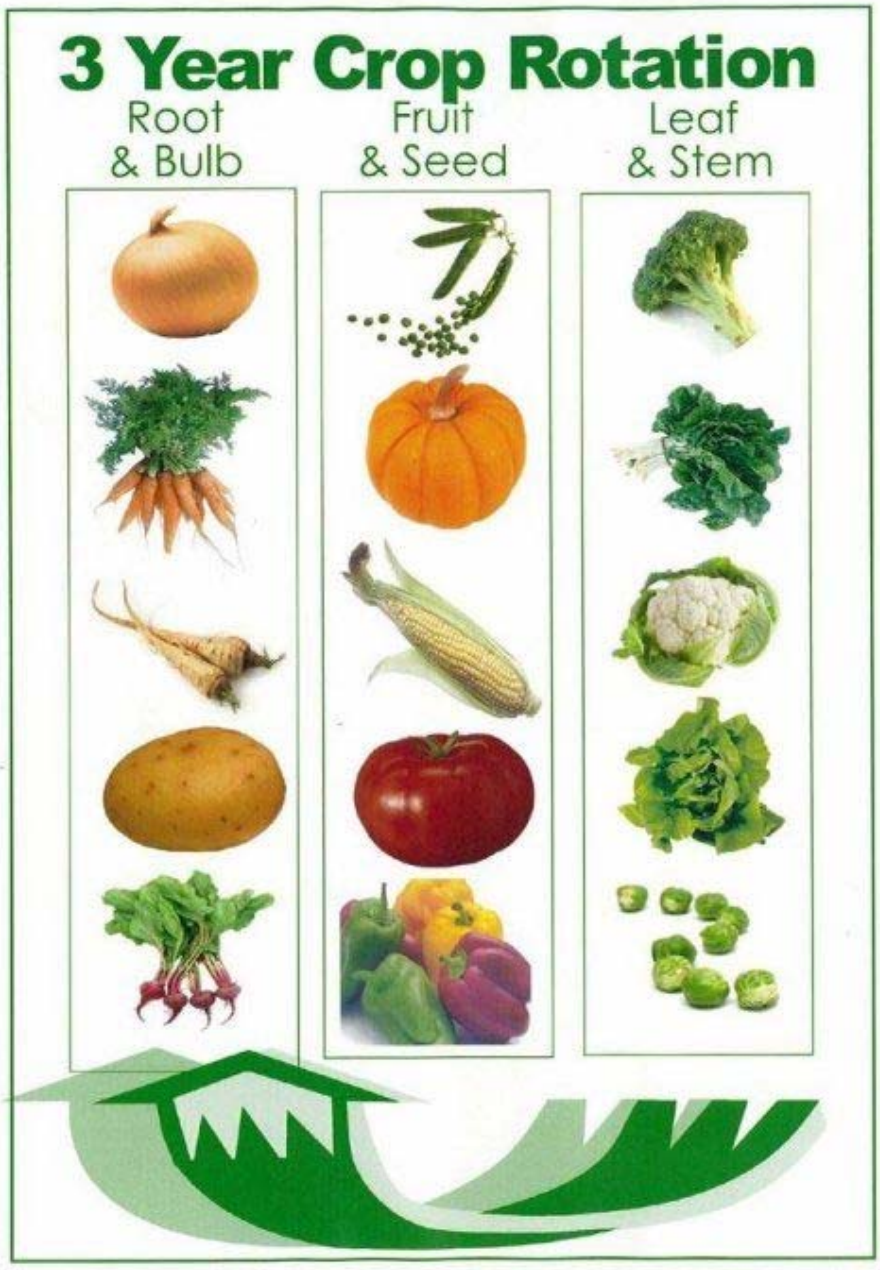
It is important to note that in intercropping, quick growing and quick maturing crops are planted between slow growing and slow maturing crops. E.g. melon intercropped with yam.

Beans and other crops in the same field.

CROP ROTATION

Another practice used in polyculture farming is crop rotation. Farmers using this system would divide their land into different sections or parts; and grow a different crop on each part. These crops would then be harvested and the land prepared for the next planting season. When the farmer plants the next time they would move the crops around so that each part or section now grows a different crop.

The diagram on the next page shows an example of crop rotation, where the crops are rotated among three sections every year.



Farmers can grow many different kinds of vegetables, by putting vegetables that belong to the same group together in the same section of the rotation.

As the picture illustrates crops of a similar nature can be grown together. For example:

- Root vegetables like beet and carrots can be grown together.
- Legumes such as peanuts, peas and other beans can be grown together.
- Leaf vegetables such as lettuce, cabbage and spinach can be grown together.

Reasons why farmers should practice crop rotation:

- It is better not to grow the same type of vegetable on the same piece of land year after year
- The risk of attack by pests and disease is reduced.
- Different crops take different nutrients from the soil. During rotation, crops make the best use of soil fertility
- Leafy crops such as lettuce and spinach are grown after a legume crop. They are then able to use the nitrogen left behind to produce large healthy leaves
- Root crops like carrot do best when they follow leaf crops since they do not need much manure. In a rotation farmers plant their root crops right after the leafy crops so that they could use up the fertility left behind by the leafy crop.

Some of the benefits of crop rotation include:

- It serves to control the spread of pests and diseases.
- It facilitates weed control.
- Crop rotation improves soil fertility.
- Reasonable income is maintained throughout the year (assuming you have a 12 month growing cycle).
- Machinery and labour are occupied year round.

CONVENTIONAL VS. ORGANIC FARMING

There considerable debate about the use of conventional methods of farming versus the organic methods of farming. Organic farming is often considered the traditional method of farming as it involves going back to traditional practices where all agricultural inputs into the production of crops and animals relied on nature for its nutrition, disease prevention methods and health of the plants and animals. Chemicals and other human made interventions were not used to support growth.

Over the next few sections we will explore the debate. It is eventually up to you on what type of farming practices you wish to embrace.

CONVENTIONAL AGRICULTURE

Conventional agriculture is also referred to as industrialized, commercial or modern agriculture. It consists of a package of technological advances such as monocropping, improved seed varieties, mechanized intensive soil tillage and large scale irrigation systems. Crop protection and soil fertility are achieved through heavy use of herbicides, pesticides and intense chemical fertilization.

Conventional agriculture is a proven method of farming in the small-states. Some of the reasons for its adoption in developing regions include:

- It significantly increases the production output thereby increasing the food supply in the state and providing better food security to the nation.
- Conventional methods often tend to be more mechanized, making the work of the farmer easier at almost every stage of production.

However there are some drawbacks to conventional methods. These include:

- The high costs for agro-chemicals are most often purchased on loans. If the farmer's crop fails, the high investment makes it almost impossible to make the loan repayment.
- This often throws the small scale farmer into a prolonged indebtedness with many falling deeper and deeper into debt.
- Negative impacts on both human health and the natural environment. Specifically,
    - **Impact on the soil:** The practice of conventional agriculture, with its package of technological advances, (implementation of the green revolution), vast areas of once fertile lands were subject to soil erosion and salination or a general loss if soil fertility, due to the use or overuse of chemical agro-inputs.
    - **Impact on the water:** Excessive irrigation coupled with intense use of agro-chemicals lead to pollutants trickling into lakes, streams and other fresh water resources (E.g. over exploitation of water resources).
    - **Impact on biodiversity:** Many wild and cultivated plant and animal species have become extinct or have depleted in number as agro chemicals are spread to natural habitats that surround or are in close proximity to conventional farms especially when farmers focus on sale crop.

ISSUES WITH CONVENTIONAL AGRICULTURE

The practice of conventional agriculture, ultimately cause farmers to face emerging issues that points to an uncertain future such as:

- Increase in commodity prices.
- Market pressure on commodities because of demand for bio-fuels.
- Increased demand for food from small states due to changes in their consumption pattern.
- Increasing environmental concerns.
- The increased use and spread of transgenic production and GMOs.
- Unfavourable trade regimes with small scale farmers making up the base of its agricultural sector.
- A great decrease in assistance (both internal and external) for agriculture, as is the case with public expenditure on the same.

Recognizing all the above issues, the pursuit of organic agriculture as an alternative, is often seen as a way out of the dilemma and also a solution to the problem of food scarcity. We will now explore organic agriculture's pros and cons.

ORGANIC AGRICULTURE

Organic agriculture is a form of agriculture that relies on crop rotation, green manure, compost biological pests control and mechanical cultivation to maintain soil productivity and control pests. It aims to strictly limit or exclude the use of plant growth regulators, livestock feed additives, genetically modified organisms and chemical and synthetic pesticides and fertilizers. The genesis of organic agriculture came about as a reaction to the growing reliance on chemical and synthetic fertilizers.

Organic agricultural methods are in most jurisdictions regulated and legally upheld and enforced by the national governments. To ensure uniformity in the techniques used in organic agriculture, certain standards are set to govern the practice worldwide. These standards are set by the International Federation of Organic Agricultural Movements (F.O.A.M.), which is the umbrella organization or Organic Organizations.

Organic agriculture is widely regarded as a production system that helps sustain the health of soils, ecosystems and people. In fulfilling this mandate those that practice organic agriculture rely on ecological processes, biodiversity and cycles adapted to local conditions rather than the use of chemical inputs with adverse effects.

ORGANIC AGRICULTURE GOALS

Organic agriculture is a holistic approach to farming and has certain specific goals such as:

- To promote fair relationships and a good quality of life for all involved. This is hoped to be achieved by combining tradition innovation and science which will also benefit the shared environment.
- To enhance and sustain health of soil, plants, animals, humans and ecosystems, ensuring that in the process it takes into account the entirety and interrelationships of the system. It must be understood that healthy soils produce healthy crops that in turn fosters the health of animals and humans
- Intends to produce high quality, nutritious food that contributes to preventative health care and well-being.

One of the great fears for the future is the seeming illusiveness of **food security** among nations. Now more high and sustainable yields per hectare can be achieved in employing organic agriculture techniques, especially in the developing world. It increases yield per hectare (in the long run) and reduces costs thereby increasing production and income. This increase in levels of food per farm and food per person enhances food security. Ultimately, this improved food security and consistent agricultural programs will serve to brighten the outlook for the future of the world.

It is important to keep in mind that increases in yield are only in the long run. Initially, the conversion from conventional to organic will result in reduced yields as the soil will take time to rejuvenate itself. Subsidies from the government or other supporting agencies are necessary for the small scale farmers to survive during the process of conversion.

ORGANIC VS. CONVENTIONAL AGRICULTURE

Compared to conventional agriculture, organic agriculture:

1. Improves soil fertility by applying organic compost and bio-fertilizers, mulching, crop rotation and intercropping.

2. Is still done at a smaller scale. However the trend has been increasing rapidly.

3. Crops produced organically are much higher priced that the same crops produced conventionally. This provides a much higher income to the farmer.

4. Organic food is believed by many to be healthier than food produced through conventional techniques and practices. Through this belief the market for Organic Agriculture products is growing steadily and becoming increasingly profitable

5. Whether or not organic foods are healthier than their conventional counterparts, consumers are paying a high premium price for them. Why is this so?

Consumers increasingly want to know that their agricultural purchases are produced in an environmentally and socially responsible manner. Being somehow satisfied that it is so, they are willing to pay more for the product. Organic Agriculture could therefore clearly be the way forward and they may also hold the key to the prevention or significant reduction of world food security.

HYDROPONICS - AN ALTERNATIVE

Hydroponics is a specialized method of growing plants without soil. In this practice, mineral nutrients solutions in water are in the place of soil, hence on some areas it is referred to as soilless agriculture. In comparison to vegetables growing in soil, hydroponics vegetables are said to be healthier, and faster growing. This is believed to be the case due to the automatic method of plant feeding used in hydroponics. Here, hydroponic nutrients, fertilizer for soilless gardening or plants food, are first dissolved in water and ten fed directly to the rest of the plants. Many hydroponics farmers contend that production yields under that system is consistently reliable comparatively. They claim that hydroponic gardens require only about 20-25% of the overall space required of soil gardens for the same vegetable production. There is support for this claim because hydroponic plants generally have a smaller root system and can therefore be grown closer together than plants in soil gardens.

In soil gardens, the plants grow large root system, which enables them to more effectively search for their required food and water. In hydroponics this large root system is needed since the food and water required by the plant are fed directly to the roots.

The word hydroponics is derived from two Greek words, 'hydro' meaning “water” and ‘ponos’ meaning "Labor”. It must be remembered that under natural conditions the soil acts mainly as a reservoir for mineral nutrients for plant growth, but of itself is not essential to plant growth nutrient-wise. Since the required minerals are fed directly to the foot of the plant soil becomes unnecessary. Hence the term soil-less gardening. This being the case, hydroponic gardeners can utilize an inert medium such as perlite, vermiculite, mineral root, sand, gravel and wood fibre. According to the above, some argue that since sand and gravel are considered types of soil, their use should not be considered in a truly hydroponic system.

Documentation of hydroponic gardening was made as early as 1627 by Sir Frances Bacon, All plants need light for photosynthetic actively, therefore it is necessary to provide artificial light which would them copy sunlight to hydroponics systems, since they are normally found inside.

Typical Hydroponic System

HYDROPONICS - ADVANTAGES & DISADVANTAGES

Advantages: The advantages of hydroponic agriculture are:

- Lower water costs because water stays in the system and can be reused.
- No soil is needed.
- Nutrition cost is reduced since it is possible to directly control the nutrition levels.
- Resulting yields are both high and stable.
- It is much easier to pest and disease control
- It is possible to produce crops and other plants out of season
- Nutrient pollution of the environment is avoided due to the controlled system utilized in hydroponics
- Weeds are almost absent or ever non-existent
- Urban and city dwellers that formally could not grow vegetables due to lack of garden space can now grow in their patios verandas, in window boxes and even on their flat roofs.
- Some areas are too mountainous or rocky and creates a barrier for the soil gardening. Hydroponics now allows these areas to become highly productive.

Disadvantages: All is certainly not perfect in Hydroponics. There are some draw backs that comes with its use.

- Due to high humidity coupled with the presence of fertilizers, an environment stimulating salmonella growth is developed.
- Verticulum wilt associated with high moisture levels can develop in hydroponics, leading to damp-off and other pathogen attack.

GREENHOUSES - PROTECTED AGRICULTURE

Agriculture faces many problems associated with weather conditions such as, heat and cold, flooding, drought, wind damage and growing seasons. Low rainfall and lack of much available land in some small states poses quite a challenge to profitable agriculture production. Green house structures have proven to overcome such challenges and revolutionize agricultural production in these and other areas.

In greenhouse projects, farmers are able to bring about modification of the natural environment to achieve controlled or improved plant growth. The greenhouse itself is a framed structure used for cultivating crops/plants in a controlled environment. It is covered with a transparent material that allows for optimum light transmission. Due to its' design and construction a greenhouse allows the farmer to protect his crops against adverse climatic conditions and bring about control of the environment to achieve desired goals such as optimum yield. Additionally greenhouse structures can provide protection of plants from insects using insect exclusion sheets.

Some crops that can be grown in green houses include bell peppers, tomatoes, Melons and cucumbers.

Commercial Greenhouse

SUMMARY

As the diagram below illustrates there are four growing or production options that farmers can embrace when operating their farms. As we discussed there are positives and negatives of each operation.

	Conventional	Organic
Monoculture	Option 1	Option 2
Polyculture	Option 3	Option 4

In the next lesson we will explore some other options to consider when deciding on what type of farming you should embrace.

LESSON 5.2 – LIVESTOCK PRODUCTION SYSTEMS

OVERVIEW

There are different systems utilized in livestock production. The major types of livestock production systems are classified as Intensive, Extensive and Semi-Intensive. The choice of the system is often determined by various factors such as:

- Land size,
- Tenure,
- Quantity and quality of livestock,
- Labour force availability,
- Available capital, and
- Expertise or knowledge of the farmer.

However, the key factors which determine the production system are:

- The level of production; e.g. subsistence or commercial.
- The purpose for which the animals are kept; e.g. beef fattening, dairy / milk production, breeding stock (upgrading).

OBJECTIVES

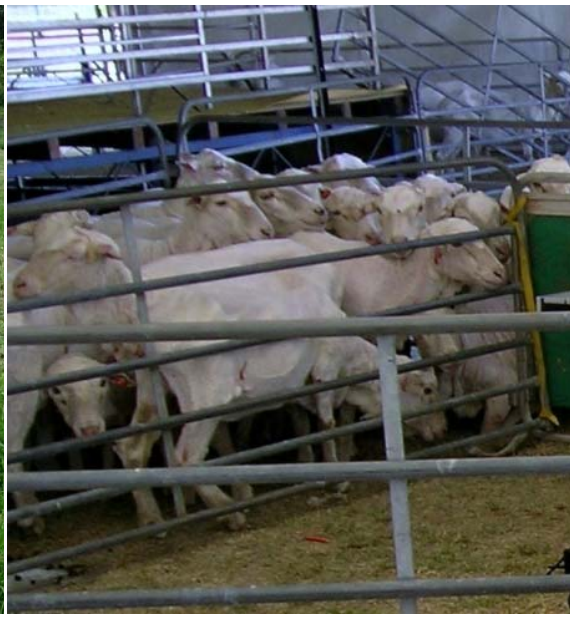
Upon completion of the lesson you will be able to:

1. Describe the following three livestock production systems:
    a. Intensive production system.
    b. Extensive production system.
    c. Semi-Intensive production system.

INTENSIVE PRODUCTION SYSTEMS

Under this system the animals are kept in an enclosed area (protected from predators) and are fed according to their specific needs. The animals are not allowed to graze in the pasture but rather have their feed brought to them. This arrangement severely limits or restricts the animals' movements. Energy, normally used in roaming is thus conserved, allowing the animal to increase its feed intake and gain weight at a faster rate.

Confined like this (as illustrated on the next page), the farmer has greater control over the animals' activities and especially on the animals' diet.



In small states, this system has proven to be economical for:

- Beef fattening, Dairy/Goat Production and Poultry Farming.
- Subsistence Production.
- Farmers with limited;
    - Land for grazing.
    - Number of animals; like sheep, goats or cattle.
    - Capital.
    - Inputs.

Intensive production is also a type of zero grazing system of livestock production. Free growing and more natural rather than cultivated forage such as mulberry, african star, para, pangola and tanner grasses or legumes such as leuceaena , desmodium, glinicidia, centrosema and kudzu are used.

Dairy production is particularly suited to this system, and can be done using a small herd of 1-6 cattle. Even the crop residue can also be incorporated into the animals feed.

In some highly intensive systems only the calves are catered for; especially male calves. They are bucket fed, as well as given arable fodder crops and concentrates.

EXTENSIVE PRODUCTION SYSTEMS

Under this system animals are allowed to graze extensively on individual or cooperative ranches or pastures. They are not penned at night and except for specific management purposes like shearing, wool clipping, hoof trimming, milking, and medicinal treatments, the animals are allowed to remain in the open pastures.

Extensive production can only be done where there are large enough acreages of fenced land. The fencing serves to protect the animals from predators, control their movement and better manage the pasture. It is highly advisable to plant shade trees in the pasture at different areas to protect the animals from excessive heat of the sun and also to facilitate rumination.

Ponds or other water catchments must be provided to allow adequate access to fresh water. To effect adequate management and record keeping, farmers using this system separate the animal into different groups e.g. fattening bulls, heifers, steers, lactating cows, pregnant or expectant cows, calves and dry cows. In this way, specific treatment and management practices can be administered to each group. The same is done to group sheep and goats accordingly.

Proper management of breeding among the various herds must be strictly adhered to, especially to limit or prevent in-breeding. It is therefore mandatory that bulls are not allowed to graze freely in the same pasture or paddock with the heifers or cows. The same applies to rams and ewes. If however, space mandates that bulls remain with heifers and cows, then they should be castrated.

Special service bulls, of good genetic stock should therefore be kept in separate paddocks and utilized specifically for mating purposes.

Extensive Production system requires the farmer to keep a watchful eye on his herd. Regular inspection must be carried out for disease detection and also to detect signs of heat.

Based on the way the animals are fed, Extensive Production System can be further classified into: continuous grazing; communal grazing; and rotational grazing. Let's explore each one.

CONTINUOUS GRAZING

This can be considered an alternative to rotational grazing. In this system the animals are kept on the pasture for extended periods of time without rotation. The major drawback with this system is that during its use, the pasture has no recovery period. This is most disadvantageous to both the animal and the pasture.

With the animals constantly on the pasture, the plant species has no time to rejuvenate or re-grow due to the constant grazing and trampling by the animals. The grass or legume species then becomes very unproductive and could eventually die off. It is important to note that some grasses and legumes are not conclusive to this type of grazing system and eventually dies off fairly quickly, e.g. elephant grass, panola grass and guatemala grass.

If the grass / legumes production falls and stay that way for an extended period of time, productivity levels of milk or meat would eventually fall likewise. In most areas where continuous grazing is practiced there is usually a scarcity of land and farmers normally have no option but to use the system.
Experience have shown that with the use of continuous grazing, incidence of pests and other insects have developed causing a further reduction in profitability.

COMMUNAL GRAZING

This grazing system is most times practiced by landless farmers. In many instances the farmers are able to neither lease nor rent the land, but have the interest and some expertise to get into livestock production.

The lands in question are usually owned by the government and other private land owners, who refuse to sell or lease the land. The best option given is usually a yearly rental agreement.

In other areas it is the agreed policy that livestock owners in a particular general area are allowed to graze their animals together on lands belonging to the king or government. In addition to the permission to communally graze their animals, farmers are also given allocations of land to plant crops and also to build their homestead.

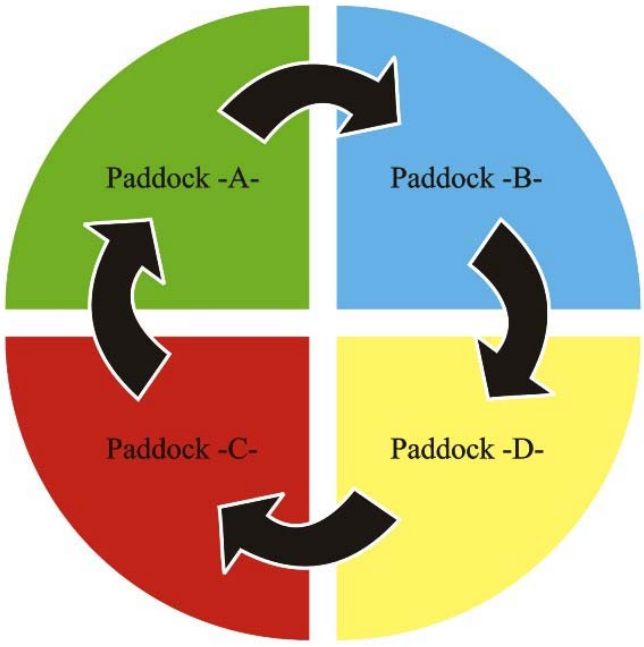
It would be understood that there are certain drawbacks with this production system. One disadvantage being the spread of pests and disease from one farmer's animals to another. The major cause of this would be the different management practices carried out by each farmer with his animals. Grazing together facilitates the easy spread of diseases and especially internal parasites among the herds. This build up of parasites both internal and external is attributed to poor housing structure.

ROTATIONAL GRAZING

To effect proper pasture management and gain optimum results which are sustainable, farmers using the extensive production system must encourage even grazing throughout the ranch or pasture; through rotational grazing.

To achieve this method of grazing, pastures and ranches are divided up into paddocks. Animals are then grazed systematically from one paddock to another, utilizing a fresh paddock at a time. The animals are allowed on a paddock for a specific period of time, thus preventing or discouraging over grazing.

Animals would be allowed to graze paddock "A" for a week, then moved to paddock "B". When this is done, Paddock "A" is given certain pasture management treatment such as weed control, fertilizing, mending of fence, pest control, irrigation...etc. It is then allowed to rejuvenate and rest before animals are put back on it.



Paddock Rotation

During rotational grazing, some farmers usually put young calves and or lactating cows on a fresh paddock first. This practice ensures that the high producing animals and those most vulnerable are given first choice to the fresh or rejuvenated pastures. This type of rotational grazing is referred to as "Top and Bottom Grazing".

SEMI-INTENSIVE PRODUCTION SYSTEMS

The semi-intensive production system is like a cross between the extensive and intensive production systems and often tends to be more complex as well in the structure and functionality. Under this system the animals are allowed to roam free in the pasture for a certain number of hours. Once the allotted time has been passed, they are then placed in secured pens, preferably close to the homestead.

Good quality fodder cut from the field as well as concentrate are now provided to the animals to supplement the grass eaten during free grazing. The fodder provided can either be in a green or dry state.

Semi-intensive production system is especially conclusive to small ruminant production is small states. Sheep and goat rearing have proven to have good economic returns to farmers in these areas even where there is minimal land available for livestock production.

To utilize this system more efficiently, pasture land of about 1-2 acres is necessary. This land should be cultivated with improved grasses and legumes such as pangola, para, african star 'guinea' grass, centrosema, glivicialia desmodium and kudzu. These could be pure grass

and legume stands or mixed stands of grass and legumes. Leucaena can be planted at specific areas. These would provide high quality feeding material as well as badly needed shade.

In addition to these improved grass/legume stands, there should be a pasture for free grazing. This could be similar in size to the forage pasture. To ensure the longevity of a suitable grazing area, this pasture for free grazing should be divided into paddocks and grazed systematically.

A farmer implementing the semi-intensive production system should consider the following requirement:

- Good / High quality and adaptable breed of animals to ensure profitable production.
- Good Management knowledge and skills of livestock production.
- Provide proper Facilities:

  These would include farmland for year round supply of fodder, first aid and veterinary service, feed formulation skill, minimum housing among others.

- Availability of a stable market:

  This should be ascertained even before starting the business. Farmers could conduct a small survey of their locality to find out what is being sold and what is being missing in the market to go ahead and establish themselves in that market.

- Establishing an integrated Value added business:

  In addition to meat production or other farm specific purpose the farmer should keep in mind to make the best use of all available resources. For e.g. to make a profit sale by converting his animals waste to organic manure, breeding good livestock to sell their young...etc

- Updating yourself in education and record keeping:

  Farmers in this system should always keep up with current trends in the market along with maintaining proper records of their business. They should be prepared to keep their system as flexible as possible to meet with those trends.

SUMMARY

During this lesson we explored different livestock production systems. We examined the advantages and disadvantages of each. In addition we discussed different types of livestock grazing options.

LESSON 5.3 – MIXED AND INTEGRATED FARMING

OVERVIEW

Mixed farming is normally the use of a single farm for multiple purposes such as the raising of livestock and growing of cash crops. Another workable definition shows mixed farming simply as a type of commercial agriculture concerned with producing animals and crops, vegetable or other types of crop, on one plot of land. In this lesson we will explore the impact of mixed farming.

OBJECTIVES

Upon completion of this lesson you should be able to:

1. Explain why farmers would embrace mixed farming.
2. Describe the advantages and disadvantages of mixed farming.
3. Examine the idea of integrated agriculture.

MIXED FARMING - DEFINED

Mixed farming is the use of a single farm for multiple purposes such as raising of livestock and growing of cash crops. Another workable definition shows mixed farming simply as a type of commercial agriculture concerned with producing animals and crops, vegetable or other types of crop, on one plot of land.

Mixed farming can also be the combination of two independent agricultural enterprises on the same farm, for example, combining a crop enterprise with a dairy farming, or livestock farming with crop cultivation. Whatever definition of the term is more conducive to the users understanding, mixed farming may be treated as a special case of diversified farming.

The combination or joint production of crop and animals provides a support base for each other. The animals eat the left over from crops and enjoy any shade provided and in return deposit their droppings on to the field or into the housing area from where it is collected and added to the field. This practice adds to the farmers profitability, in the short term (sale of manure) and in the long term with the increase in soil fertility which increase crop yields and hence quantity of products available for sale.

Mixed farming is labour intensive in the sense that there is always something to do. In other-wards there is always something happening on the farm, wither with the crops, the soil, and the animals or livestock houses. Crops must be planted, cared for and harvested almost year round. Mixed farming is mainly practiced under the subsistence method rather than for the commercial market. Crops grown are generally used by the family with excess sold in the local community. In Small States some schools practice small scale mixed

farming, where the output are sold to teachers, students and in the immediate community in which the school is located.

THE PRACTICE OF MIXED FARMING

Farmers who practice mixed farming realize many gains over other farmers using monoculture systems:

1. Livestock in the system produces the needed fertilizer for the crops and pasture through their manure. This is free fertilizer. Monocropping farmers however, must purchase their fertilizers which are expensive and harmful to the soil with prolonged use.

2. Manure fertilizer is good for the soil and helps build more soil. This is not true with chemical fertilizers. They are bad for the soil as they leave residue of salts that build-up over time.

3. There is no major manure build-up when livestock is mixed with crops on the land. The livestock is raised naturally by grazing. This manure is not deposited at any one area.

4. Mixed farming provides something for every member of the family to do.

5. With mixed farming, farmers are kept out of huge debt. This is because there is no need for expensive planting and harvesting equipment. These practices are done manually (by hand).

6. The pest population is significantly kept down or reduced, as crops are mixed and animals are also involved. This makes it difficult for a particular pest species to be established.

Here is an example of a mixed farming practice.

Growing cabbage and raising pigs on the same land in rotation. In this practice, the land is divided in to two. The pigs are on one section and cabbages are grown on the other. Rotation is then done and pigs are put on the land where the cabbage was, the pigs then will invert the soil as they naturally do. They also eat any leftover cabbage as well as eating or exposing bugs or worms and in addition dropping their manure. This improves the soil fertility for the cabbage. The cabbage then grows in soil fertilized by the pigs in the next growing season.

BENEFITS & DRAWBACKS

Benefits of Mixed Farming

- Adds income. Farmer had many crop and animal sources from which to sell.
- Year round sales or income generation. Whether from crops or from animals, the farmer always has produce from which he can generate an income.
- Optimum land use. Land is utilized for pasture development, animal grazing and housing and crop cultivation.
- The droppings from the soil are easily incorporated into the soil and adds to the fertility of the soil.
- Food is believed to be much healthier and taste better especially since only natural fertilizers are used.
- Much of the practices are done manually, this creating more jobs.

Drawbacks of Mixed Farming

The benefits of mixed farming are many, however there are a few disadvantages or challenges to the practice:

- Less crops are grown on a comparative basis to a monoculture system because only manual operations are carried out such as land preparation, planting and harvesting.
- Animals could feed on cultivated crops thus close management must be done.

Finally because of the diversified nature of the practice, especially as it involves both crops and animals in close proximity to each other, the farmer's attention is constantly divided among the many necessary farm chores. There is really always something to be done.

Supplementary Readings: If you want to learn more about mixed farming systems you should read the following online article:

FAO. Mixed farming systems and the environment.

(http://www.fao.org/docrep/x5303e/x5303e09.htm)

INTEGRATED AGRICULTURE

This is a term broadly used to explain a more integrated approach to farming as compared to existing monoculture approaches. It refers to agricultural systems that integrate livestock and crop production, a practice that can also be called Integrated Bio-systems.

As it can be noticed, integrated agriculture is a type or form of mixed farming. The practice of integrated agriculture is believed to be traditional to China, where fish farming is incorporated with livestock rearing and cultivation of agricultural crops including vegetable farming.

One example of this practice is their integration of pigs, grass and fish. Pig farms produce large quantities of excrete which is treated and then used as fertilizer for good quality, high yielding folder grasses such as rye grass, Sudan grass and Napier grass. The grass is later harvested, chopped into small pieces and fed to herbivorous fish. The pig manure can also be added directly into the fish pond. In addition to the manure from pigs, the excrete from the fish also fertilizes the pond water for the support of fish growth. Pond humus produced in the process can then be used as manure for plant cultivation. We therefore have the productivity of both fodder grasses and phytoplankton utilized.

Another example of integrated agriculture is the use of Animal Tractors. This is a sustainable, cost effective, and humane way to integrate animals into an agricultural system. Notwithstanding use of the term "tractor", animal tractor systems do not involve draft animals. In some areas, animal tractors are referred to as shelter-pen systems where animals such as chicken, turkeys, geese, ducks, pigs or goats are used as integral parts of agricultural environments.

In animal tractor systems, the animal in use is managed for productivity of eggs, milk or meat; and also to prepare, clean or maintain planting areas. The farmer must ensure that he integrates the needs, behaviours and products of the animals with the farm system as a whole. In doing this the animals are located where its food is abundant, where the animal enjoys relative freedom, and where the natural behaviours of the animal are put to best use. The animal provides a handy tillage tool with its continual scratching, pecking or rooting behaviour. At the same time, it becomes a biomass recycler, consuming excess weeds, grasses, insects, etc. The manure returns to the earth as fertility for the crops.

Two simple animal tractor systems are:

1. Confining pigs in a crop field prior to planting, by its natural habit or behaviour of digging for roots, the pig inadvertently ploughs the field.
2. Cattle is placed on cleared land for a period of time and then taken off. The very next day after the cattle is taken off the land, cereal seeds are broadcasted in the holes left by their hoofs.

We have looked at two different ways in which integrated agriculture can be carried out. One is the animal tractor system and the other is the integration of livestock and crop production as in fish farming. In both cases we have seen how animals and crops can combine with the land to provide optimum agricultural production.

LESSON DISCUSSION

Now that you have completed a number of lessons on the different type of crop and livestock farming systems it is time to think about what type of farm you would like to create. Under the guidance of your instructor participate in a small group discussion and review your options with your peers. Consider the following question:

Think about the farming community you currently live in. Consider the type of farms that currently exist in the area. Are these farms using the most appropriate farming methods and system to maximize the potential of the land and to increase their production? Discuss.

SUMMARY

During this lesson you explored the idea of mixed farming. It is an alternative to consider since it allows the farm to be used year round.

LESSON 5.4 – AGRO-FORESTRY SYSTEMS

OVERVIEW

"Agroforestry is a collective name for land use systems and practices in which woody perennials are deliberately integrated with crops and/or animals on the same land management unit. The integration can be either in a spatial mixture or in a temporal sequence. There are normally both ecological and economic interactions between woody and non-woody components in Agroforestry" .

From http://en.wikipedia.org/wiki/Agroforestry

This definition implies that:

- Agroforestry normally involves two or more species of plants (or plants and animals), at least one of which is woody perennial,
- An Agroforestry system will always have more than one output.
- The cycle of an Agroforestry system will always be more than a year.
- That most Agroforestry system are very complex; ecologically and economically, than other agriculture production systems.

In simpler terms, Agroforestry is the inclusion of woody perennials (trees) into a crop production system or a livestock production system. In some cases woody perennials are incorporated into mixed farming systems as well.

OBJECTIVES

Upon completion of this lesson you should be able to:

1. Describe what an agro-forestry system is and the different types of systems.
2. Explain the history of agro-forestry systems.
3. Explore productivity and agro-forestry.
4. Examine the role of Fodder Trees in agro-forestry.
5. Explain the ecological impact of an agro-forestry system.

HISTORY OF AGROFORESTRY

In Europe, it used to be customary to clear-fell degraded forests and cultivate food crops for varying periods on the cleared area. They would often plant woody perennials together with agriculture crops on the same land.

In tropical America, it was a bit more different. Their society's simulated forest conditions to obtain the beneficial effects of a normal forest ecosystem. The traditional practice

involves farmers planting more than a dozen species of plants on plots that are not bigger than only a 1000sq.m.

The practice in Asia was more compound and complicated in which they utilized the concept of shifting cultivation. They would often leave some trees untouched as they cleared land for agriculture. This provided partial protection to the soil from the sun. Additionally, the trees used to provide timber, medicinal ingredients, food and even cosmetics.

In southern Nigeria root crops and vegetables were normally grown together under a cover of scattered trees. This method is similar to constructing a multi-storied building in a congested area, where you make use of the vertical space that is available to you (in our case, the canopy).

In temperate areas, Mono-cropping systems focusing on one or a few products are gradually replacing Agroforestry. This major force driving this trend is more economical rather than ecological.

The situation is a lot different in the tropics and other developing countries including the small states across the world. These states are often faced with an unfavourable political economy; there is a lack of infrastructure, lack of marketing and most importantly a deficit of land. These reasons force small land holders to reduce risks by satisfying most of their basic needs directly from the land resources, giving birth to most of the Agroforestry systems in place today.

Agroforestry has been practiced under different surroundings and localities for many centuries. It is most common in places with a history of urbanization and high population densities, as Agroforestry systems often provide some relief in their application as a high efficiency land-use system.

Agroforestry Plots

TYPES OF AGROFORESTRY SYSTEMS

Different Agroforestry systems can be found according to various criteria used for classification.

The most common criteria used for classification are:

1. Structure of the system - Nature and arrangement of components.
2. Function of the system - Role and output of components.
3. Socio-economic scales and management levels of the system.
4. Ecological criteria.

Since the components (plants and/or animals) are always present in all Agroforestry practices, the most common criteria used for classification are the structural. Using the structure of the system, an Agroforestry system can be classified into the following:

- Agrisilvicultural System: (Crops and trees including shrubs / vines / and timber crops)
- Silvopastoral System: (Pasture/animals and trees)
- Agrosilvopastoral System: (Crops, pasture/animals and trees)
- Other Systems:
    - Apiculture
    - Aquaculture in mangrove areas
    - Multipurpose tree lots
    - Agro-silvo-fishery (Aquaforestry)

Agroforestry has both a productivity role and a protective role to play in the agriculture system of a community.

The productive role of the Agroforestry system refers to the food producing plants, fodder trees and shrubs for and fuel wood production while the protective role refers to the soil productivity and soil/crop protection.

Supplementary Readings: To learn more about how agroforestry systems are used in India you should review the following online article:

Pandey, D.N. (2007). Multifunctional agroforestry systems in India. Current Science, Vol. 92, NO. 4, 25 February 2007. Retrieved from: http://www.ias.ac.in/currsci/feb252007/455.pdf

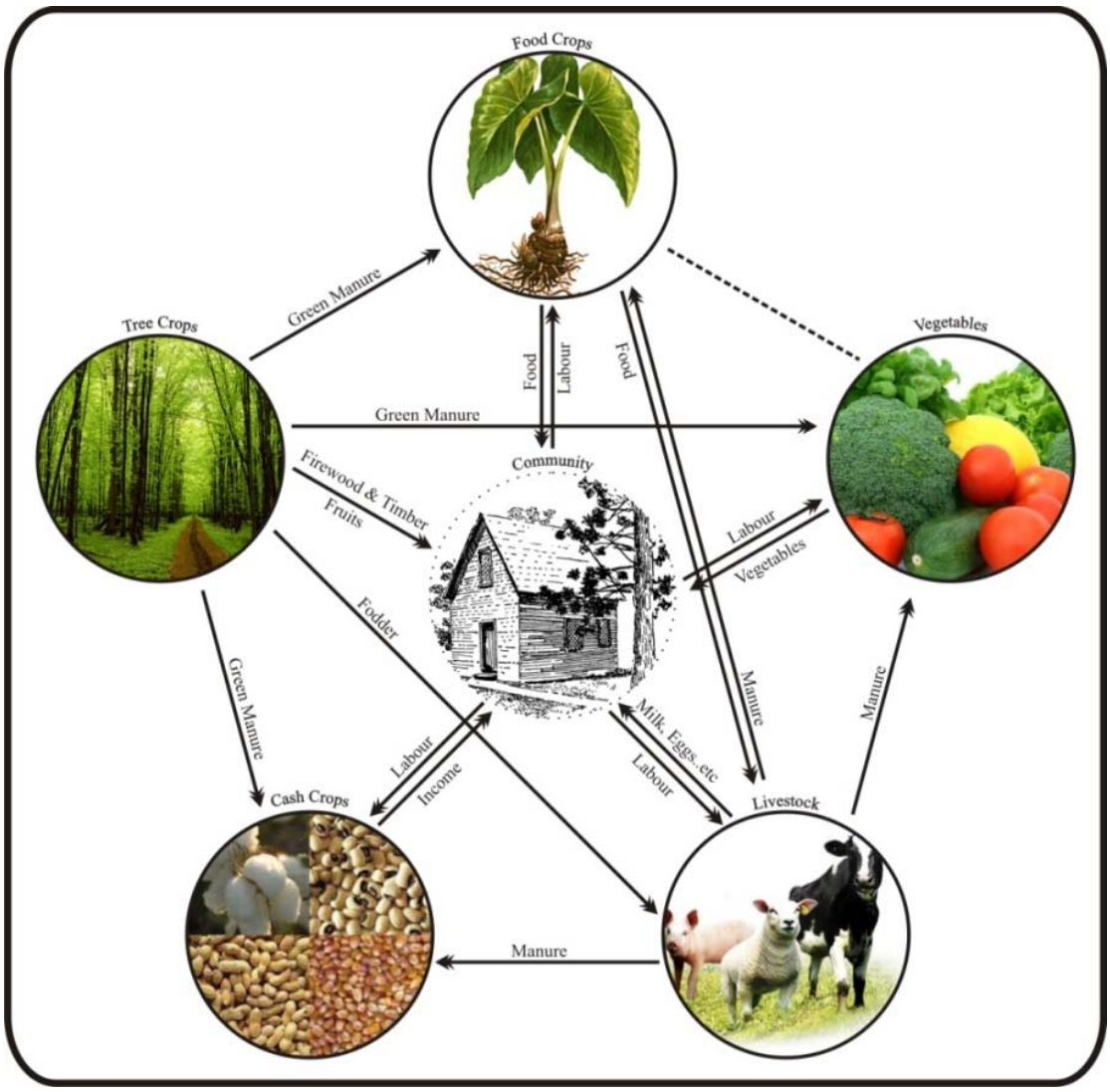
EXAMPLES - HOME GARDENS

They are the most typical type of Agroforestry systems found across small states. They are a type of subsistence land-use system found almost in all the tropical and sub-tropical eco-zones, as they often tend to be more:

- Economically efficient.
- Ecologically sound.
- Biologically sustainable.

They can be simple practices of growing fruits and vegetables in your backyard to more complex multi-storied systems. Most home gardens are agrosilvopastoral systems consisting of herbaceous crops, woody perennials and animals; some are agrisilvicultural systems consisting of only herbaceous crops and woody perennials. However, all home gardens have a few factors that are in common:

- crops-trees-animals are used in different combinations, often determined by:
    - Environmental factors,
    - Socio-economic factors,
    - Dietary habits,
    - Market demands of the locality.
- It is managed intentionally.
- Multi-purpose trees and shrubs are utilized.
- Food Production is the main objective.
- An almost continuous production throughout the year.
- Everything is within the compounds of individual houses.
- Managed by family labour.



Interactions Between Components of a Home Garden

EXAMPLES - TREE GARDENS

They are like a forest system consisting commercial tree crops along with forest species. A key difference compared to home gardens is that the tree gardens often tend to be a bit away from the house.

Characteristics of Tree Gardens

Tree gardens consist of a large variety of multipurpose plants in the various layers of vegetation. This ensures a varied production of a range of materials throughout the year and utilized the environmental factors like water, nutrients and sunlight at its optimum level.

Most tree gardens are dominated by perennial rather than annual crops. Thus, a large proportion of the nutrients are stored on the upper level rather than in the soil. This ensures an effective nutrient cycle and relatively small leaching and erosion hazard.

Tree gardens often produce supplementary products with high nutritive value (proteins, vitamins and minerals), medicinal products and spices, firewood, and sometimes also forage crops and construction wood.

Normally it is for subsistence production and a possible small surplus for sale to local markets.

Tree Garden with Crops and Animals

ROLE OF FOODER TREES

Fodder trees play a significant role in food security through their function as a source of food for animals and as support for water reserves during times of drought. Agroforestry systems consisting of a tree + animal combination are called silvopastoral systems.

Depending on the role of the tree / shrub component, the system and practices can be identified as:

Cut and Carry System: The species are grown in blocks or along boundaries. The foliage is then lopped periodically and fed to animals that are kept in pens.

Live Fence System: The fodder trees are left to grow and develop in to maturity and serve as fences for grazing units and other plots. They are also used as fodder trees within those units.

Browsing System: The animals are allowed to browse on the foliage; specifically the tender twigs, stems and leaves of the fodder trees. Sometimes fruits and pods of

standing shrubs are also consumed. The role of the tree is more direct in this system compared to the grazing system. E.g. Goats are browsers.

Grazing: The animals graze on grass or low vegetation. The role of the tree is more indirect; providing shade to animals, promoting grass growth and providing tree fodder and other products. E.g. Sheep's are grazers.

Supplementary Readings: To learn more about using trees as fodder you should review the following online article:

Andrews, G.J. (1998). The use of trees and shrubs for livestock production. ***Australian Biologist*** Volume 11 Number 2, June 1998. Retrieved from: http://www.grahamandrews.com/fodder_trees.htm

ECOLOGICAL IMPACTS OF AGROFORESTRY

Due to the complex nature of agroforestry systems, they often have considerable ecological impact on the environment. A significant impact is made on the physical and chemical aspects of the soil; augmenting additions, reducing losses and affecting soil biological processes.

An agroforestry system can have the following impacts on an ecosystem:

- Improve soil physical properties (water holding capacity, permeability, drainage).
- Enrich organic matter into the soil through carbon fixation in photosynthesis and its transfer via litter and root decay.
- Nitrogen fixation by some leguminous and a few non-leguminous trees.
- Protects the soil from erosion, especially on slopes.
- Uptake of nutrient from deeper soils and transferred on the top layer via fallen fruits and leaves.
- Breaks up of compact or indurate layers by roots.
- Provides shade for shade-tolerant species.
- Reduction of acidity, through addition of bases in tree litter.
- Improves bio-diversity within the system.

However in agroforestry systems;

- Organic matter and nutrients are lost during tree harvest.
- There is a competition for nutrient, water, moisture…etc between trees and crops.
- Production of substances which inhibit germination or growth of plants (allelopathy)
- Trees which produce Mor-type humus cause acidification of soils.

WINDBREAKS AND SHELTERBELTS

Windbreaks as the name suggests, helps to break the force of the wind and anything else that is being blown along with it, e.g. sand. Windbreaks are narrow rows of trees, shrubs or even grasses that are planted around farm fields, homes and other areas for the purpose of protecting against the wind and the blowing sand.

Shelterbelts are a form of a windbreak. They are trees and shrubs that are planted in many rows wide, each being fairly long and perpendicular to the prevailing wind.

The main function of windbreaks and shelterbelts is to:

- Reduce wind speed at the level of the ground surface.
- Reduce wind erosion and prevent decline in soil fertility.
- Reduce water loss from evapotranspiration.
- Reduce wind damage to crops, both directly and as frost scorching `and sand blast.
- Provide shelter for livestock.
- In some cases, provide timber, fuel wood, fodder and fruits.

When setting up a windbreak / shelterbelt at any given site, the protective and productive benefits of establishing it must be weighed against its costs. It should also be in harmony with the detailed plans of your crop / livestock production and the overall farm layout.

When incorporating a windbreak / shelterbelt into your farm design, keep in mind that;

- It involves direct costs for labour and planting material.
- It will take space from your land that could have been used for crop / livestock production.
- It will compete for water, light and nutrients.

If you effectively establish a windbreak or shelterbelt it should:

- Increase crop yields.
- Improve soil conditions.
- Support the production of other by-products from the trees.

AGROFORESTRY AND BIOMASS ENERGY

In the developing world, more than half of their energy requirements of those nations are derived from wood and charcoal. This feeds the energy hunger of over 1.5 billion people. The case is no different in most small states. Even today, there are millions of people in the rural population across the small states cutting fuel wood to prepare their meals, produce energy and heat their homes. This cutting of fuel wood is the second largest contributor for deforestation across the world (first is clearing land for agriculture).

Wood Burning Stove

Agroforestry systems can contribute with:

- Fuel wood for direct combustion.
- Pyrolytic conversion products such as charcoal, oil and gas.
- Ethanol from fermentation of high carbohydrate fruits or other tree parts.
- Methanol from destructive distillation or catalytic synthesis processes using woody feed stocks like corn, sugarcane…etc.

When designing your farm layout, keeping in mind an integrated agroforestry system can prove to be more beneficial both ecologically and economically. However, If a small scale farmer wishes to have his agroforestry system provide fuel wood as well, he must ensure that the choice of his plants for fuel wood production to:

- Be established easily,
- Require little care,
- Be multi-purpose plants, having more than one output,
- Be well adopted to different ecological conditions as well as environmental problems,
- Have special desirable characteristics, such as:
    - Nitrogen fixing ability,
    - Produce wood of high calorific value that burns without sparks or toxic smokes.

SILVICULTURE AND AGROFORESTRY

An agroforestry system works properly when harmony is maintained between all of its various components. Based on the actual type of agroforestry system, there are interactions between trees, crops and animals in various combinations. Each element needs to be examined on how it contributes economically to the farm as well as environmentally to the other components. This is most significant when it comes to the component tree, as they have a more dominating place both spatially and ecologically in the agroforestry system, making its management crucial.

A farmer wishing to incorporate trees into his crop / livestock production system must consider:

- The choice of tree species according to;
    - The environment of your farm (climate, soil, water…etc),
    - The role of the tree (windbreak, fodder, fence…etc), and
    - The management system.
- How he will arrange the trees and its spacing.
- How he will tend them, whether it is by individual trees (pruning) or by stands (thinning).
- How he will exploit them;
    - To cut for stems and branches,
    - Collect fruits,
    - Tapping for resin, and
    - Harvesting the bark…etc.

SUMMARY

Agroforestry is an important and necessary form of farming in the developing world. If practiced properly it will help preserve the environment, enrich the soil and support the growth of a variety of crops and farm animals.

LESSON 5.5 – AGRICULTURAL DIVERSIFICATION

OVERVIEW

There a variety of ways to increase production and the diversity of any agricultural system. Agricultural diversification is essential to agriculture in the developing world. Diversification requires that farms allocate their resources to other activities, the governments support the diversification process with policies and where necessary infrastructure. Diversification requires the use of new technologies and new or evolving best practices to maximize the potential of the land.

Often agricultural diversification is necessary becomes of national or global competition. Diversification can include:

1. The use of technologies or methods to increase productivity and product quality.
2. Using the land in a different way.
3. Embracing new agriculture related industries, such agri-tourism.

This lesson will explore some of these applications.

OBJECTIVES

Upon completion of this lesson you should be able to:

1. Describe the impact of apiculture on agricultural productivity.
2. Examine the potential of aquaculture as a new business.
3. Examine different forms of horticulture.
4. Explore agro-tourism as a potential business.

APICULTURE

Apiculture or beekeeping can be simply defined as the maintenance of honey bee colonies, commonly in hives, for commercial or agricultural purposes. Someone involved in culturing bees is referred to as an apiarist or a bee keeper.

Some of the uses of bees include:

- Pollination of crops destined for human consumption.
- Pollination of crops destined for livestock feed.
- Production of natural honey.
- Collecting beeswax.
- Collecting "***Propolis***" (used in health products).

Bees have been used for these purposes as far back as during the old Egyptian empire. Although most of the traditional ways of bee keeping are being lost to commercial farming, many households are reverting back to what is now called "*Urban Apiculture*". Also known as, natural beekeeping, urban beekeeping is an attempt to revert to a less industrialized way of obtaining honey by utilizing small-scale colonies that pollinate urban gardens.

Modern apiculture is something that is missing in a lot of the small states but has a lot of potential to it. Some of the key reasons that apiculture attracts a lot of small-scale farmers are:

- It does not require much technology and is often easy to set up.
- It does not take much farm space.
- It can be carried out at small scale (even in backyards).

However, they should be aware of:

- Any apiary laws concerning inspection, registration, and permits that are enforced in their states'.
- Any pesticide application laws and pesticide notification laws relative to bees that are placed by their state.

Supplementary Readings: To learn more about apiculture review the following web site. It is recommended you review the background information and read one of the region/country specific articles that describe the impact of beekeeping in the developing world.

Why Beekeeping is so cool
(http://forest.mtu.edu/pcforestry/resources/studentprojects/beebutts5.htm)

AQUACULTURE

It is the raising of fish and shellfish on a commercial basis for food purpose. This can include vertebrate animals such as marine and freshwater fish species; invertebrate animals such as clams, oysters, and shrimp; or certain species of edible aquatic plants such as seaweed. One have to make sure that there are no overfishing which may results in serious problems. Some commonly used fish species in aquaculture include mussels, oysters, shrimp, clams, carp, Tilapia, salmon...etc.

The two main fish farming systems are:

Fish farming: Is carried out in a controlled area which can be a pond or tank, for breeding and rearing until they reach the adult stage.

Fish ranching: The fish is kept in an enclosure for some years, and then released. Later the adults are harvested when they return to breed. This practice is good with salmon, as they always return to the exact place of their birth for breeding.

Some of the advantages of aquaculture include:

- A high harvest with no by-catch.
- High yield of fish in a small volume of water.
- The use of cross-breeding and genetic engineering in order to further increase yield.

Impact of Aquaculture on the Ecosystem

It produces large amount of waste which often leak into and contaminate the surrounding areas. The high quantity of water fertilizers used during the farming poses a particular problem, for they contain nutrients that cause eutrophication in nearby ecosystems. Since the farming system uses large amount of organisms, these species are more susceptible to diseases, and once infected, they sometimes transmit diseases to neighbourhood wild organisms.

Supplementary Readings: The World Bank reports that aquaculture as the fastest growing portion of the agriculture industry. You can download the report at:

Fish Farming Fastest Growing Field of Agriculture
(http://www.worldbank.org/html/cgiar/newsletter/sept99/fish.htm)

AGRO-TOURISM

Formerly agro-tourism was recognized as a part of ecotourism because both have similar principles to conduct nature attractions (Rilla, 1999). In this case, the history of ecotourism

can also be seen as history of agro-tourism. Agro-tourism started from rural tourism as well. In addition, both have been identified as the fastest tourism development model in the world, and get very serious responses. They have been widely developed in developing countries as a potential development models as natural resources and support of local society economically (OTA, 1992).

Agro-tourism is a mild form of sustainable tourist development and multi-activity in rural areas through which the visitors has the opportunity to get acquainted with agricultural areas, occupation, local production, traditional cuisine and the daily life of the people, as well as the cultural elements and the authentic feathers of the area. Examples of activities that the visitors and local people are allowed to do; tour the farm areas to view them growing, harvesting both crops and fruits, feed the animals, purchasing of goods farm products, processing local grown foods or any produce that the person would not encounter in their home country and the farmer can also offer a home stay opportunity. It also gives enjoyment for the site seeing and educates the visitors.

PHILOSOPHY

The philosophy of agro-tourism is inspired to improve the farmers' earnings and the quality of rural society lives which then expectedly represents opportunity and the quality of rural society lives which then expectedly represents opportunity to educate the societies on agriculture and ecosystems. Related and similar opinions described by Lobo, et al (1999), whereas the development of agro-tourisms will offer opportunities for local farmers to increase their earnings and improve their lives as well as sustain their operations. The opinions can be detailed as such:

- It educates people or society about agriculture and contribute to local economic;
- It decrease the flood of urbanization as people are able to get jobs and earnings from agro-tourism; and
- It promotes local and regional products in marketing effort and creates value added and direct-marketing and stimulates economic activity as well as give benefit to society where agro-tourism developed.

Rilla (1999) describes more clearly the reasons of developing agro-tourism as such:

- it educates for the purpose of keeping the relationship among local societies, interest sectors, and visitors;
- it improves the health and freshness of visitors;
- relaxation;
- adventure;
- natural food or food organic;
- unique experiences; and
- cheap tourism.

CONTRIBUTIONS

At the moment, the information of agro-tourism contributions in many destinations is still limited since agro-tourism is a newly tourism development model. Though, Afandhi (2005) asserts that the main purpose of agro-tourism development is an innovated tourism attraction. Besides, it also has a number of purposes such as media promotion of agriculture products, increasing foreign exchange and farmers' earnings.

In tourism product concept, agro-tourism as a tourism attraction may not be separately measured as the total of tourism product is actually the interaction and interconnection among transportation sectors, accommodations, and food and beverage sectors, etc.

FACTORS TO CONSIDER

The Indonesian Agriculture Department (2005), identifies there are some aspects relating to agro-tourism development which should be well concerned such as human resources, natural resources, promotion, infrastructure, and also organizations linkages.

Spillane (1994) mentions whereas areas developed area as agro-tourism should be able to provide five elements such as attraction, facilities, infrastructure, transportation, and hospitality. They relate and work systematically and holistically in an agro-tourism system.

A similar assumption, Postma (2006) states there are three stakeholders which should be harmonized to create a successful agro-tourism destination, such as; tourists as consumers, providers as business owners, and host communities.

Supplementary Readings: To learn more about how to establish an agro-tourism industry it is suggested you review the following articles:

Developing agro-tourism in the Caribbean (http://www.new-ag.info/00-4/develop/dev04.html)

Agrotourism and agricultural diversity (http://www2.gtz.de/dokumente/bib/04-5104a3.pdf)

IMPACT AND THINGS TO CONSIDER

Almost all models of tourism developments have dilemmas both positive and negative impacts. Developments of agro-tourism in many destinations in Indonesia have been positively seen as opportunities for the local communities to undergo diversification and investment, as well as increasing awareness and responsiveness on environmental conservation (Indonesian Agriculture Department, 2005).

Rural tourism or agro-tourism generates a significant contribution to the rural development process in rural areas and does indeed do so in many cases (Hall et al. 2003). The contributions could be in the forms of income increase and job opportunities, exchange between rural and urban areas, multiplier effects particularly for small-scale direct investments, strengthening local or regional structures by creating networks and the like, stimulating physical infrastructure developments, increasing the diversity of economic activities, raising awareness of the value of an area, such as its landscape, nature and culture, and the economic potencies, as well as improving the infrastructure which help to provide opportunities for other economic developments.

Things to Consider:

- Minimize impact.
- Build environmental and cultural awareness and respect.
- Provide positive experiences for both visitors and hosts.
- Provide direct financial benefits for conservation.
- Provide financial benefits and empowerment for local people.
- Raise sensitivity to host countries' political, environmental, and social climate.
- Support international human rights and labour agreements.

Advantages of Agro-tourism

- Its acts as a sustainable economical growth approach for the country.
- The farmers can get a choice to showcase their products.
- It improves the financial situation for the family, which can help them to have better life-style; such as better education, health care…etc.
- It creates more employment opportunities for the community.
- The benefit is for local people not for hotel or tour operators.

SUMMARY

A number of different agricultural systems were explored. The use of natural means, like beekeeping, was discussed as a way of increasing production. The idea of agro-tourism as an alternative approach to farming is a potential for some small state farms. You are

encouraged to explore the positives and negatives of each system we have discussed in this unit.

UNIT FIVE DISCUSSION

Your instructor should now organize a small group discussion. In preparation of the discussion think about the different types of agricultural systems and consider what your ideal farm would be. Discuss with your peers what you believe to be the ideal farm operation. Explore how to make your peers "ideal farm" more effective and efficient.

UNIT FIVE ASSIGNMENT

Instructions: In Unit 5 you explored a number of agricultural systems. Your task is to examine at least two different systems located in your community. You need to produce a report that describes the type of system that the farm characterizes. You need to describe:

1. The type of system.
2. The characteristics of the farm that makes it embrace a typical system.
3. The type of products that the two farms produce.
4. The basic layout and size of the farm.
5. The number of labourers that are required to support the farm.
6. The similarities and differences between the two systems.

Once you have completed your report submit it to your instructor for review, feedback and grading.

UNIT FIVE SUMMARY

In this unit you have learned the various types of agriculture production systems in use today and the factors that influence the choice and management of these systems, specifically relating back to the small states of the world. Namely, the crop and livestock was discussed in detail along with mixed and integrated methods of farming.

Livestock production systems were discussed in detail, highlighting on rotational grazing system being the most sustainable method of livestock production. Students have been introduced to different types of livestock production systems suitable for different types of livestock species.

Mixed farming along with a special emphasis on integrated farming and its contribution to be the most sustainable was highlighted upon in this unit. You discovered that agroforestry systems are very common in the small states. Exploring the history, productive and protective role of agroforestry has on the eco system were discussed.

Moreover, an introduction to several other production systems for agricultural diversification was included. The agriculture sector is a highly diversified sector with opportunities to embark in being several. It is essential that a student completing this course has a view on the various types of farming systems out there, if he is able to apply what is most suitable for his own state both in terms of being the most economically and ecologically beneficial.

COURSE SUMMARY

This course provided the foundation upon which to build an agricultural career. No matter what path you choose you now have an understanding of soil, climate and the factors that impact most agricultural environments. You explored a number of different agricultural systems and examined the concept of food safety.

You now need to complete a few final activities. You must submit your final assignment, complete the lessons learned discussion organized by your instructor and provide your instructor feedback via the course evaluation questionnaire. He or she will complete these activities on the last day of the course.

Good luck in your future academic studies and professional pursuits.