COURSE NAME	**:**	**AGRICULTURE AND THE ENVIRONMENT**
COURSE CODE	**:**	**BAGE 1106**
LEVEL OF COURSE	**:**	**YEAR I, SEMESTER II**
CREDIT UNITS	**:**	**3 CU**

BRIEF COURSE DESCRIPTION

The course introduces students to the effects of agriculture on the environment, the concept of sustainable agriculture and strategies that can be adopted to ensure sustainable agricultural production. The course also takes the learner through global and regional climate and weather systems; weather synoptic and forecasting and relate them to agricultural production.

COURSE OBJECTIVES

The course aims to provide students with;

- Knowledge of the effects of agricultural activities on the environment.
- An understanding of the concept of sustainable agriculture and strategies that can be used to attain it.
- An understanding of climatic and weather patterns and their impact on agricultural production.

LEARNING OUTCOMES

By the end of the course the student shall be able to;

- Explain the impact of agriculture on the environment
- Explain the concept of sustainable agriculture.
- Explain the strategies for increasing agricultural production while maintaining its sustainability.
- Measure and record the elements of weather.
- Interpret meteorological data.
- Plan farming activities according to seasonal variations in weather.
- Apply appropriate farming practices to maintain the energy budget.

DETAILED COURSE DESCRIPTION

Agriculture and the environment

Farming systems and the environment: modern and subsistence farming; the effects of agriculture on the environment (forest clearance; persistent residues, global warming)

(3hours)

Concept of sustainable agriculture (ecological, economic, social, human, and adaptive aspects); trends in tropical agriculture, implications for agricultural research and extension.

(6 hours)

Strategies for increasing agricultural production in Uganda; improved agricultural production and environmental concern;, problems associated with agriculture in Uganda

(3 hours)

The use of external inputs and their implications in low external input agriculture (LEIA) areas; sources of additional inputs for LEIA farmers; the move towards better agriculture; sustainability and farmers; managing decisions at farm level; the concerns in sub-saharan African agriculture; population growth, agricultural performance and stagnation; environmental degradation

(6 hours)

Water and air pollution, invasive exotic species and over harvesting contributions towards climatic change and biodiversity loss, consequences on genetic resources for agriculture.

(*2 hours*)

Climatology

Introduction to meteorology and climatology. **(4 hours)**

The atmosphere and earth energy budget. **(2 hours)**

Global and regional climate and weather systems. **(2 hours)**

Instrumentation and weather observation techniques. **(2 hours)**

Practicals (30 hours)

Selecting a site for a weather station and installing weather instruments.

Weather observation and recording.

Analyzing and presenting meteorological data in various ways (graphs, etc.)

Interpreting meteorological data.

Field visits to observe and report on the ecological, economic and social impacts of agriculture on the environment.

MODE OF DELIVERY

The course shall be conducted through lectures, tutorials and field visits.

MODE OF ASSESSMENT

The course will be assessed as follows;

Course works	40%
Final Examination	60%
Total	**100%**

LIST OF REFERENCES

White, R. E. (2006): Principles and Practices of Soil Science: The soil as a natural resource, 4th Edition. Blackwell Publishing

Chiras, D. D. and Reganold, P. J. (2009): Natural resource conservation: Management for a suitable future, 10th Edition, Benjamin Cummings ISBN-10: 0132251388, ISBN-13: 978-0132251389

Maltzaman, R. and Shirley, D. (2010): Green project management, CRC press, ISBN-10: 1439830010, ISBN-13: 978-1439830017

Kooten, V. G. (2002): Land resource economics and sustainable development: Economic policies and the common good, UBC press ISBN-10: 0774804459, ISBN-13: 978-0774804455

AGRICULTURE AND THE ENVIRONMENT

1. Introduction

Agriculture provides a wide variety of environmental amenities and disamenities.
On the positive side, farms provide open space and scenery. On the negative side, agriculture is a major contributor to numerous environmental problems. Nitrate and pesticide runoff impair drinking water quality and degrade habitat for aquatic organisms including fish, affecting commercial fisheries and recreational uses of estuaries, lakes, and streams. Bacterial contamination from animal wastes impairs drinking water quality and contaminates shellfish. Odor from concentrated livestock facilities worsens the quality of life in nearby residential areas. Erosion-induced sedimentation of waterways increases drinking water treatment costs and accelerates the need for dredging to maintain navigability. Pesticide exposure causes both acute and chronic illness among farmers and farm workers, while pesticide residues on foods may also threaten human health.

FARMING SYSTEM

What is a System?

A system is a group of interacting components, operating together for a common purpose, capable of reacting as a whole to external stimuli: it is unaffected directly by its own outputs and has a specified boundary based on the inclusion of all significant feedbacks. For example, the human body is a system-it has a boundary (e.g., the skin) enclosing a number of components (heart, lungs) that interact (the heart pumps blood to the lungs) for a common purpose (to maintain and operate the living body). Collection of unrelated items does not constitute a system. A bag of marbles is not a system: if a marble is added or subtracted, a bag of marbles remains and may be almost completely unaffected by the change. The marbles only behave as a whole if the whole bag is influenced, for example by dropping it, but if it bursts the constituent parts go their own ways. It is the properties of the system that chiefly matter and they may be summarized in the phrase 'behavior as a whole in response to stimuli to any part'.

Farming system can be defined as the distribution of plants and animals in space and time and combination of inputs believed to give maximum production in socio-economic, cultural and political context as dictated by the environment.
A farming system can be described as a system beginning with land clearing of pre-existing vegetation and subsequently involving land preparation, planting, fertilizer application, weeding, harvesting and finally storing of the harvested produce.
The method deployed in accomplishing the above operations in a given crop production system depends on the available technical know-how and the climatic factors prevalent in such areas.
Cropping system is the arrangement of crops in time and space as dictated by the prevailing ecological situation.

WEATHER, CLIMATE AND CROPS

Weather is the term used to describe the state of the atmosphere at a given point in time over a given area or location. Climate denotes a summary of weather over a long period of time (usually 30-35yrs) over a given area.
Information about weather is derived from weather observation. Whereas, climate represent a generalization of the characteristics of the atmosphere over a period of time.

Weather is about the specific atmospheric characteristic at a given time. Agriculture is perhaps the most weather sensitive of all human socio economic activities. In spite of recent technological and scientific development, weather remains a key variable in agricultural production.
Weather and climate affect agriculture and determine the adequacy of food supplies. Climate determines whether or not rain-fed agriculture would be feasible and the type of crops that can be successfully cultivated in a given area. All stages of agricultural production from land clearing and preparation through crop growth and management to harvesting, storage, transportation and marketing of agricultural products are subject to the influence of weather and climate.
Weather and climate act as both a resource and a constraint to Agric production. The resource value of weather has to be optimized while the hazards posed by weather have to be managed.

CLIMATE-CROP RELATION

An agricultural system is basically a man made ecosystem which depends on weather and climate to function just like the natural ecosystem. Crops like wild plant require moisture, heat, light as well as nutrient for their growth and development. All crops consequently have their climatic limit for economic production. This limit can be extended to some extent by plant breeding and selection, irrigation and other cultivation methods that modify the natural micro-climate under which the crop grows

SOLAR RADIATION AND CROPS

Solar radiation is of vital importance to crops. An agricultural system though a largely man-made ecosystem, is powered by solar radiation. Solar radiation determines the thermal characteristics of the environment namely air and soil temperature. Solar radiation is also linked to the amount of sunshine, day length or photo period in an area. Photosynthesis, the basic process of food manufacture in nature and photoperiodism, the flowering response of crop today length are both controlled by solar radiation. Assuming unlimited amount of Co2, H20 and soil nutrients, the maximum amount of plant tissues that can photosynthesize within a crop depends on the availability of solar radiation. The visible rays are the most effective in photosynthesis, although UV-rays can influence the germination and the energy and quality of seeds. The intensity of radiation is also important, not just the wavelength.

The optimum light values for normal crop growth and development are generally around 8-20 kilolux. Insufficient radiation is harmful to crops. The root system of the crop is underdeveloped, the foliage becomes yellowish and there is tendency for the stalk to grow at the expense of the foliage.

Some plants are light-loving (e.g pine, birch and larch trees) while some are shade-loving (e.g beech and spruce). This does not imply that shade loving plants do not require solar radiation.

Plants can be categorized into 3 groups based on their photoperiodism.

1. Long day plants: - This flower only under day length longer than 14 hours e.g Barley, Clover, Mustard, Date, Rye and Wheat.
2. Short day plants: - This flower with less than 10hours of day length e.g Beans, Millet, Cucumber, Cotton, Corn and Sweet potatoes.
3. Day-neutral plants: - This flower under any period of day length e.g Carrot, Tomatoes and Celery.

Temperature and crops

The temperature of air and soil affects all the growth processes of crops. All crops have minimal, optimal and maximal temperature limit for each of their stages of growth tropical crops such as Cocoa and Date requires high temperature throughout the year. Low temperature kill or damage crop, prolonged chilling of crops at temperature above freezing retards crop growth and may kill those crops adapted only to warm conditions. Although chilling may not directly kill plant cells, it reduces the flow of water from the roots and so interferes with plant transpiration and nourishment.

When temperatures are below freezing, the living matter of cells may freeze and cell dehydration may occur and this will eventually kill up the crops.

High temperature is generally not as destructive to crops as low temperature. Provided the moisture supply is adequate to prevent wilting and the crop is adapted to the climatic zone.

Excess heat may however destroy plant protoplasm; it has a desiccating effect on crops as a rapid rate of transpiration may lead to wilting.

Temperature determines the growing season in the temperature region while the growing season in the tropics is determined by rainfall conditions and evapotranspiration rate which are temperature dependent.

Soil temperature is widely recognized as an important control of crop growth and development. In many cases, it is of greater ecological significance to crop life than air temperature. Soil temperature affect the germination of seed and later influences the root development and the growth of the entire crop. Soil temperature apart from influencing seed germination also affects physical, chemical and biological processes in the soil that determines overall crop growth and development

Moisture and crops

Moisture plays a vital role in crop growth and development. It is the medium by which chemicals and nutrients are carried from the soil to various parts of crops. Moisture is also the main constituent of plant tissues and a reagent for photosynthesis. Soil moisture is the source of moisture of importance to the soil. The state of soil moisture is controlled by rainfall, evaporation rate and soil characteristics. The supply of soil moisture may vary from wilting point (when no water is available for crop use) to field capacity (when the soil is fully saturated with moisture but it is still when drained).

When soil moisture is excess, all the soil pores are completely filled with water and water logged condition prevails. In such a situation, free movement of air within the soil is impeded. At the other extreme is the condition of drought in which the amount of water required for evapotranspiration exceeds the amount available in the soil unless this water deficit is made good by rainfall or irrigation, crops will wilt and eventually die. Thus, extremely low or high temperature, too much or too little water is not good for agriculture.

Wind and crops

Wind, air in motion, affects agriculture in diverse ways. On the positive side, wind is an effective gent for dispersal of plants. The C02 intake of crops and their rate of transpiration tends to increase with increasing wind speed up to a certain level. On the negative side, wind may cause physical damage to crops. Wind also helps in the transport of pollens and seeds of undesirable

SHIFTING CULTIVATION

In the practice of shifting cultivation, the farm is not at a permanent location instead a piece of land is cleared, farmed for a few years and then abandoned in preference for a new site. While the new site is being farmed, natural vegetation (bush fallow) is allowed to grow on the old site.

Eventually after several years of bush fallow, the farmer returns to the original location in its original and more primitive form.

Shifting cultivation involves moving the home along with the farm but this form of shifting cultivation exist in only a few places in the world today. On the other hand, shifting cultivation in which the farm is moved while the home is stationary is a common practice today in most part of the tropic including tropical Africa.

The details of the practice of shifting cultivation vary from place to place, the farmer first selects the site which has been under bush fallow for several years the vegetation is then cleared using hand tools. This clearing is done during the dry months preceding the planting season. The plant debris is allowed to dry foe a few weeks and then set on fire. Any remaining un burnt material is

either left on the field or gathered together again for burning. Crops are then grown on the field for 2 or 3 years starting with crop with high fertility requirement and ending with crop whose fertility requirement is low.
shifting cultivation as practiced in the tropics is invariably linked with low level of input with low level of input of technology and management cost of the operations are carried out with simple hand tools and labour requirements are high. Unfortunately, the very nature of shifting cultivation tends to discourage a high level of input because the farm stays in one location only a short time; there is no incentive to invest in permanent structure such as storage facilities and irrigation facilities. Even certain pest control or soil conservation measures which may have long term benefit will only be carried out reluctantly on a field that is soon to be abandoned.
Consequently shifting cultivation continues to be characterized by low level of technology and correspondingly low yield.
To the shifting cultivator, bush burning constitute a technologically easy answer to the problem of clearing plant debris from the field prior to cropping. However, the practice of bush burning has certain serious adverse consequences; most of the nutrients e.g nitrogen and sulphur present in the debris are converted to oxide during burning and lost to the atmosphere. In addition burning may destroy beneficial microorganism and have adverse effect on soil structure.

On the other hand, burning may also be of benefit.

- It is an easy and inexpensive way of getting rid of excessive plant debris.
- It may serve to kill pests, pathogens and weed seeds which may be present in the soil.
- The alkaline ash left on the soil after burning serves as a good soil amendment in most location of the humid tropics which because of high rainfall and leaching have acid soils.
- Apart from its effect on soil acidity, ash also serves as an immediate source of certain mineral nutrients such as k and Ca for the planted crops. If not for the burning, such nutrient will have remained tied up in un decomposed vegetation for several months.

Fallowing system economically termed ‘low input agricultural production system entails allowing a crop land to return to its original vegetation prior to clearing and farming. By so doing, restores lost nutrients. It is a period during which nutrient removed in crops and for leaching into the sub soil during cropping phase are accumulative in biomass.
Pest and disease infestation are as well reduced. Rate of mineralization decline due to change in microclimate and soil. The magnitude of nutrient loss by run-off and leaching is considerably negligible.
However, the ecological sustainability and fertility restoration potential of the fallow depends on its age and prevalent edaphic factors peculiar to their area. In view of the fact that the land is most fertile at the end of the bush fallow period, most shifting cultivators plant their most nutrient demanding crops such as yam in the 1st season after bush burning while crops such as cassava which can tolerate less fertility are planted in the 2nd or 3rd season just before the land is reverted to bush fallowing.

The real trouble about shifting cultivation nowadays is the lack of land. The land has-been used for industrialization purposes. When the pressure becomes too great, shifting cultivation is abandoned completely in favour of continuous cropping on the same piece of land.

CONTINUOUS CROPPING

In contrast to shifting cultivation, continuous cropping implies the cultivation of the same piece of land year in year out. Fallowing may occur but it never occurs for more than a season or two. The absence of fallow period means that other soil management procedure must be used to maintain high soil fertility. Partly for this reason, continuous cropping is usually associated with a higher level of technology and management than shifting cultivation

Since the land will be used for cropping on a long term basis, it is economical to carry out various operations of long term values on the land after clearing. Such operations include

- Construction of contour bunds for erosion control
- grading of land for irrigation purposes e.t.c

Each of this is a valuable long term investment under continuous cropping. With the absence of bush fallowing, it might be wondered how soil fertility can be maintained under continuous cropping. This is done in at least in 3 ways.

1. Continuous cropping does not rely solely on the native fertility of the soil. Fertilizers and other soil amendments are applied to the soil at various times in order to boost fertility. These fertilizers may range from natural organic product such as manure and compost to artificially produced chemical fertilizer
2. By judicious selection of the crops and crop combinations to be grown. In this respect, crop rotation and carefully planned inter-crop combinations are indispensable. This practice ensures that nutrient removal from the soil is relatively uniform and that soil nitrogen is occasionally replenished by the cultivation of leguminous crops.
3. By introducing short term fallow period into the cropping cycle. After every 3 or 4 years of continuous cropping, the land is allowed to lie fallow. This fallow period does not last for several years as with bush fallow. It usually last for a few months. A leguminous cover crop may be planted on the land and allowed to grow on it for the duration of the fallow

One major objective of fallow is the improvement of soil fertility through the fixation of nitrogen by legumes and through increasing the soil organic matter content when the fallow crop or vegetation is ploughed under.

Soil structure is also improved and the cover crop protects the soil from erosion. The practice of continuous cropping is therefore based on the judicious management and conservation without this, soil fertility becomes depleted and crop yields are adversely affected.

CROP ROTATION AND MONOCULTURE

In the practice of continuous cropping, it is theoretically possible to grow the same crop on the same land, season after season. Such a practice is referred to as monoculture.

Alternatively, the farmer may plan a definite sequence for growing his crops on the land.

This practice of growing different crops one at a time in a definite sequence on the same piece of land is referred to as Crop Rotation.

The farmer must decide what crops to add in the rotation, in what sequence the crops should occur and for how many years or season each cycle of the rotation must run. Several factors have to be considered in deciding the sequence of crops. Usually the target crop comes immediately after the legume or the fallow period at this time, the fertility of the soil is at its peak and the best realizable yield of the target crop can be expected. Crops which are known to have a high demand for nutrients are also timed for the 1st or 2nd season after the fallow

Another principle is those crops which are deep feeders should alternate with shallow feeders. In this way, nutrient removal occurs uniformly from the various soil layers rather than occurring in only one layer. Furthermore, the crop sequence is influenced by disease and pests

(including weeds). Crops that are botanically similar (e.g tomatoes and potatoes) are likely to be attacked by the same diseases and pests, should not follow each other in the rotation. Even dissimilar crops which are known to suffer from the same diseases or pests should not follow each other in the rotation unless those particular diseases or pests are absent from the

e.g yam should not follow cowpea in rotation if the root knot nematode is prevalent e.g as the nematode left over from the cowpea crop will severely reduce yam yield. However if the nematode does not exist in the area, yam could conveniently follow cowpea.

HAVE A FOCUS ON THIS THREE YEAR PROGRAM

	Year 1	**year 2**	**Year 3**
Plot A	Cotton	Maize	Beans
Plot B	Maize	Beans	Cotton
Plot C	Beans	Cotton	Maize

Crop Rotation is an effective means for controlling diseases and pests. In monoculture for example, diseases and pest of a particular crop always have their host around and therefore have the opportunity to build up over the years.

In crop rotation, the pathogens and pest of a particular crop are more likely to die off when their host crop is followed by a completely different non-host crop.

Crop rotation is a device for maintaining high soil productivity over several years of continuous cropping. The inclusion of legumes and fallow in the cycle and the use of crops that feeds at different levels are devices to sustain soil productivity. Monoculture does not provide this device. The type of crop rotation where the field is divided to several plots offers the farmer some insurance against crop failure and enable him to spread out his labour needs.

INTERCROPPING AND SOLE CROPPING.

The practice of growing one crop variety alone in pure stand on a field is referred to as sole cropping. In this practice, only one crop variety occupies the land at a time. The alternative practice of growing two or more crops simultaneously on the same field is called Inter-Cropping.

The various crops in the inter-crop do not necessarily have to be sawn or harvested at the same time; the main requirement is that they are on the field at the same time for a significant part of their growing period.

There are various kinds of intercropping system based on the exact arrangement of crops on the field, when the various crops are grown in separate rows. It is called ***Row Intercropping*** when the various crops are grown intermingled, more or less at random with each other; it is called ***Mixed Inter-Cropping/Mixed Cropping***

Mixed cropping stabilize the environment and protect it from hazard like high rainfall intensity which result in the erosion of land, loss of nutrient and high temperature which leads to high rate of mineralization.

The planting of several crops which differ in height, root development and light requirement allows for more efficient use of solar radiation, soil nutrient and water.

MIXED FARMING

Mixed farming is a system of farming in which the cultivation of crops is kept side by side with the rearing of farm animal. Most farmers in the sub - Sahara Africa are practicing mixed farming to some extent. In some cases this practice may not be deliberate on their part but rather accidental in that keeping of a few chickens, goat and sheep are taken as a way of life. Hence, we can’t compare the level of mixed farming practice by most sub-Sahara African farmers to that practice in the temperate region or in other part of Africa such as Kenya and Uganda. Mixed farming requires more technical skills in the various aspects of crop and animal production. It also requires much land and large capital outlay.

Advantages of Mixed Farming

1. Provision of variation in farm work.

2. Better use of farm labour and equipment throughout the year
3. The spread of farm risk.
4. The waste and by-product from crops can be used directly in feeding the animals while animal waste products can be used in manuring the soil.

PASTORALISM

Cattle, sheep and goat keepers in West and East Africa are nomads or wandering herdsmen. They wander from place to place with their cattle mainly because of their seasonal grazing requirement or need for pasture. They move from area where pasture is scarce to those where pasture and water supply are plenty. Other causes of this movement include: - the need to get away from areas with animal diseases such as sleeping sickness and to escape from tax collectors.

Generally these wandering herdsmen destroy the grassland area because of keeping too many cattle (over-stocking).

Normadism is not the best method of keeping animals because animals rarely make steady gain in weight owing to seasonal variation in feeding and the need to walk long distances in search of grazing grounds.
Animals are also more open to attack by predators under this system. This system relieves the herdsman from the burden of establishing a pasture for his cattle.

Normadism as was practiced by Fulani of West Africa and the Masai of East Africa is dying out and being replaced by semi-permanent settlement husbandry.

RANCHING

This is the opposite of pastoralism. Ranching involves the conferment of animals particularly beef or dairy (milk-producing) cattle to an area of land where they are controlled and fed for market purposes.

This method of raising cattle was first practiced in Spain and was later introduced to
South America which is now world-famous. Ranching is not widely practiced in West Africa except on a few government farms which can provide the amount of care and investment it entails.

Usually, ranching call for pasture development i.e the deliberate planting of grass for the use of the animals. It therefore entails the use of large expanses of land. It also entails making drinking water available constantly all year round.

Ranched animals do not usually do very well in areas where there are marked weather or seasonal differences.

Factors limiting ranching in the tropics include:-

1. Lack of technical and managerial expert in ranch management.
2. Poor communication and marketing facilities.
3. Marked seasonal variation in weather condition.
4. Absence of mechanization in the farming system which does not allow the establishment of large acreages
5. Shortage of constant sources of drinking water in area where cattle can perform well (as in Northern Nigeria, Northern Ghana and Ivory Coast).
6. Low availability of crop by- product necessary for the efficient grazing of cattle.

TERRACE FARMING

This system of cultivation is typically of mountainous and hilly areas consists of making a series of steps cut into a slope where the forward edges of the slope are never cultivated and are constructed as nearly vertical as possible. The land is intensively cultivated and the soil fertility is maintained by the use of organic waste of all types as a means of building up the soil fertility and reducing or eliminating the land extensive system of bush fallowing

UPLAND FARMING

The most important problem of the upland cereal-based system is very rapid decline in soil fertility, erosion and other agro-ecological problems.

Improved upland farming systems that enable sustained production should be based on those cultural practices that alleviate resource production constraint due to bio-physical and socioeconomic factors. The major relevant cultural practices that can be considered include

1. Planted fallow
2. Green manure and mulches.
3. Balanced fertilization and manuring
4. Agroforestry and mixed cropping
5. Soil conservation

The above (5) intervention cannot be seen independently, there is always a need for a combination of sub-systems and cultural practice.

Advantages of planted fallow (live mulch).

- Provision of surface cover to the soil thus reducing evaporation, improving soil moisture holding capacity, moderating daily soil temperature fluctuation and increasing microbial biomass activity.
- Reducing rain drop impact of the soil thereby reducing soil surface run off and erosion.
- Serving as biological agent of weed control.
- Addition of above and below ground organic input to the system.

ALLEY CROPPING

In this system, food crops such as maize and cowpea are grown in alleys along the contours formed by hedge rows planted 3 - 4 m apart of fast growing leguminous shrubs and trees. E.g Leucaena. The hedge rows are periodically pruned during the cropping season to prevent shading. Prunings are used as mulch and green manure for the associated food crop.

The woody portion of pruned branches can also be used as fuel woods or sticks for yam. Leaves may also be used as fodder for livestock.
When trees and shrubs with their deep root system are planted along contours on sloppy land they are not only able to recycle soil nutrients but also minimize water runoff and soil erosion.

A beneficial effect of alley cropping on acidic soils is the use of pruning as leguminous green manure can reduce soluble and exchangeable aluminium in the soil by forming less soluble organo-aluminium complexes.

Maintains soil moisture and provide an environment that favour micro and macro organisms and soil flora and fauna and suppress weeds.

DRY SEASON FARMING

The **dry season** is a yearly period of low rainfall, especially in the tropics. The weather in the tropics is dominated by the tropical rain belt, which moves from the northern to the southern tropics and back over the course of the year. The tropical rain belt lies in the southern hemisphere roughly from October to March; during that time the northern tropics have a dry season with sparser precipitation, and days are typically sunny throughout. From April to September, the rain belt lies in the northern hemisphere, and the southern tropics have their dry season.

The dry season has low humidity, and some watering holes and rivers dry up. This lack of water (and hence of food) may force many grazing animals to migrate to more fertile spots. Examples of such animals are zebras, elephants, and wildebeest. Because of the lack of water in the plants, bushfires are common.[3]

Farmers take advantage of the cool harmattan to grow irrigated wheat, beans, carrot, irish potato, tomatoes and other vegetables in monoculture between November and March.

IRRIGATION

Irrigation can be defined as the application of water to soil to provide moisture for crop growth. Irrigation could be supplementary when water is applied to supplement deficient rainfall or it may be total when the entire crop water requirement is supplied by irrigation because of total lack of rainfall.

Importance of irrigation

Crop growth is impossible without moisture, and irrigation is necessary to ensure crop growth and development whenever and wherever there is not enough water for crop growth.

The following objectives can be achieved by irrigation:

1. All year round agricultural production is possible by irrigation where temperature poses no constraint.
2. Crop yield can be improved by application of irrigation which ensures that crop water requirement is always satisfied.
3. Application of irrigation consequently helps to avert crop losses in areas subject to incidence of draught.
4. Irrigation can facilitate the cultivation of crops which could not have been possible to cultivate under rain-fed agriculture.

Steps in planning an irrigation projects

1. Land capability assessment
2. Estimation of irrigation water requirement.
3. Determination of the quantity and quality of water available for irrigation use.
4. Design of water supply scheme for the project and the water distribution works.
5. Economic analysis of the project to determine its viability.
6. Establishment of appropriate organization to operate and manage the project.
7. An EIA of the project.

The aim of land capability assessment is to determine the ability of the land to produce crops which provides adequate returns of investment in the proposed irrigation project.
It includes analysis of the soil, topography and climate and hydrology of the project site. The soil must have high water holding capacity, reasonably permeable, well drained and deep enough to allow root development.

Sources of water for irrigation

There are 2 basic types

1. Surface water – rivers, streams
2. Ground water – well, borehole

Irrigation water may be directly abstracted from rivers and streams where possible. But considering the fact that irrigation is most needed when the weather is dry and stream flows are at or near their minimum, it is in most cases necessary to build reservoirs by damming the river.
Groundwater from wells and boreholes may sometimes be used for irrigation depending on local geology. Again, groundwater tends to be at minimum during dry weather when irrigation is most needed. Also, if the rate of recharge of ground water is low, mining of groundwater may occur.

Groundwater needs to be pumped out to the farm. The water may not also be of the right quality for irrigation especially if it is saline.

Methods of irrigation

i. Sub-surface irrigation
ii. Surface irrigation
iii. Overhead irrigation

Sub-surface irrigation

Water is applied to crops at their roots. Different techniques are employed to deliver the water to the base of the crops. These include the use of porous or open-jointed pipes buried underground allowing water to seep into the soil.

Advantages

1 Minimum loss of water by evaporation
2 Minimum waste of surface water
3 Minimal field preparation and labour cost.

Surface irrigation

Two main techniques of delivering irrigation water to crops under surface irrigation are
By flooding the field known as flooding irrigation. The Disadvantages of this system are

i. Wasteful of water
ii. Require fairly smooth ground to achieve even irrigation.
iii. Controlled flooding which is achieved by the use of ditches, borders, checks or basins

The flow is turned into the borders, checks or basin to stand until it infiltrates.
Limitation of Surface Irrigation

i. It requires land with gentle or regular slope which may not be available.
ii. Soil erosion may constitute a problem.
iii. Inefficient use of water by crops.
iv. The various water channels reduce the area available for planting some crops apart from the fact that weeds may grow on them.

Over head irrigation

Over head irrigation is the irrigation water applied above the crops mainly by the use of sprinklers. Over head irrigation is therefore synonymous with sprinkler irrigation.
Water is pumped under pressure and carried through a network of pipes from where the water is sprinkled over the crops.

Factors favouring overhead irrigation are:

i. Excessive soil porosity
ii. Land gradient unsuitable for surface irrigation
iii. The need for high application efficiency for irrigation water.

iv. It can be used in hilly or mountainous terrain.
v. It can flexible such that the application rate can be selected to suit the soil type and infiltration rate.
vi. Little water is wasted or lost as over head irrigation requires only 1/3rd of the quantity of water required by surface method for the same crop treatment.
vii. It can be used to distribute fertilizer or organic manure to crops.

Disadvantages

i. Large drops of water with high terminal velocity may damage the soil surface.

Environmental and Health Problems Associated with Irrigation farming.

1. Irrigation may increase the incidence of diseases such as malaria especially in semi-arid environment.
2. The incidence of some pests, diseases and weeds may increase with the introduction of irrigation.
3. There are also socio-economic problems of resettlement of people displaced by irrigation projects as well as problems of evaporation from reservoir.
4. Soil erosion
5. Soil salinity
6. Water logging
7. Leaching of nutrient and fertilizers
8. Lack of oxygen supply to the roots of crop
9. Pollution of ground water.

CONCEPT OF SUSTAINABLE AGRICULTURE

Sustainable agriculture is agricultural production that is economically viable and does not degrade the environment over the long run. (OECD).

Sustainable Agriculture refers to a production process that utilizes resources in a manner that reduces negative impact on the surroundings and ensures that such resources are available for use by future generations

Rationale

Agriculture Education in Papua New Guinea should teach a farming system, which promotes and plans for generations ahead rather than for the next day or year. The efficiency of such an Agricultural system must be measured by its use of energy, raw materials, it minimization of waste, and its ability to adapt to change. Papua New Guinea needs farming practices that can produce, using methods that above all ensure long-term fertility of the land, crops and animals of the highest quality in nutritional value.

This module should provide student teachers with an insight and understanding of the ways subsistence farmers can best look after the land and optimize rather than maximize food production. By doing this they should encourage agricultural systems in their teaching that promote sustainable agricultural systems

COURSE OBJECTIVES:

By the end of this module, students will be able to:

1. identify the different sustainable agricultural activities practiced in the tropics particularly in the sub-Sahara -Africa

2. identify and describe the different ways and strategies for improving subsistence

taking place in Papua New Guinea. Particular attention should be placed on agricultural practices in students' own communities. As much as possible, include the local community and invite someone in the community who is engaged in major agricultural activities to assist the course.

Definition and aims of sustainable agriculture

As a group, we already have some idea of what the concept sustainable agriculture is! It is possible that your understanding is derived from your aim within agriculture. Let us see if we can develop our own definition.

THE IMPACT OF AGRICULTURAL PRACTICES ON THE ENVIRONMENT

Farming can have an enormous impact on the environment and the availability of resources, and if not monitored and controlled the impact is not often good. If we want to enjoy the environment and have access to natural resources in the future, we will need to think of ways to ensure our activities have minimal impact. But first, what are these potential impacts?

Environmental impacts of agriculture

a) Land clearing for cultivation purposes leading to
   - Loss of biodiversity
   - Loss of natural habitats and potential human/wildlife conflicts
   - Disruption of ecosystem balances and their functions

b) Changes in regions reflectance and water balances
   - Loss of forest cover leads to heat build ups
   - Lack of vegetation, especially trees, means that less water is held underground

c) Tillage of cropland
   - -Loosening of soil exposes it to erosion agents (water, wind)
   - -Loss of nutrients such as nitrogen from evaporative processes
   - -Creation of hard pan in ploughing

d) Input demands for large scale/mechanized/entrepreneurial farming
   - -Pressure on natural resources such water (depletion of ground and surface reservoirs) and fossil fuels (petrol for machines)
   - -High input of inorganic fertilizers and application of chemicals such as pesticides and herbicides among others

e) Negative impacts on soils including:
   - -Loss of nutrients/fertility especially from reducing soil organic matter additions
   - -Changes in soil structure and soil chemistry
   - -Salination and alkalization from irrigation and inorganic fertilizers respectively

f) Eutrophication of water bodies from:
   - -Inorganic fertilizer run-offs
   - -Excess manure run-offs

g) .Negative effect of applied chemicals including:

ENVIRONEMTNTAL POLLUTIION

5.1 Introduction

The major environmental problem today is global warming or climatic change due to accumulation of several gases like carbon dioxide, and nitrous oxide, Chlorofluorocarbons, along with water vapour in the atmosphere causing greenhouse effect and depletion of ozone layer in stratosphere affecting the several aspects of humanity on planet earth. 5.2 Greenhouse effect

The earth receives energy from the sun, which warms the earth's surface, as this energy passes through the atmosphere, a certain percentage (about 30) gets scattered. Some part of this energy is reflected back into the atmosphere from the land and ocean surface. The rest (70%) actually remains behind to heat the earth. In order to establish a balance, therefore, the earth must radiate some energy back into the atmosphere. As the earth is much cooler than the sun, it does not emit energy as visible light. It emits thorough infrared or thermal radiation. However, certain gases in the atmosphere form a sort of blanket around the earth and absorb some of this energy emitted back into the atmosphere. Without this blanket effect, the earth would be around 30oC colder than it normally is. These gases like carbon dioxide, methane, and nitrous oxide, along with water vapor, comprise less than one per cent of the atmosphere. They are called "greenhouse gases", as the working principle is same as that which accurs in a greenhouse. Just as the glass of the greenhouse prevents the radiation of excess energy, this "gas blanket" absorbs some of the energy emitted by the earth and keeps temperature levels intact. This effect was first recognized by a French Scientist, Jean Baptiste Fourier, who pointed out the similarity in what happens in the atmosphere and in a greenhouse. Hence the term the "greenhouse" effect. The greenhouse effect is essentially a positive, life-giving process that maintains the earth's temperature at levels tolerable by its life forms. This gas blanket has been in place ever since the creation of the earth. Since the industrial revolution, human activities have been releasing more and more of these greenhouse gases into the atmosphere. This leads to the blanket becoming thicker and upsets the

"natural greenhouse effect". Activities that generate greenhouse gases are called 'source' and those that remove them are known as 'sinks'. A balance between 'sources' and 'sinks' maintains the levels of these. Humankind upsets this balance when new sources that interfere with the natural sinks are introduced. Carbon dioxide is released when we burn such fuels as coal, oil, and natural gas. In addition, when we destroy forests, the carbon stored in the tree escapes as carbon dioxide into the atmosphere. Increasing agriculture activities, changes in land-use patterns, and other sources lead to rising levels of carbon dioxide, methane and nitrous oxide . Industrial processes also release artificial and new greenhouse gases like CFCs (chloroflurocarbons).The resulting enhanced greenhouse effect is more commonly referred to as global warming or climate change

Potential Effects of Greenhouse effect or Global Warming

Some potential effects on agriculture and others associated with climate change are listed in the following (From U.S. Climate Action report). Therefore, climate change is a threat to humanity!

1. **Biomass production-** decrease in productivity of crops and grazing lands directly through changes in temperature and precipitation, frequency of droughts/floods and indirectly through changes in soil quality, pests, and diseases, shifts in agro ecological zones. Alteration in the species diversity and die-back of tropical forests and grasslands due to change in the pattern of rainfall etc.

2. **Decline in soil quality-** due to decline in soil structure, increased soil crusting and compaction, accelerated soil erosion, leaching & acidification, salinization, and organic carbon decline and nutrient depletion.

3. **Water resources & quality**- warmer climate will change rainfall & snowfall patterns leads to increased droughts & floods, melting of glaciers and polar ice sheets resulting in accelerated sea-

level rise affecting freshwater resources, coastal agriculture, fisheries & aquaculture, forests, natural ecological systems, human settlements, loss of land due to inundation & erosion, salt-water intrusion, increased sediment load, eutrophication etc.

4. **Air quality- increase dust concentrations,** greenhouse gases, industrial pollution etc.

5. **General** – warmer and wetter climate will favour the growth and spread of vector borne diseases like malaria & dengue affecting human health increased frequency of storm and other extreme event cause decrease in hydro-power generation, loss of infrastructure, tourism, disruption in transport routes, human settlements, industries, building

Lecture No.6

FERTILIZER AS A SOURCE OF POLLUTION AND CONTROL MEASURES

6.1 Introduction

Throughout human history, increasing population growth and changing dietary patterns have resulted in more and more land moving from forest or grasslands into agricultural production. Over the past few decades, the greatly increased use of chemical fertilizers plus changes in irrigation practices and improved crop varieties, have enabled land already under cultivation to be farmed much more intensively. Synthetic fertilizers have played a dominant role in agricultural intensification in industrialized and developing countries like India for decades. Both fertilizers and pesticides have become widely distributed in the environment and most of the concern today related to the health consequences of agriculture now centers on these two (as a source of environmental pollution).

6.2. Fertilizers as a source of pollution India has come a long way, since independence, in respect of production and consumption of fertilizers. In the year 1951-52 the country produced a mere 27,000 tonnes of fertilizers, which now rose to a level of 13,4 million tone (2000-01). Likewise the per ha consumption of fertilizers, which was as low as 1,5 kg/ha during 1951-52 has now increased to 94 kg/ha in 2000-01. the increased use of fertilizers beginning with the year 1966-67 was due to intensification of agriculture, particularly in irrigated areas. Several problems linking excessive use of fertilizer with environment have been identified. The increase of nitrates in the drinking water, a development about which general public is greatly concerned, and believed to be due to excessive use of N fertilizers and animal manures, is regarded as most important fertilizer related pollution issue. Nutrient enrichment, eutrophication and deterioration of surface water quality due to transpiration of nutrients applied through fertilizers via leaching and /or runoff and sediment erosion is another problem. The contamination of soils by heavy metals through fertilizers such as cadmium from phosphatic fertilizers, is also receiving increasing attention of environmentalists.

Lecture No.7

PESTICIDES AS A SOURCE OF POLLUTION AND CONTROL MEASURES

7.1. Introduction

In 1995, world pesticide consumption reached 2.6 million metric tons of "active ingredients", the biologically active chemicals at the heart of commercial pesticide formulations, with a market value of $38 billion (US dollars). Roughly 85% of this consumption was used in agriculture. India is currently the largest manufacturer of pesticides and the second largest producer of agrochemicals in Asia. The use of pesticides (insecticides, fungicides, herbicides) in India is increasing at the rate of 2 to 5% per annum. The pesticide demand is close to 90,000 MT per annum. The per capita consumption is 600 gm per hectare as compared to 10-12 kg/ha in developed economies. Yet, the problem of pesticide use has assumed serious proportions in India because of the non-uniform use of the plant protection chemicals in different regions, cropping systems and crop and indiscriminate use and misuse and abuse of these chemicals. Obviously, there is a mismatch between pesticide use and cropped area. Cotton, rice, fruits and vegetables, which account for less than 35 per cent of the cropped area, consume 84 per cent of the pesticides. On the other extreme, wheat, coarse cereals, millets and pulses contributing to 54 per cent of the cropped area consume only 3per cent of the pesticides used. Insecticide (73%) dominates the market, followed by herbicide (14%) and fungicide (11%). Although it is expected that herbicide will grow faster in the future, insecticides will continue to dominate the market. Cotton, rice and wheat growers account for almost 70% of pesticide consumption, and the states consuming more in the decreasing order are Andhra Pradesh, Punjab, Karnataka and Gujarat.

Pesticides were considered as panacea to contain pestilence on crops. This attitude led to a phenomenal growth of pesticide use in agriculture. The pesticides upset natural balance and ecosystem and also affect the field workers. If the residues go undetected, the consumer may also be affected. Pesticides residues in soil, water, environment, foods etc, are of serious environmental concern.

7.2. Insecticides

In almost all the soils that have been surveyed for insecticide residues in India, the most common chemical, and the one that is found in the largest amounts is DDT, followed by HCH and dialdrin. In a study in Punjab, out of 106 soil samples, 91 were found contaminated with insecticide residues. The highest level of 0.08 mg/g DDT-R was found in cotton growing areas, which is four times its permitted level of 0.02 mg/g. The presence of cholinesterase inhibitors in 19% soil samples indicated contamination with organophosphates and carbamate insecticides. Data collected by Acharya N.G. Ranga Agricultural University Scientists over years indicated presence of high and toxic amounts of pesticide residues in food grains fruits, vegetables, milk and milk products, eggs, soils, water etc. (Table 7.1). Even human breast milk is reported to contain pesticide residues.

Pesticide residues in food items, which are on the increase, have become a matter of threat to man. Even small quantities of these residues ingested daily along with food can build-up high levels in the body fat. The long-term effects of these residues in the human body include carcinogenicity, high infant mortality and varied metabolic and genetic disorders. The major source of dietary intake of DDT residues is through milk and milk products followed by oils and fats, in both vegetarian and non-vegetarian diet. The dietary intake of HCH is also mainly through milk and milk products followed by meat and eggs for the nonvegetarian diet, whereas it is through cereals followed by milk and milk products in vegetarian diet

7.3 Fungicides The residues of fungicides based on the inorganic compounds of sulphur copper, and mercury accumulate in soil because the heavy metals contained in them are irreversibly adsorbed on soil colloids. Under certain conditions, toxicity from the accumulation of copper and sulphur containing fungicides may render the soil useless for growing crops and cause significant yield depressions. Depressing effect of fungicides on the nodule formation and yields of groundnut were also reported.

De easing order

7.4 Herbicides In intensive and diversified cropping rotation systems, the herbicide applied to one crop may persist in the soil at concentrations high enough to damage the subsequent sensitive crops. Under Indian conditions, when a herbicide dose of 0.5 to 2.0 kg/ha is applied, it results in a buildup of residues in the range of 0.25 to 1.0 mg/g/, which is safely below the potential residual effect. But the same herbicide when applied repeatedly it starts building undesirable residues in the soil. For example, fluchloralin, metabenzthiazuron and atrazine were detected in amounts that could adversely affect not only other crop plants but also several processes in soil leasing to inefficient nutrient management and in turn, reduced crop yields. The herbicide, 2, 4-D, restricts the growth of azotobacter, Lindane applied at normal rates considerably reduces the number and weight of nodules in groundnut.

7.5 Control measures to reduce pesticide pollution • Application of easily decomposable organic matter • Use of large quantities of organic manures • Raising high N cover crops • Growing of crop plants that a tendency to accumulate the pesticide • Follow soil management practices leading to increased leaching of pesticides • Adoption of biological control methods • Use of biochemical pesticides • Need based plant protection

7.6 Biopesticides and bioherbicides

7.6.1 Introduction Biological control is defined as applied natural control wherein man intervenes to improve the efficiency of natural enemies including parasites, predators, and pathogens of pest species by introductions, conservation, or augmentation to maintain pest populations below

economically injurious levels. Biological control by means of entomopathogens and other microbial pest control agents involves the application of
microorganisms on to the crop for ingestion by insect's pests or directly on the noxious insects, fungus or weed with the objective of destroying the, these bio control agents include bacteria, protozoa, fungi, viruses and nematodes.

7.6.2 Biopesticdes Biopesticides also known as biological pesticides are certain types of pesticides dervived from such materials as animals, bacteria, and certain minerals. These are an important group of pesticides that can reduce pesticide risks.

7.6.2.1 Characteristics of Bio-pesticides • Have a narrow target range and a very specific mode of action • Are slow acting • Have relatively critical application times • Suppress, rather than eliminate, a pest population • Have limited field persistence and short shelf life • Are safer to humans and the environment than conventional pesticides • Present no residue problems

7.6.2.2 **Advantages of using bio-pesticides**

i. Biopesticides are inherently less harmful than conventional pesticides
ii. Biopesticides are designed to affect only one specific pest or, in some cases, a few target organisms, in contrast to broad spectrum, conventional pesticides that may affect organisms as different as birds, insects, and mammals
iii. Biopesticides often are effective in very small quantities and they decompose quickly thereby resulting in lower exposures and largely avoiding the pollution problems caused by conventional pesticides
iv. When used as a component of integrated pest Management (IPM) programs, biopesticides can greatly decrease the use of conventional pesticides while crop yields remain high
v. To use biopesticides effectively; however, users need to know a great deal about managing pests

7.6.2.3 **Microbial pesticides**

Microbial pesticides contain a microorganism (bacterium, fungus, virus. Protozoon or algae) as the active ingredient. They suppress pests by • Producing a toxin specific to the pest; • Causing a disease; • Preventing establishment of other microorganisms through competition; or • Other modes of action

An example of microbial pesticide is Bacillus thuringiensis ot Bt. Bacillus thuringiensis is a naturally occurring soil bacteria that is toxic to the larvae of several species of insects but non-toxic to non-target organisms. Bacillus thuringiensis can be applied to plant foliage or incorporated in to the genetic material of crops eg. Bt cottons. Bacillus thuringiensis as discovered is toxic to the caterpillars (larvae) of moths and butterflies. Several strains of Bt have been developed and now strains are available that control fly larvae. These can be used in controlling mosquitoes and black flies. Microbial pesticides need to be continuously monitored to ensure they do not become capable of harming non-target organisms, including humans. Other examples of microbial pesticides include the following: • Bacillus thuringensis against caterpillars of Heliothis, Earias, Spodoptera etc • Pseudomonas fluoroscenes against Pythium spp., Rhizoctonia spp., Fusarium spp. • Nematodes like Green commandoes and Soil commandoes against caterpillars & grubs • Nuclear Polyhedrosis Virus(NPV) • Trichoderma virdi against many common diseases of vegetables and spices • Weevils Neochitina eichorniae & N bruchi against water hyacinth • Beetle Zygogramma biocolorata against Parthenium

7.6.2.4 **Biochemical pesticides**

These are naturally occurring substances that control pests by non-toxic mechanisms. (Conventional pesticides, by contrast, are synthetic materials that usually kill or inactivate the pest). Biochemical pesticides include substances that interfere with growth or mating, such as growth regulators, or substances that repel or attract pests, such as pheromones. Pheromones are often used to detect or monitor insect populations, or in some cases, to control them.

7.6.3 Bioherbicides The biological control of weeds involves the use of living organisms such as plant pathogens, insects and mites, herbivorous fish, nematodes, other animals and competitive plants to limit their infestation. The objectives of biological control are not eradication, rather the reduction and, regulation of weed population below the levels of economic injury. A successful bio-agent is host specific, rapid destroyer of the target weed, effective on several taxa of the weed in question, adjustable to new environment and easy to multiply. Biological control of weeds has had a long and successful record in the United States and several other countries. "A bioherbicide is a plant pathogen used as a weed control agent through inundative and repeated application of its inoculums or by augmentation of natural, seasonal disease levels through small releases of inoculums. The bioherbicide can provide an effective, safe and viable method of weed control". A list of bioherbicides is presented in Table 7.3.

A bioherbicide can often live in the environment and wait for the next growing season when there will be more weeds to infects. This reduces the farmer's cost of applying herbicides year after year. A new range of bioherbicides may essentially allow farmers to replace or reduce the expensive chemical herbicides that they now use. They also allow farmers to get rid of weed that interfere with their crop's productivity without threatening the environment.

Lecture No. 8

MANAGEMENT OF NATURAL RESOURCES (SOIL, WATER, VEGETATION AND ENERGY)

8.1. Introduction Man has been relaying on the natural resources to meet the basic requirements since time immemorial. With the unprecedented increase in the population during the last few decades, clearly mankind faces formidable problem to ensure food and nutritional security for all, considering reduced per capita land, reduced availability of water, depleting biodiversity and need to preserve ecology and environment. The physical and biological environment of the earth is so rich in its potential that is can support the need of its inhabitants for a long time to come. However, the man's greed rather than his needs is putting enormous pressure in the capacity of the biosphere resulting in over-exploitation of the natural resources, as the demand is not within the paradigm set by ecological constraints. The natural resource management at most places in the world including India is inappropriate, exploitative and unscientifically planned. Even today, land and water are being exploited without restraint considering them inexhaustible, and wastes are discharged freely into air and water assuming that these have unlimited assimilative and carrying capacities. As a result, very disturbing trends of natural resource degradation have emerged. Human activities inflict harsh and often irreversible damage on the environment and on the critical natural resources. If not checked, many of our current practices will put, at serious risk, the future that we wish for human Society and the plant and animal kingdom.

Agenda 21 for Natural Resource management The United Nations Conference on Environment and Development (UNCED) at the earth summit held in Rio-deJanario, Brazil in 1992 focused attention on the harmful effect of development of the earth's life sustaining capacity. The conference also adopted Agenda 21- a global blue print for
environmental action. It revolves around seven themes, one of which is "Efficient use of natural resources of land, water, energy, forests and biological resources". This is unquestionably the theme for the survival of humanity and for the sustainability of future agriculture. 8.2 Management of natural resources 8.2.1 Land resource India has only 2.4% of the land resource of the world to meet their basic requirements of 18% of the world's population and over 25% of the world's livestock. Nearly 57% of the land resource in India is facing degradation due to water erosion, wind erosion, loss of productivity and chemical and physical degradation. About 5.3 million ha of topsoil is displaced every year only through water erosion which also accounts for a loss of 8 million tones of plant nutrients. While most of the land resource faces nitrogen deficiency, nearly 50% and 20% of the land resource is deficient in phosphorus and potassium. Deficiencies of micronutrients have been widely reported. It is assessed that 8.6 million ha of agricultural land is affected by both the problems of water logging and soil salinity. About 65% of which is the most productive irrigated land resource. Added to these the per capita arable land which was 0.121 ha in 1990, 0.176 ha in 1996 and 0.163 ha in 2000 is projected to be 0.121 ha in 2025 and 0.087 ha when the population stabilizes by the year 2050 or later. Therefore, meeting all basic necessities from degrading and low per capita arable land area of 0.087 ha is bound to be major challenge and calls for appropriate soil restoration and conservation technologies. The best means of improving and maintaining soil quality which determines soil productivity and environmental quality is adoption of alternative agricultural practices such as crop rotation, recycling of crop residues and

animal manures, green manures, biofertilizers and intergrated nutrient management for encouraging balanced use of fertilizers and manures, and reduced use of pesticides. These are some of the components of a strategy for obtaining sustainable high productivity in any farming system. The relationship between the soil degradation processes and soil conservation practices as outlined by Hamick

STRATEGIES FOR INCREASING AGRICULTURAL PRODUCTION IN UGANDA

Land degradation and low agricultural productivity are severe problems in Uganda. Although Uganda's soils were once considered to be among the most fertile in the tropics (Chenery 1960), problems of soil nutrient depletion, erosion, and other manifestations of land degradation appear to be increasing. The rate of soil nutrient depletion is among the highest in sub-Saharan Africa (Stoorvogel and Smaling 1990), and soil erosion is a serious problem, especially in highland areas (Bagoora 1988).
Land degradation contributes to the low and in many cases declining agricultural productivity in Uganda. Farmers yields are typically less than one-third of potential yields found on research stations, and yields of most major crops have been stagnant or declining since the early 1990's (Deininger and Okidi 2001)

Finding ways to reverse these trends is an urgent need in Uganda and many other developing countries. In order to do that, information is needed to help identify strategies that will lead to more productive and sustainable land use. Because of the diverse agro-ecological and socioeconomic conditions in Uganda and the complex set of factors and interactions that influence farmers' land management decisions and their implications for productivity and land degradation, addressing this information need is a formidable challenge. This paper addresses this challenge by developing and estimating a structural econometric model of household decisions regarding income strategies, participation in programs and organizations, crop choices, land management, and labor use, and their implications for agricultural production and land degradation; based upon a survey of over 450 households and their farm plots in central and sou

ENVIRONMENTAL CONCERNS IN MODERN AGRICULTURE

Overview

This unit introduces students to the most common agricultural practices employed in conventional production, and the major agricultural, environmental, and human health concerns that have arisen as a result of

Two lectures cover the socioeconomic factors that shape conventional modern agricultural production; key elements of modern agriculture and their environmental and human health impacts; and critical interactions between natural and agro ecosystems. The lectures also present the set of alternative farming practices that have been used to avoid risks to environmental quality and human health.

The lectures conclude with a discussion of the policy, regulatory and economic factors that reinforce the conventional agriculture model and the policy and economic changes that need to take place in order to develop more sustainable productions systems

Note: It is important to convey to students that many "conventional" farming operations, though not operating under
National Organic Program organic certification, often integrate many of the "sustainable agriculture" practices outlined in this manual. Further, it is important to discuss that mere adherence to the minimum requirements of organic certification does not necessarily constitute sound agricultural practices. Students should understand that agriculture itself (whether "certified organic" or "conventional") is one of the most extensive and environmentally disruptive land use practices that human beings currently employ

Additionally, it is important to stress that it is often market pressures and the need to maintain a competitive advantage/economic viability that have encouraged individual farmers to adopt agricultural technologies that have later proven to have negative environmental or human health consequences. Lastly, though environmental degradation often results from the

TECHNOLOGICAL INNOVATIONS

A. The Shaping of Conventional Agriculture: Technological Innovations, Investment CapitaLand the Technology Treadmill (see Cochrane 1993; FitzSimmons 1986; Heffernan et al. 1999)

1. The initial resistance of agriculture to the forces of capitalism

a) Crop production as high-risk investment: Capital investors initially reluctant to invest in agriculture with productivity and profit being tied to biological processes and variables of natural environment

2. New agricultural technologies and capitalist investment
   a) As new agricultural technologies were developed and introduced into agriculture, capitalist investors found it more profitable to invest in the technologies rather than crop production itself
   b) Consequences
      i. Farmers become dependent upon constantly evolving inputs of agricultural technology
      ii. Agricultural technologies require substantial financial investment, thus requiring many farmers to obtain loans to reinvest in technology
      iii. Capital investors and technology manufacturers control agricultural technology
      iv. The restructuring of farm economics: New technology requires access to capital (loans, credit) for investment. This favors larger, well-capitalized farmers or farming corporations and puts smaller farmers at a competitive disadvantage, who often have to sell out, contributing to the growth in farm size and the loss of more small

3. "The technology treadmill"
   b) The technology treadmill defined: The self-reinforcing cycle of technological dependency, driven by the application of technology and investment capital to agriculture
      i. Competition in the marketplace encourages the adoption of new agricultural technologies that allow for increases in efficiency or increases in the scale of production
      ii. Increased efficiency, increases in the scale of production convey a competitive advantage through the economies of scale
      iii. Crop prices are driven down because of efficiencies in production and the reduced costs per unit produced
      iv. This drives some small producers out of business because they cannot access the credit needed to invest in the latest technology that is now essential in competing in the market place
      v. Concurrently, this encourages producers to further increase the scale of production to have the size of operations necessary to cover their debts incurred through purchases of technology inputs
      vi. The agricultural technologies used in expanding the scale of production have had a significant social and environmental consequences

B. Technological Innovations and Practices Used in Conventional Agriculture

1. Fossil fuel use in conventional agriculture

a) Fossil fuel was first used on the farm to replace human labor and animal power. It was a great labor saving device. It laid the foundation for monoculture production (through tractors) and long distance shipping of agricultural products.

b) The influence of fossil fuel

i. Economically subsidized in many ways: Highways; lower prices for larger volumes of fuel used; externalized environmental costs (e.g., CO2, oil spills, etc.)

ii. Inexpensive fossil fuel power makes long-distance, cross-country, and international transportation of food and fiber cost effective. Cost effectiveness of international import agriculture is further assured by lower costs of production in developing nations due to lower environmental and social justice standards.

iii. Local and sustainable food systems cannot compete against large-scale agriculture with economically efficient long-distance food transport and the suite of externalized

POPULATION GROWTH, AGRICULTURAL STAGNATION AND ENVIRONMENTAL DEGRADATION: THE NEXUS

Multiple and synergistic links between rapid population growth, poor agricultural performance and environmental degradation

Relationships are difficult to analyze, as multiple factors affect rate of population growth, environmental degradation, and pace and direction of agricultural development

Boserup hypothesis: Agriculture intensification occurs as population density on agricultural land increases. Sub-Saharan Africa: Agriculture expansion rather than intensification.

Expansive agriculture involved conversion of large areas of forest, wetlands, river valley bottoms, and grassland savanna to crop land. Agriculture expansion + rapid population growth = accelerated degradation of natural resources = agricultural stagnation.

FACTORS PERPETUATING THE NEXUS

Deficiencies in economic policy environment (e.g. agricultural pricing, excessive control of agricultural marketing, lack of empowerment of farmers): Slowed the evolution of ancestral systems into systems more sustainable with higher population density Lack of rapid and widespread technological change

Traditional tenure systems and the nexus

Rapidly rising population pressure makes effective common ownership regulation increasingly more difficult Rapid population growth led to an erosion and breakdown in customary laws and rules governing sustainable use and management of land and other common property resources

Deforestation, fuel wood, and the nexus
90% of households in Sub-Saharan Africa use wood-fuel as the staple source of energy. Slow economic growth will impede the switch to non-wood fuels. Hence the demand for wood-fuel would increase with population growth
In 1980s, eleven countries including Uganda, faced negative fuel-wood supply- demand balances. Have important negative effects on rural women, health, nutritional patterns and soil conservation

Labor Force and Population Growth
Labor force: population 15-65, who is actively seeking jobs. Growth of the labor force in future will depend upon:
– Age structure of the population: younger the population-faster will be the growth
– Current fertility levels
– Economic activity rates by age and sex

Climate change, Natural resource degradation and Biodiversity

- Collapsing fisheries
- Loss of animal and plant species due to shrinking forests
-

Climate Change and Green House Emissions

Global warming
Increased flooding
Pattern of precipitation also likely to change with global warming reduced agricultural productivity are linked to both population increases , development and consumption patterns

Farming activities that may affect greenhouse gas levels

1. Carbon capture in vegetation
2. Methane release from waterlogged soils
3. Methane release from ruminant animals
4. Nitrous oxides released by fertilisers
5. Use of fuels in farming machinery
6. Uses of biofuels.

REFERENCES:
Cheak Kok Kheong, Hewitt, B., Hsu Yu-Chu, Joseph, K. and Williams, C. (1972). *Modern Agriculture for Tropical Schools.* Kuala Lumpur, Malaysia: Bangunan Loke Yew

Cox, E. (1980). *Good Gardens for Good Food. Lesson guides for teaching agriculture*

and nutrition in community schools.
Cox, E. and Fitzpatrick, E. (1981). *Good Gardens Good Food Good Development. A handbook of practical agriculture and nutrition for development workers in*

Morrow, R. and Allsop, R. (1993). *Earth User's Guide to Permaculture*. Kangaroo Press.
National Department of Education (1981). *Learning About Gardening Science Resource Book*. Port Moresby, Papua New Guinea: Curriculum Unit

W.C. 1990. Raising and sustaining productivity of smallholder farming systems in the tropics: A handbook of sustainable agricultural development. AgBbe Pub., Alkmaar, Holland. Buresh,

Taylor, P. (1999). *The Agricultural Teachers' Handbook*: VSO Books.
Trautmann, N. and Krasny, M. (1999). *Composting in the Classroom: Scientific Inquiry for High School Students*. ISBN 0-7872-4433-3.

A, Madison, WI.Clarke, W.C., and R.R. Thaman. 1993. Agroforesty
in the Pacific Islands:Systems for sustainability. United Nations Univ. Press, Tokyo, Japan. Conway
,
G. 1998. The doubly greenrevolution: Food forall in theTwenty-First Century. Comstock Publishing, Cornell Univ. Press. Ithaca, NY.

Edwards,C.A. et al. (ed.) 1990. Sustainable agricultural systems. Soil and Water Conservation Society. Akeny, IA.Gliessman,