COURSE GUIDE

SLM 306
SOIL EROSION AND CONSERVATION

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INTRODUCTION

SLM 306: Soil Erosion and Conservation is a two-credit course for students offering B. Agriculture in the School of Agricultural Science.

The course consists of three modules which is divided into15 units. The material has been developed to suit undergraduate students in Agriculture at the National Open University of Nigeria (NOUN) by using an approach that treats Soil Erosion and Conservation.

A student who successfully completes the course will surely be in a better position to manage soil erosion and conservation in both private and public organisations.

The Course Guide tells you briefly what the course is about, what course materials you will be using and how you can work your way through these materials. It suggests some general guidelines for the amount of time you are likely to spend on each unit of the course in order to complete it successfully. It also gives you some guidance on your tutor-Marked assignments. Detailed information on tutor-Marked assignment is found in the separate assignment file which will be available in due course.

WHAT YOU WILL LEARN IN THIS COURSE

The course is made up of fifteen units, covering areas such as:

- Farm and Farming Systems
- Classification of Farming Systems
- Husbandry
- Land Use in the Tropics
- Matching Land Uses to Land Types
- Soil Erosion
- Processes of Soil Erosion
- Economic importance of Soil Erosion
- Types of Soil Erosion
- Soil productivity relation and Modelling
- Meaning of soil conservation
- Agronomic Soil Conservation Measures
- Soil Management Strategies for Soil Conservation
- Mechanical Strategies for Soil Conservation
- Extension Approaches for Soil Conservation

In all, this course will introduce you to some fundamental aspects off arm and farming systems, classification of farming systems, husbandry, land use in the tropics, matching land uses to land types, soil erosion, processes of soil erosion, economic importance of soil erosion, types of soil erosion, soil productivity relation and modelling, meaning of soil conservation, agronomic practices for soil conservation measures, soil management strategies for soil conservation, mechanical strategies for soil conservation and extension approaches for soil conservation

COURSE AIM

The aims of the course will be achieved by your ability to:

- Explain the concept of a farming system and list the components of a farming system
- State general classification of farming system in a pictorial or diagrammatic form.
- List and briefly explain two main classes of farming system.
- Classify farming system according to cultivation with example in each classification.
- Explain the concept of land husbandry and state the characteristics of land husbandry.
- List and briefly explain the principles of land husbandry
- Define land use with examples and list the functions of land use.
- Explain land capability classification and give examples of land use matching land type
- Define soil erosion and outline causative agent of soil erosion
- Explain the three processes of soil erosion, outline factors of water erosion and
  factor affecting water erosion
- Explain major soil properties controlling soil erosion at field-scale, on-site and
  off-site problems of erosion
- List and discuss briefly different kinds and types of erosion
- Outline the relationship between soil erosion and agricultural productivity
- Explain the erosion modeling, differentiate between empirical and conceptual models
  and the universal soil loss equation
- Explain soil conservation and control measures.
- List and highlight the various extension approaches of soil conservation.

COURSE OBJECTIVES

At the end of this course, you should be able to:

- Explain the concept of a farming system and list the components of a farming system.
- State general classification of farming system in a pictorial or diagrammatic form.
- List and briefly explain two main classes of farming system.
- Classify farming system according to cultivation with example in each classification.
- Explain the concept of land husbandry and state the characteristics of land husbandry.
- List and briefly explain the principles of land husbandry.
- Define land use with examples and list the functions of land use.
- Explain land capability classification and give examples of land use matching land type.
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- Explain the erosion modelling, differentiate between empirical and conceptual models
  and the universal soil loss equation,
- Explain soil conservation and control measures.
- List and highlight the various extension approaches of soil conservation,

WORKING THROUGH THE COURSE

To successfully complete this course, you are required to read the study units, reference books and other materials on the course.

Each unit contains self-assessment exercises in addition to Tutor-Marked Assignments (TMAs). At some points in the course, you will be required to submit assignments for assessment purposes. At the end of the course there is a final examination. This course should take about 15 weeks to complete and some components of the course are outlined under the course material subsection.

COURSE MATERIALS

The major components of the course are:

1. Course Guide
2. Study Units
3. Textbooks
4. Assignment File
5. Presentation schedule

STUDY UNITS

There are three modules of 15 units in this course:

Module 1

Unit 1	Farm and Farming Systems
Unit 2	Classification of Farming Systems
Unit 3	Husbandry
Unit 4	Land Use in the Tropics
Unit 5	Matching Land Uses to Land Types

Module 2

Unit 1	Soil Erosion
Unit 2	Processes of Soil Erosion
Unit 3	Economic importance of Soil Erosion
Unit 4	Types of Soil Erosion
Unit 5	Soil productivity relation and modelling

Module 3

Unit 1	Meaning of soil conservation
Unit 2	Agronomic Soil Conservation Measures
Unit 3	Soil Management Strategies for Soil Conservation
Unit 4	Mechanical Strategies for Soil Conservation
Unit 5	Extension Approaches for Soil Conservation

REFERENCES AND FURTHER READINGS

Every unit contains a list of references and Further Readings. Try to get as many as possible of those textbooks and materials listed. The textbooks and materials are meant to deepen your knowledge of the course.

ASSIGNMENT FILE

There are many assignments in this course and you are expected to do all of them. You should follow the schedule prescribed for them in terms of when to attempt the homework and submit same for grading by your Tutor.

PRESENTATION SCHEDULE

The presentation schedule included in your course materials gives you the important dates for the completion of tutor-Marked assignments and attending tutorials. Remember, you are required to submit all your assignments by the due date. You should guard against falling behind in your work.

ASSESSMENT

Your assessment will be based on tutor-Marked assignments (TMAs) and a final examination which you will write at the end of the course.

TUTOR-MARKED ASSIGNMENTS (TMAs)

Assignment questions for the 15 units in this course are contained in the Assignment File. You will be able to complete your assignments from the information and materials contained in your set books, reading and study units. However, it is desirable that you demonstrate that you have read and researched more widely than the required minimum. You should use other references to have a broad viewpoint of the subject and also to give you a deeper understanding of the subject.

When you have completed each assignment, send it, together with a TMA form, to your tutor. Make sure that each assignment reaches your tutor on or before the deadline given in the presentation file. If for any reason, you cannot complete your work on time, contact your tutor before the assignment is due to discuss the possibility of an extension. Extensions will not be granted after the due date unless there are exceptional circumstances. The TMAs usually constitute 30% of the total score for the course.

FINAL EXAMINATION AND GRADING

The final examination will be of two hours' duration and have a value of 70% of the total course grade. The examination will consist of questions which reflect the types of self-assessment practice exercises and tutor-Marked problems you have previously encountered. All areas of the course will be assessed

You should use the time between finishing the last unit and sitting for the examination to revise the entire course material. You might find it useful to review your self-assessment exercises, tutor-Marked assignments and comments on them before the examination. The final examination covers information from all parts of the course.

COURSE MARKING SCHEME

The table below indicates the total marks (100%) allocation.

ASSESSMENT

Assignment (best three assignments out of the four Marked)	30%
Final Examination	70%
Total	**100%**

COURSE OVERVIEW

The table below indicates the units, number of weeks and assignments to be taken by you to successfully complete the course.

Units	Title of Work	Week's Activities	Assessment (end of unit)
	Course Guide		
Module 1			
1	Farm and farming systems	Week 1	Assignment 2
2	Classification of farming system	Week 2	Assignment 3
3	Husbandry	Week 3	Assignment 3
4	Land use in the tropics	Week 4	Assignment 2
5	Matching land uses to land types	Week 5	Assignment 2
Module 2			
1	Soil Erosion	Week 6	Assignment 2
2	Processes of soil erosion	Week 7	Assignment 3
3	Economic importance of soil erosion	Week 8	Assignment 3
4	Types of soil erosion	Week 9	Assignment 2
5	Soil productivity relation and modelling	Week 10	Assignment 3
Module 3			
1	Meaning of soil conservation	Week 11	Assignment 2
2	Agronomic Soil Conservation Measures	Week 12	Assignment 3

3	Soil Management Strategies for Soil Conservation	Week 13	Assignment 3
4	Mechanical Strategies for Soil Conservation	Week 14	Assignment 2
5	Extension Approaches for Soil Conservation	Week 15	Assignment 4
	Total	**15 Weeks**	

HOW TO GET THE MOST FROM THIS COURSE

In distance learning, the study units replace the university lecturer. This is one of the great advantages of distance learning; you can read and work through specially designed study materials at your own pace and at a time and place that suit you best. Think of it as reading the lecture instead of listening to a lecturer. In the same way that a lecturer might set you some reading to do, the study units tell you when to read your books or other material, and when to embark on discussion with your colleagues. Just as a lecturer might give you an in-class exercise, your study units provides exercises for you to do at appropriate points.

Each of the study units follows a common format. The first item is an introduction to the subject matter of the unit and how a particular unit is integrated with the other units and the course as a whole. Next is a set of learning objectives. These objectives let you know what you should be able to do by the time you have completed the unit. You should use these objectives to guide your study. When you have finished the unit you must go back and check whether you have achieved the objectives. If you make a habit of doing this you will significantly improve your chances of passing the course and getting the best grade.

The main body of the unit guides you through the required reading from other sources. This will usually be either from your set books or from a readings section. Self-assessments are interspersed throughout the units, and answers are given at the ends of the units. Working through these tests will help you to achieve the objectives of the unit and prepare you for the assignments and the examination. You should do each self-assessment exercises as you come to it in the study unit. Also, ensure to master some major historical dates and events during the course of studying the material.

The following is a practical strategy for working through the course. If you run into any trouble, consult your Tutor. Remember that your Tutor's job is to help you. When you need help, don't hesitate to call and ask your Tutor to provide the help.

1. Read this Course Guide thoroughly.

2. Organise a study schedule. Refer to the `Course overview' for more details. Note the time you are expected to spend on each unit and how the assignments relate to the units. Important information, e.g. details of your tutorials, and the date of the first day of the semester is available from study centre. You need to gather together all this information in one place, such as your dairy, a wall calendar, an iPad or a handset. Whatever method you choose to use, you should decide on and write in your own dates for working each unit.
3. Once you have created your own study schedule, do everything you can to stick to it. The major reason that students fail is that they get behind with their course work. If you get into difficulties with your schedule, please let your Tutor know before it is too late for help.
4. Turn to Unit 1 and read the introduction and the objectives for the unit.
5. Assemble the study materials. Information about what you need for a unit is given in the `Overview' at the beginning of each unit. You will also need both the study unit you are working on and one of your set books on your desk at the same time.
6. Work through the unit. The content of the unit itself has been arranged to provide a sequence for you to follow. As you work through the unit you will be instructed to read sections from your set books or other articles. Use the unit to guide your reading.
7. Up-to-date course information will be continuously delivered to you at the study centre.
8. Work before the relevant due date (about 4 weeks before due dates), get the Assignment File for the next required assignment. Keep in mind that you will learn a lot by doing the assignments carefully. They have been designed to help you meet the objectives of the course and, therefore, will help you pass the exam. Submit all assignments no later than the due date.
9. Review the objectives for each study unit to confirm that you have achieved them. If you feel unsure about any of the objectives, review the study material or consult your Tutor.
10. When you are confident that you have achieved a unit's objectives, you can then start on the next unit. Proceed unit by unit through the course and try to space your study so that you keep yourself on schedule.
11. When you have submitted an assignment to your Tutor for marking, do not wait for its return `before starting on the next units. Keep to your schedule. When the assignment is returned, pay particular attention to your Tutor's comments, both on the tutor-Marked assignment form and also written on the assignment. Consult your Tutor as soon as possible if you have any questions or problems.

12. After completing the last unit, review the course and prepare yourself for the final examination. Check that you have achieved the unit objectives (listed at the beginning of each unit) and the course objectives (listed in this Course Guide).

TUTORS AND TUTORIALS

There are some hours of tutorials (2-hours sessions) provided in support of this course. You will be notified of the dates, times and location of these tutorials, together with the name and phone number of your Tutor, as soon as you are allocated a Tutorial group.

Your tutor will mark and comment on your assignments, keep a close watch on your progress and on any difficulties you might encounter, and provide assistance to you during the course. You must mail your tutor-Marked assignments to your tutor well before the due date (at least two working days are required). They will be Marked by your Tutor and returned to you as soon as possible.

Do not hesitate to contact your Tutor by telephone, e-mail, or discussion board if you need help. The following might be circumstances in which you would find help necessary. Contact your Tutor if:

- You do not understand any part of the study units or the assigned readings
- You have difficulty with the self-assessment exercises
- You have a question or problem with an assignment, with your Tutor's comments on an assignment or with the grading of an assignment.

You should try your best to attend the tutorials. This is the only chance to have face to face contact with your Tutor and to ask questions which are answered instantly. You can raise any problem encountered in the course of your study. To gain the maximum benefit from course tutorials, prepare a question list before attending them. You will learn a lot from participating in discussions actively.

CONCLUSION

On successful completion of the course, you would have developed critical thinking and logical skills (from the material) for efficient and effective discussion of soil erosion and conservation. However, to gain a lot from the course please try to apply everything you learn in the course to term paper writing in other related courses. We wish you success with the course and hope that you will find it interesting and useful.

MAIN COURSE

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MODULE 1 FARMING SYSTEMS AND LAND USE

UNIT 1 FARM AND FARMING SYSTEMS

CONTENTS

1.0 INTRODUCTION

A farming system is defined as a population of individual farm systems that have broadly similar resource bases, enterprise patterns, household activities and constraints, and for which similar development strategies and interventions would be appropriate. Depending on the scale of the analysis, a farming system can encompass a few dozen or many millions of households.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- Explain the concept of a farming system
- List some of the components of a farming system

3.0 MAIN CONTENT

3.1 The Concept of Farming System

Farming system therefore designates a set of agricultural activities organized while preserving land productivity, environmental quality and maintaining desirable level of biological diversity and ecological stability. The emphasis is more on a system rather than on gross output. In other words "farming system" is a resource management strategy to achieve economic and sustain agricultural production to meet diverse requirement of the farm household while preserving the resource base and maintaining high environmental quality. The farming system in its real sense will help the following ways to lift the economy of Indian agriculture and standard of living of the farmers.

Farming system specially refers to a group combination of enterprises in which the products and or the byproducts of one enterprise serve as the inputs for production of other enterprise.

3.2 The Components of a Farming System

Farming is defined as the way in which the farm resources are allocated to the needs and priorities of the farmers in his local circumstances which include-

1. Agro climatic condition such as the quantity, distribution and reliability of rainfall. Soil type and topography temperature etc and
2. Economic and institutional circumstances like market opportunities, prices, institutional and infrastructure facilities and technology.

Therefore, Farming system is a complex inter related matrix of soil plants, animals, implements, power labour, capital and other inputs controlled in parts by farming families and influenced to varying degree by political, economic, institutional and socials forces that operate at many levels. Thus farming system is the result of a complex interaction among a number of interdependent components. To achieve it, the individual farmer allocates and qualities of four factors of production. Land, labour, capital and management, which has access to processes like management which has crop, livestock and off farm enterprises in a manner, which within the knowledge he possess will maximize the attainment of goal he is striving for. Farming system consist of several enterprises like cropping system, dairying, piggery, poultry, fishery, bee, keeping etc. these enterprises are interrelated. The end product and wastes of one enterprise are used as inputs in others. The waste of dairying like dung, urine, refuse etc. is used for preparation of farm yard manure (FYM), which is an input in cropping systems. The straw obtained from the crops is used as fodder for cattle's are used for different field operations for growing crops. Thus different enterprises of farming systems are highly interrelated.

Although the traditional tropical agricultural systems are invariably subsistence, based on how inputs, modernization strategies attempt to achieve high and economic agricultural production on a continuous basis. Improved agricultural systems should however, be sustainable preserve the resource base, and maintain high environmental quality. New and improved systems must look beyond production and specifically address the issues of biological sustainability and ecological stability. The land resource is not only finite; it is also non-renewable. The objective of improved agricultural systems, therefore, lies in preserving and improving the land in productivity while maintaining biological diversity, environmental quality, and ecological stability. The most important issue of land is to develop sustainable food systems that have high production but do not upset the delicate soil vegetation-chemical balance.

4.0 CONCLUSION

In this unit, we explained the concept of a farming system as well the components of a farming system. You learnt that a "farming system" is a resource management strategy to achieve economic and sustain agricultural production to meet diverse requirement of the farm household while preserving the resource base and maintaining high environmental quality. You also learnt that farming system is a complex inter related matrix of soil plants, animals, implements, power labour, capital and other inputs controlled in parts by farming families and influenced to varying degree by political, economic, institutional and socials forces that operate at many levels

5.0 SUMMARY

The farming system is the result of a complex interaction among a number of interdependent components. To achieve it, the individual farmer allocates and qualities of four factors of production. Land, labour, capital and management, which has access to processes like management which has crop, livestock and off farm enterprises in a manner, which within the knowledge he possess will maximize the attainment of goal he is striving for. Farming system consist of several enterprises like cropping system, dairying, piggery, poultry, fishery, bee, keeping etc. these enterprises are interrelated. The end product and wastes of one enterprise are used as inputs in others.

6.0 TUTOR-MARKED ASSIGNMENT

1. Define a farming System.
2. List some of the components of a farming System

7.0 REFERENCES/FURTHER READING

Food and Agriculture Organization, United Nations. (1981). *Agriculture: Toward 2000*. Rome, Italy. Food and Agriculture Organization, United Nations. 1983**.** *Protect and produce. Soil conservation for dlvelopmient.* Rome, Italy.

Roose, E. 1988. *Soil and vater conservationlessons from steep-slopefaninin,, in Frem'h-speakin, countries of Africa*. In *Conservation Farming,on Steep Lands.* Soil Conservation Society of America, Ankeny Iowa. pp. 129-139.

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Shaxson, T. F. 1981. *Developing concepts of land husbandry for the tropics.* In R.P.C. Morgan leditori *Soil Conservation:Problemsand Prospects.* John Wiley and Sons, Chichester, England. pp. 351-362.

UNIT 2 CLASSIFICATION OF FARMING SYSTEMS

1.0 INTRODUCTION

In the process of adapting cropping patterns and farming practices to the conditions of each location and the aims of the farmers, more or less distinct types of farm organization have developed. In fact, no farm is organized exactly like any other.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- Explain the general classification of a farming system in a pictorial or diagrammatic form.
- List and briefly explain two main classes of farming system.
- List classification of the farming system according to cultivation and give at least one example in each classification.

3.0 MAIN CONTENT

3.1 Classification of Farming System

For the purpose of agricultural development, however, in order to devise meaningful measures in agricultural policy and ensure sustainability in agricultural production, it is necessary to classify farming system according to their farm-management characteristics (Fig. 1).

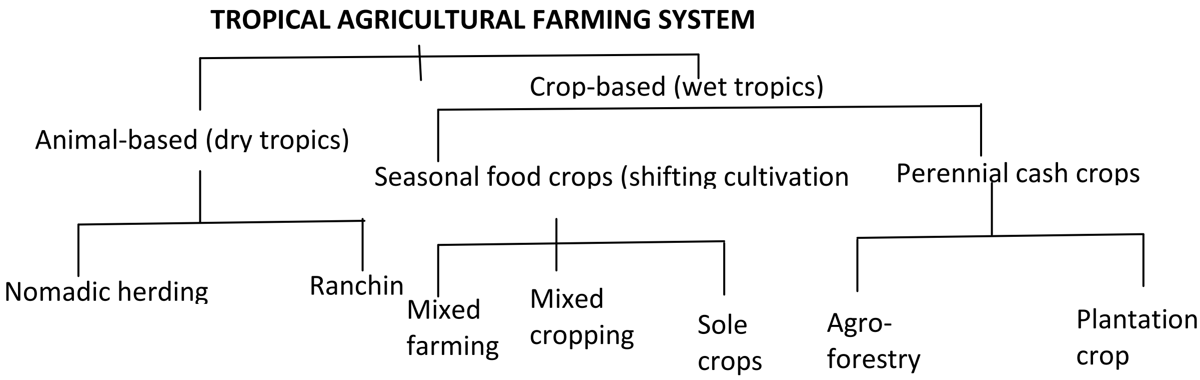

Figure 1: A generalized classification of farming system

3.2 Main Classes of Farming Systems

Farming system is classified into two main classes namely; collection and cultivation farming systems.

a. **Collection farming system:** Collection of farming system is the most direct method of obtaining plant products. It may include either regular or irregular harvesting of uncultivated plants. Hunting and fishing usually go hand in hand with collecting. In prehistoric times, activities of this kind were a major source of food supply. In some regions these activities still provide rather important additions to the subsistence food gained from organized production in arable farming and animal husbandry. Only in a few cases is collecting a major cash earning activity.

b. **Cultivation Farming System:** Much more important than collecting are the numerous types of cultivation. The different cultivation systems may be classified according to a number of particular features. The most important classifications that have been adopted are as follows;

3.3 Classification according to the type of rotation

Fallow system describes a situation where cultivation alternates with an uncultivated long-term fallow, which leads to the regeneration of a wild vegetation of trees, bush, or unused grasses. Often, but certainly not in all cases, fallow systems are practiced in conjunction with fire-farming, in which the wild vegetation is burned off before planting.

Ley *system* describes those cases where grass is planted or establishes itself on land that has carried crops for some years. The grass is allowed to remain for several years and is used for grazing. In the savannas there are extensive areas of *wild* or *unregulated* ley farming. In these areas, we find that, after a period of cultivation of several years, the field is covered with grass and shrubs for several more years and serves as rough pasture. *Regulated* ley farming, with established swards during the non-cropping period, is rare in the tropics, although it is found in some highlands (e.g. in Kenya) and in Latin America.

Field systems occur where one arable crop follows another, and established fields are clearly separated from each other. The grassland associated with fields is usually treated as permanent grassland, whether it is rough or well cared for, and it is separated from the arable land.

Systems with perennial crops: these are crops that grown to cover the land for many years and they are in a different category. These includes; perennial field crops like sugar-cane and sisal, bush crops like tea and coffee, and tree crops proper like oil-palm and rubber. Allkinds of rotation are found. In some cases tree crops are alternated with fallow, in others with arable farming, grazing, or other perennial crops.

3.4 Classification according to the intensity of the rotation

The fallow and ley systems display considerable variations and degrees of intensity. This is true for field-bush rotations and for unregulated ley systems in the African savannas. A relatively simple and appropriate criterion for classification is the relationship between crop cultivation and fallowing within the total length of one cycle of land utilization. The length of the cycle is the sum of the number of years of arable farming plus the number of fallow years.

3.5 Classification according to the water supply

One of the first steps in classifying land utilization is to question whether farming is practiced with or without irrigation. In *irrigation farming,* to ensure that the moisture level of the soil is higher than would occur naturally, a water supply is directed into the fields, or the rain-water in the fields is purposefully dammed up. Farming without irrigation is widely referred to as *dry farming.* In the interest of precise definition, however, it is advisable to speak of dry farming only where in semi-arid climates grain and leguminous crops are alternated with a fallow of one or two years. A distinction between irrigated farming and *rainfed farming* is therefore preferred.

3.6 Classification according to the cropping pattern and animal activities

The most important aspect of the definition of farming systems is usually the classification according to the main crops and the livestock activities of the holdings. Each activity has different requirements as to climate, soils, markets, and inputs. Therefore those farms can be grouped together whose gross returns (sales plus household consumption plus changes in stock) are similarly constituted, to give, for example, coffee-banana holdings or rice-jute holdings.

3.7 Classification according to the implements used for cultivation

In addition, holdings are occasionally classified according to the main implements used. In various parts of the world, the land is cultivated **by** methods that require either no implements, or a few very simple tools. Millet is sown without fire-farming or soil preparation by a few nomads in the Sahara. Shifting cultivators frequently sow in ashes without touching the soil either beforehand or afterwards. Rice growers in Madagascar, Ceylon, and Thailand make use of the treading of animals: a large number of cattle are driven across the moist field to trample down the soil until it becomes more ready for planting. In some parts of the world, planting-sticks and digging-sticks have not yet been replaced by hoes, spades, or ploughs. However, with the exception of these pre-technical methods, the main divisions are (1) hoe farming or spade farming; (2) farming with ploughs and animal traction; and (3) farming with ploughs and tractors.

3.8 Classification according to the degree of commercialization

There are a number of distinct types according to the percentage of sales in relation to the gross return. Subsistence farms are those where agricultural products are raised with the main purpose of covering only the needs of the household; selling is limited to surpluses of these products. The share of sales in relation to gross returns is less than 25%. Partly commercialized farms are those where the systematic cultivation of cash crops is practiced in addition to production for household needs. However, the percentage of sales still remains below 50% of the gross returns. Semi-commercialized farms are similar, but in addition to production for the household so much cash cropping is carried out that the share amounts to 50-75% of the gross returns. Highly commercialized farms are the remaining type, in which less than 25% of the gross output is consumed by the household.

4.0 CONCLUSION

In this unit, we explained the main classes of farming system. We also learnt that farming systems are classified according to their farm-management characteristics.

5.0 SUMMARY

In the process of adapting cropping patterns and farming practices to the conditions of each location and the aims of the farmers, more or less distinct types of farm organization have developed. In fact, no farm is organized exactly like any other. Therefore, farming system is classified into two main class which include; 1. Collection and 2. Cultivation. This was further classified according to cultivation with examples such as according to intensity of rotation.

6.0 TUTOR-MARKED ASSIGNMENT

1. In a diagrammatic form classify farming systems.
2. List the classification of farming systems according to cultivation.
3. Explain briefly the main class of farming systems.

7.0 REFERENCES/FURTHER READING

Food and Agriculture Organization, United Nations. (1981). *Agriculture: Toward 2000.* Rome, Italy. Food and Agriculture Organization, United Nations. 1983**.** *Protect and produce. Soil conservation for dlvelopmient.* Rome, Italy.

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UNIT 3 HUSBANDRY

1.0 INTRODUCTION

Husbandry is described as a process or act of putting land into different or a particular utilization such as crop husbandry, animal husbandry, and land husbandry. For example cropping husbandry is characterize with annual, biennial and perennial crops production. This could be arable crop production like maize, rice under annual crop husbandry or tree crop production like rubber, oil palm under perennial crop husbandry.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- Explain the concept of land husbandry.
- State the characteristics of land husbandry.
- List and briefly explain the principles of land husbandry

3.0 MAIN CONTENT

3.1. Concept of land husbandry

Good land husbandry is the active process of implementing and managing preferred systems of land use and production in such ways that there will be increase - or at worst, no loss – of productivity, of stability or of usefulness for the chosen purpose. Also, in particular situations: existing uses or management may need to be changed so as to halt rapid degradation and to return the land to a condition where good husbandry can have fullest effect. The concept of husbandry is widely understood when applied to crops and animals. As a concept signifying active understanding, management, and improvement, it is equally applicable to land.

3.2 Characteristics of husbandry

Husbandry is characterize with Crop husbandry, animal husbandry, and land husbandry and all imply the following:

1. Understanding the characteristics, potentials, and limitations of different types of plants, animals, and land.
2. Predicting the likely positive or negative effects on their productivity resulting from a given change in management, or of severe but rare events, such as disease or severe rainfall.
3. Working out how they can be strengthened to resist the negative effects of such events.
4. Adopting systems of management that maintains their productivity and usefulness.
5. Improving their productivity in terms of quality and quantity of output in a given time.
6. The active and central role of the farmers as steward of the land.

3.3 Principles of Husbandry

1. Effective action to prevent or to control soil erosion and water runoff is generally not an integral part of people's use and management of land. The seriousness of erosion and runoff problems is growing, and both affect the livelihood of an increasing number of small farmers struggling for subsistence. Both also diminish the profitability of other forms of rural land use, including forestry and animal production. Because most countries have little or no reserve of unused, good land, more marginal land, especially steep and semiarid areas, is being brought into cultivation.
2. If the methods of managing this land do not prevent its degradation, its use will not be sustainable. Other land will continue to be brought into production, if only to compensate for the loss of productivity on that land already cultivated.

3. Erosion and runoff also increase costs to urban communities. Damaged roads and bridges must be repaired, sandbanks and diminished stream flow during dry periods impede river navigation, river water needs additional treatment for domestic and other uses, agricultural production outputs decline on eroded land, and the effects of floods must be countered.

3.4 Sequential Look at Land Husbandry

The following is a sequence for looking at land husbandry:

a. Manage Rainfall, then Runoff

The two main processes of water erosion are detachment of soil by raindrop splash and transportation by surface runoff. The two primary elements of control are, therefore, the maintenance of cover, which reduces soil splash, and the maximizing of infiltration, which reduces the volume and, hence, the velocity of surface runoff. Where runoff is unavoidable, additional control measures will be needed. Where practical and desirable, encourage as much surface retention storage as possible. This will give water time to soak into the soil aft, r rainfall has ended. Minimize the erosive energy of unavoidable runoff by keeping it dispersed, shallow,' and slow-flowing. This limits its potential for damage as it flows downhill. Uncontrolled runoff is water that might otherwise be put to good use.

b. Improve Soil Cover

Raindrops compact and seal the top few millimeters of the soil surface, particularly when the drops are large and their kinetic energy is greater. Cover over the soil dissipates the erosive energy of raindrops by breaking them up into smaller droplets whose energy is insufficient to splash soil particles or to compact the soil surface. If soil is not covered, the most valuable particles-clays and organic materials-are moved further by splash and runoff than other soil materials, and the soil that remains behind is, therefore, impoverished. Where about 40 percent of the soil's surface is protected by low-level **(**not more than one meter above the surface) and evenly distributed cover. Splash erosion by raindrops maybe reduced as much as 90percent.

The leaf canopy of well -grown crops *can* provide effective soil cover while tile crops are growing. The faster vegetative cover develops, the quicker will bare soil patches be protected, resulting in a smaller proportion of the season's total rainfall having erosive effects. Farmer’s management decisions and skills influence this effect. Crop residues left after harvest, or well-managed pastures or forests, also provide benefits to the soil and to subsequent crops because they protect the soil against rainfall impact. If runoff should occur, the residues help to slow its Velocity. Residues also provide a source of organic materials that benefit root growth and soil structure**.** These materials have positive effects on the self-recuperating capacity of the soil (the build-up or restoration of soil structural units and their resistance to erosion by raindrop splash and surface flow), internal aeration and drainage of the soil, long-term availability of plant nutrients, and storage of soil moisture.

Any actions that diminish raindrop splash will directly or indirectly mitigate other aspects of the erosion process. Factors that favor infiltration and absorption of rainwater also favor root growth by increasing the amount of readily available soil moisture and prolonging the period over which plants can use it. These same factors can also extend the duration of flow in streams and rivers and minimize the frequency of flooding.

c. Improve Soil Structure and Rooting Conditions

Surface soil can be pulverized *and* compacted by the frequent passage of animals or heavy machinery as well as by frequent or severe tillage. Pulverized soil is highly erodible and has a low infiltration rate; compacted soil also has a lower permeability. Repeated cultivations to the same depth may cause a "pan" or layer of induced compaction at the bottom of the tilled laver. The "plow pan" resulting from repeated plowing with tractor-or ox-drawn equipment is best known, but repeated hand cultivation with a hoe can produce the same effect. Such a pan usually results in a low percolation rate, and its increased density may limit the volume of soil available for root growth and the storage of soil moisture.

Some soils have naturally occurring layers of densely packed materials, such as laterite or calcrete, which have the same effects as pans caused by cultivations. Aeration in compacted soils is reduced, and much of the soil moisture is held at tensions that make it unavailable to plant roots. Soil penetration by roots may be physically obstructed.
Where the infiltration rate is less than the rate of rainfall, excess water

begins to accumulate on the surface as potential runoff as soon as surface layers of the soil have become saturated. Sealing and compaction of unprotected soil surfaces by large raindrops can occur in a few minutes. Damage by animal or vehicular traffic may take only a few seasons to develop. Pans below the tillage layer may become serious after a number of years. Naturally occurring pans take centuries or millennia to form. In badly managed soils, the first three types of damage may all occur simultaneously.

d. Catch Rain Where it Falls

Plant roots tend to spread more or less evenly through the upper layers of soil. Water from rainfall should, therefore, also infiltrate as evenly as possible across the soil surface. It is important to catch and encourage infiltrate of rainwater where and when it falls.

A farmer can help to maintain infiltration capacity with good soil structure and by keeping the soil surface rough with appropriate tillage or ridging. This strategy also minimizes the volume and velocity of potential runoff.

e. Increase Soil Moisture

Roots require freely available soil moisture if they are to grow. The longer moisture is available, the less frequently plants will suffer moisture stress. The greater the depth to which soil moisture and air are freely available to plants, the greater the volume of soil that can be explored by plant roots and the less often a lack of available soil moisture will become a limiting factor for plant development. Where yield benefits are claimed from soil conservation practices, these benefits usually are more closely associated with water conservation and improvement in soil moisture availability than with any savings in soil and plant nutrients. Where soil conservation works really act as water conservation works, there may be simpler, less expensive, or more acceptable ways of achieving water savings. For instance, not burning crop residues increases protection of the soil surface and facilitates infiltration; not burning may even be more effective than building banks. Growing crops on a contoured ridge-and-furrow system may be more appropriate than bench terracing.

f. Increase Organic Activity in Soils

Organic materials and processes are of great importance in the formation, improvement, and maintenance of soil structure, which is essential for providing optimum conditions for root growth. Rotational agriculture and mixed cropping, when well-planned and properly managed, restore organic materials and promote organic activity in one period of a rotation that may have declined during an earlier period of the rotation.

4.0 CONCLUSION

In this unit, we explained the concept of husbandry, characteristics, principles of husbandry and sequential looking at husbandry for agricultural sustainability.The concept of husbandry is widely understood when applied to crops and animals production. As a concept signifying active understanding, management, and improvement, it is equally applicable to land.

5.0 SUMMARY

Good husbandry is the active process of implementing and managing preferred systems of land use and production in such ways that there will be increase - or at worst, no loss – of productivity, of stability or of usefulness for the chosen purpose; also, in particular situations: existing uses or management may need to be changed so as to halt rapid degradation and to return the land to a condition where good husbandry can have fullest effect.

6.0 TUTOR-MARKED ASSIGNMENT

1. State the principles of husbandry
2. Outline the characteristics of husbandry
3. Briefly explain any five sequential looking at land husbandry

7.0 REFERENCES/FURTHER READING

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UNIT 4 LAND USE IN THE TROPICS

1.0 INTRODUCTION

Land is one of the most essential natural resources for the survival and prosperity of humankind, and it is the platform on which human activities take place. It is also the source of materials needed for these activities. This implies that land has many functions that need to be taken into consideration when planning development, to ensure that an efficient and balanced allocation of land resources results.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- Define land use with examples.
- List and explain the functions of land use.
- Outline uses of land as a natural resources with examples each

3.0 MAIN CONTENT

3.1 Concept of Land Use in the Tropics

Land allows for a variety of uses and can satisfy a diverse range of objectives. Land use is a basic element in human activity. Thus, the concept of land use refers to a series of activities done to generate one or more products or services. Land is defined as man’s activity on the land or the purpose for which the land is being used. The same land use can occur on several different parcels of land, and reciprocally, the same land may have several uses. An activity-based definition of land use allows for a detailed quantitative analysis of both economic and environmental impacts, as well as enabling different land uses to be clearly distinguished.

3.2 Functions of Land Use in the Tropics

These functions are:

Productive: land underpins many life support systems, through production of biomass that provides food, fodder, fiber, fuel, timber and other biotic materials for human use, either directly or through animal husbandry including aquaculture, and inland and coastal fisheries;

Biotic environmental: land is the basis of terrestrial biodiversity – it provides the biological habitats and gene reserves for plants, animals and micro-organisms, above and below ground;

Climate regulation: land and its use are a source and sink of greenhouse gases, and form a co-determinant of the global energy balance – along with reflection, absorption and transformation of the sun's radioactive energy, and the global hydrological cycle;

Hydrologic: land regulates the storage and flow of surface and groundwater resources, and influences their quality;

Storage: land is a storehouse of raw materials and minerals for human use;

Waste and pollution control: land absorbs, filters, buffers and transforms many hazardous compounds;

Living space: land provides the physical basis for human settlements and everything done from there **-** from industry to sports and recreation;

Archive or heritage: land stores and protects the evidence of the cultural history of humankind; it is also a source of information on past climatic conditions and past land uses; and

Connective space: land provides space for the transport of people, inputs and products, and for the movement of plants and animals between discrete areas of natural ecosystems.

3.3 Uses of Land as natural Resources

Globally, the available country area was 136,096,598 km^2 including 130,121,447 km^2 for land area and 5,975,151 km^2 for inland water. The land area is divided among different types of use. Agricultural land accounts for 49,322,388 km^2 (arable land accounts for 14,121,800 km^2 and permanent crops 1,426,704 km^2); forests: 39,394,070km2; and other land represents 41,404,989 km^2. Land is highly sought for various human activities. Such activities (current or future) depend, to a greater or lesser degree, on the surface of the earth, its minerals, its water and its other renewable and non-renewable resources. Generally, the same parcel of land cannot be used for more than one object simultaneously; this generates competition between different land-use activities for a piece of land.

Land is a limited resource with increasing substantial demands placed on it. As a result of increasingly heavy pressure on land resources, agricultural production declines, the quantity and quality of land deteriorates, and there is increasing competition for access to land Increasing demand for land for various uses generates fierce competition among users. Thelogical way to accommodate these needs is for government to evaluate the land resources available, assess present and future requirements, and then allocate uses within areas to provide the optimum match between the land's ecological characteristics around the various uses imposed. Good uses of land resources for agricultural production is achieved when each required use has been located on suitable land and when each combination of land type and use is being managed in a way to avoids land degradation that might prevent such uses from being sustained.

Poor land use decisions (e.g., about the sorts and intensity of development that will be allowed on a piece of land) can result in big changes to natural land watersheds and water quality. Low-intensity uses include open spaces including woodlands, shrubs, grassland, farmland, and managed green spaces, whereas high-intensity uses include the likes of residential, commercial and industrial land use.

4.0 CONCLUSION

In this unit, we explained land use and its functions in the tropics. We also learnt that land can be defined as man’s activity on the land or the purpose for which the land is being used. The same land use can occur on several different parcels of land, and reciprocally, the same land may have several uses.

5.0 SUMMARY

Globally, the available country area was 136,096,598 km^2 including 130,121,447 km^2 for land area and 5,975,151 km^2 for inland water. The land area is divided among different types of use. Agricultural land accounts for 49,322,388 km^2 (arable land accounts for 14,121,800 km^2 and permanent crops 1,426,704 km^2); forests: 39,394,070km2; and other land represents 41,404,989 km^2. Land is highly sought for various human activities. Such activities (current or future) depend, to a greater or lesser degree, on the surface of the earth, its minerals, its water and its other renewable and non-renewable resources.

6.0 TUTOR-MARKED ASSIGNMENT

1. Define land use with examples.
2. Explain the functions of land use.

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UNIT 5 MATCHING LAND USES TO LAND TYPES

1.0 INTRODUCTION

The most appropriate way to match land uses to land types is to locate those uses that provide the most protection on the hazardous areas of land and to use the least hazardous areas for those uses offer the least protection. Land varies in its ability to provide suitable environmental conditions for different uses. It also varies in its stability and its capacity to resist erosive forces when subjected to inadequate management. Land suitability classification characterizes the former, and land capability classification the latter.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- Explain land capability classification with examples.
- Explain land use for perennial crops.
- Give examples of land use matching land type

3.0 MAIN CONTENT

3.1 Land capability classification

Land capability classification permits the ranking of the land's natural units according to their relative erosion hazards. Combining this information with the distribution and characteristics of different soils across an area enables the delineation of distinct units of land that differ according to their management needs. Within the boundary of any one such unit, a specific form of management for the chosen use is applied to give even crop yields over the entire unit. In a neighboring unit, different management may be needed to achieve the same or similar result. Different forms of land use vary in their capacity to protect or damage land resources. It is not sufficient to classify the many different types of agricultural use into “annual crops”, “pastures”, or “forests”. This is because the ways in which they are managed have significant effects on their capacity for production and on their protective characteristics. These are closely related to the amount of low-level cover that they provide to the soil surface and to the ways in which their management affects soil structural conditions. For example, poorly managed pasture on a steep slope with compacted soils and little vegetative cover may be less productive or protective use than a well-managed system of annual crops under minimum tillage and maintenance of excellent cover and structural conditions on the same slope.

3.2 Land use for Perennial Crops

Perennial crops, such as citrus, coconut, and apple trees, provide almost no effective protection to any bare soil beneath them. They may be too widely spaced to provide an even cover on the one hand, and on the other the leaves are so far off the ground that big water drops gain high speed before reaching the soil surface. It is the low-growing g-asses, legumes, or mulch covering the soil surface between the trees of a well-managed plantation that provide protection, not the trees themselves. If uniform management is applied equally across an area, which is in fact a mosaic of units of differing characteristics, that management will be appropriate for some of the area and less appropriate for the remainder. By affecting crop cover and yields to different extents, this may unnecessarily expose parts of the area to risk of degradation; it may also represent an inefficient use of inputs.

3.3 Land Use Matched with land type.

In many situations, current land use may appear inappropriately matched with land type, such as the poorly managed cultivation of annual crops on steep slopes normally considered non-arable in an area of erosive rainfall. Often, for social or political reasons, a change in land use, from annual cropping to forest plantations, for example, may be impossible. Nevertheless, a better matching of use with land type can often be made by improving the characteristics of the current use. For example, improvements in the physical and chemical conditions of fertility can enhance crop yields, with which are associated a better cover of plant leaves and litter above and on the soil surface. The better the characteristics of the use are matched with the characteristics of the land, the easier it will be keep that use productive and the land stable.

4.0 CONCLUSION

At the end of this unit, we explain land capability classification which permits the ranking of the land's natural units according to their relative erosion hazards. We also learnt that combining this information with the distribution and characteristics of different soils across an area enables the delineation of distinct units of land that differ according to their management needs. This includes land use as perennial crop and match with land type.

5.0 SUMMARY

In many situations, current land use may appear inappropriately matched with land type, such as the poorly managed cultivation of annual crops on steep slopes normally considered non-arable in an area of erosive rainfall. Often, for social or political reasons, a change in land use, from annual cropping to forest plantations, for example, may be impossible. Nevertheless, a better matching of use with land type can often be made by improving the characteristics of the current use. For example, improvements in the physical and chemical conditions of fertility can enhance crop yields, with which are associated a better cover of plant leaves and litter above and on the soil surface.

6.0 TUTOR-MARKED ASSIGNMENT

1. Give one example each for good and poor matching land use to land type.
2. Briefly explain land use type for perennial crops with example.

7.0 REFERENCES/FURTHER READING

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MODULE 2 SOIL EROSION AND CONTROL

UNIT 1 SOIL EROSION

CONTENTS

1.0 INTRODUCTION

Soil is an important factor for crop and livestock production. The plants depend on it for support; nutrients, water and air and the animals depend on it for the grazing materials they need. It takes 300-1000 years for nature to build a single inch of soil. It therefore follows that if we allow our soils to be destroyed it will take many generations before it can be built up again for use. The process by which soil is removed in part or whole by rainwater or wind is called "soil erosion." Some understanding by which soil erosion occurs and the factors which influence it will help us appreciate the measures for control.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- Define soil erosion
- Outline causative agent of soil erosion
- Explain drivers of erosion

3.0 MAIN CONTENT

3.1 Concept of soil erosion

The term "Erosion" comes from *erodere*, a Latin verb meaning "to gnaw." Soil erosion is defined as the part of the overall process of denudation that includes the physical breaking down, chemical solution and transportation of material. Soil erosion occurs in both temperate and tropical regions and it is widely considered to be a serious threat to the long-term viability of agriculture in many parts of the world. This concern is not without precedent. Erosion requires an agent, either wind or water. The level of erosion in a given place is determined by the interaction of a number of factors including climatic erosivity, soil erodibility and land use/management.

Climatic erosivity can be more acute in many tropical areas, particularly where rainfall is concentrated in fewer, more intense events. Soils in the tropics are often highly erodible, given their relatively shallow depth and low structural stability. While certain tropical soils are not particularly erodible in the absence of human interference, they can still be very susceptible to dramatic fertility decline. Indeed, the consequences of soil erosion are often more severe in the tropics than in temperate regions because of the greatly inferior fertility of the subsoil. As climatic erosivity and soil erodibility are essentially given, land use and management practices are the deciding factor in determining the extent of soil erosion and erosion induced degradation.

On a given plot of agricultural land, erosion can vary from acute to almost nil depending on the cropping system. Vegetative cover plays a crucial role as erosion is significantly reduced under thick cover. In some cases a vicious cycle can arise, where erosion reduces soil productivity, resulting in less crop cover and hence more erosion and so on. This “self-reinforcing feedback” highlights the problems facing poorer smallholder farmers in developing countries. Due to this sector’s lack of access to external resources, productivity on agricultural land is already low. In other words, generally poor crop cover means that poorer farms may suffer from more severe erosion on their land, resulting in less future production and even more erosion.

3.2 Causative Agents of Soil Erosion

There are two main types of erosion: geologic and accelerated erosion.

a. Geologic erosion

This is a normal process of weathering that generally occurs at low rates in all soils as part of the natural soil-forming processes. It occurs over long geologic time horizons and is not influenced by human activity. The wearing away of rocks and formation of soil profiles are processes affected by the slow but continuous geologic erosion. Indeed, low rates of erosion are essential to the formation of soil. In contrast, soil erosion becomes a major concern when the rate of erosion exceeds a certain threshold level and becomes rapid. One of the most natural causes of erosion is rainfall. Rainfall can be devastating to soil because of the force and impact in which it hits the topsoil with. These splashing affects cause soil to lose particles and shift and move around into unknown places. When the eroded area (which has been caused by water) dries up it is known to form gullies and large cracks in the surface which can be so damaging to rural and farming properties. Wind is another natural factor which causes erosion. Wind is known to pick up soil and shift it to another space whilst it does so the actual soil decomposes and loses its soil particles. Wind and water together can cause erosion to occur severely. Wind itself can not cause as much harm as they do together. Ice and snowfall are another 2 natural causes of erosion and they too can be devastating to crop yields, landscaped gardens, land investments and commercial parks.

b. Accelerated Erosion

This type of erosion is triggered by anthropogenic causes such as deforestation, slash-and burn agriculture, intensive plowing, intensive and uncontrolled grazing, and biomass burning. Control and management of soil erosion are important because when the fertile topsoil is eroded away the remaining soil is less productive with the same level of input. While soil erosion cannot be completely curtailed, excessive erosion must be reduced to manageable or tolerable level to minimize adverse effects on productivity. Magnitude and the impacts of soil erosion on productivity depend on soil profile and horizonation, terrain, soil management, and climate characteristics. The specific rates of maximum tolerable limits of erosion vary with soil type. In fact, moderate soil erosion may not adversely affect productivity in well-developed and deep soils, but the same amount of erosion may have drastic effects on shallow and sloping soils. Thus, critical limits of erosion must be determined for each soil, ecoregion, land use, and the farming system.

3.3 Drivers of Soil Erosion

Anthropogenic activities involving deforestation, overgrazing, intensive cultivation, soil mismanagement, cultivation of steep slopes, and urbanization accelerate the soil erosion hazard. Land use and management, topography, climate, and social, economic, and political conditions influence soil erosion). In developing countries, soil erosion is directly linked to poverty level. Resource-poor farmers lack means to establish conservation practices. Subsistence agriculture forces farmers to use extractive practices on small size farm (0.5–2 ha) year after year for food production, delaying or completely excluding the adoption of conservation practices that reduce soil erosion risks. The leading three causes of accelerated soil erosion are: deforestation, overgrazing, and mismanagement of cultivated soils. About 35% of soil erosion is attributed to overgrazing, 30% to deforestation, and 28% to excessive cultivation.

4.0 CONCLUSION

At the end of this unit, we learned the concept of soil erosion, causative agents and drivers of soil erosion. We also defined soil erosion as the part of the overall process of denudation that includes the physical breaking down, chemical solution and transportation of material. Soil erosion occurs in both temperate and tropical regions and it is widely considered to be a serious threat to the long-term viability of agriculture in many parts of the world. This concern is not without precedent. Erosion requires an agent, either wind or water. The level of erosion in a given place is determined by the interaction of a number of factors including climatic erosivity, soil erodibility and land use/management.

5.0 SUMMARY

On a given plot of agricultural land, erosion can vary from acute to almost nil depending on the cropping system. Vegetative cover plays a crucial role as erosion is significantly reduced under thick cover. In some cases a vicious cycle can arise, where erosion reduces soil productivity, resulting in less crop cover and hence more erosion and so on. This “self-reinforcing feedback” highlights the problems facing poorer smallholder farmers in developing countries. Due to this sector’s lack of access to external resources, productivity on agricultural land is already low.

6.0 TUTOR-MARKED ASSIGNMENT

1. Define soil erosion
2. List and explain causative agent of erosion

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UNIT 2 PROCESSES OF SOIL EROSION

CONTENTS

1.0 INTRODUCTION

Water erosion is a complex three-step natural phenomenon which involves *detachment*, *transport*, and *deposition* of soil particles. The process of water erosion begins with discrete raindrops impacting the soil surface and detaching soil particles followed by transport. Detachment of soil releases fine soil particles which form surface seals. These seals plug the open-ended and water-conducting soil pores, reduce water infiltration, and cause runoff. At the micro scale level, a single raindrop initiates the whole process of erosion by weakening and dislodging an aggregate which eventually leads to large-scale soil erosion under intense rainstorms. The three processes of erosion act in sequence.

The first two processes involving dispersion and removal of soil define the amount of soil that is eroded, and the last process (deposition) determines the distribution of the eroded material along the landscape. If there were no erosion, there would be no deposition. Thus, detachment and entrainment of soil particles are the primary processes of soil erosion, and, like deposition, occur at any point of soil. When erosion starts from the point of raindrop impact, some of the particles in runoff are deposited at short distances while others are carried over long distances often reaching large bodies of flowing water.

2.0 OBJECTIVES

At the end of the unit, you should be able to:

- Explain the three processes of soil erosion.
- Outline the factors of water erosion.
- State the factor affecting water erosion
- Explain major soil properties controlling soil erosion at field-scale.

3.0 MAIN CONTENT

3.1 Three main processes of soil erosion

1. Detachment

- Soil detachment occurs after the soil adsorbs raindrops and pores are filled with water.
- Raindrops loosen up and break down aggregates.
- Weak aggregates are broken apart first.
- Detached fine particles move easily with surface runoff.
- When dry, detached soil particles form crusts of low permeability.
- Detachment rate decreases with increase in surface vegetative cover.

2. Transport

Detached soil particles are transported in runoff which involves the following;

- Smaller particles (e.g., clay) are more readily removed than larger (e.g., sand) particles.
- The systematic removal of fine particles leaves coarser particles behind.
- The selective removal modifies the textural and structural properties of the original soil.
- Eroded soils often have coarse-textured surface with exposed subsoil horizons.
- Amount of soil transported depends on the soil roughness.
- Presence of surface residues and growing vegetation slows runoff.

3. Deposition

It occurs when the detached and transported soil particles by rain are deposited as sediment. This is because the level area causes a decrease in the velocity which results in deposition. It involves the following;

- Transported particles deposit in low landscape positions.
- Most of the eroded soil material is deposited at the downslope end of the fields.
- Placing the deposited material back to its origin can be costly.
- Runoff sediment transported off-site can reach downstream water bodies and cause pollution.
- Runoff sediment is deposited in deltas along streams.
- Texture of eroded material is different from the original material because of the selective transport process

3.2 Factors of water erosion

The major factors controlling water erosion are:

- Precipitation,
- Vegetative cover,
- Topography, and
- Soil properties.

The interactive effects of these factors determine the magnitude and rate of soil erosion. For example, the longer and steeper the slope, the more erodible the soil and the greater the transport capacity of runoff under an intense rain. The role of vegetation on preventing soil erosion is well recognized. Surface vegetative cover improves soil's resistance to erosion by stabilizing soil structure, increasing soil organic matter, and promoting activity of soil macro- and micro-organisms. The effectiveness of vegetative cover depends on plant species, density, age, and root and foliage patterns.

3.3 Factors affecting water erosion

1. Climate; This involves;

- All climatic factors (e.g., precipitation, humidity, temperature, evapotranspiration, solar
  radiation, and wind velocity) affect water erosion.
- Precipitation is the main agent of water erosion.
- Amount, intensity, and frequency of precipitation determine the magnitude of erosion.

- Intensity of rain is the most critical factor.
- The more intense the rainstorm, the greater the runoff and soil loss.
- High temperature may reduce water erosion by increasing evapotranspiration and reducing the soil water content.
- High air humidity is associated with higher soil water content.
- Higher winds increase soil water depletion and reduce water erosion.

2. Vegetative cover

- Vegetative cover reduces erosion by intercepting, adsorbing, and reducing the erosive energy of raindrops.
- Plant morphology such as height of plant and canopy structure influences the effectiveness of vegetation cover.
- Surface residue cover sponges up the falling raindrops and reduces the bouncing of drops. It increases soil roughness, slows runoff velocity, and filters soil particles in runoff.
- Soil detachment increases with decrease in vegetative cover.
- Dense and short growing (e.g., grass) vegetation is more effective in reducing erosion than sparse and tall vegetation.
- The denser the canopy and thicker the litter cover, the greater is the splash erosion control, and the lower is the total soil erosion.

3. Topography

- Soil erosion increases with increase in field slope.
- Soil topography determines the velocity at which water runs off the field.
- The runoff transport capacity increases with increase in slope steepness.
- Soils on convex fields are more readily eroded than in concave areas due to interaction with surface creeping of soil by gravity.
- Degree, length, and size of slope determine the rate of surface runoff.
- Rill, gully, and stream channel erosion are typical of sloping watersheds.
- Steeper terrain slopes are prone to mudflow erosion and landslides

4. Soil properties

- Texture, organic matter content, macro porosity, and water infiltration influence soil erosion.
- Antecedent water content is also an important factor as it defines the soil pore space available for rainwater absorption.
- Soil aggregation affects the rate of detachment and transportability.
- Clay particles are transported more easily than sand particles, but clay particles form stronger and more stable aggregates.
- Organic materials stabilize soil structure and coagulate soil colloids.
- Compaction reduces soil macro porosity and water infiltration and increases runoff rates.
- Large unstable aggregates are more detachable.
- Interactive processes among soil properties define soil erodibility.

3.4 Major Soil Properties Controlling Soil Erosion at Field-scale

1. Particle size distribution

Particle size analysis has an advantage over texture determinations carried out by hand in the field, in that it enables the classification of sandy loams as either very fine, fine, medium, or coarse based on the exact particle size range within the sand fraction, which is difficult to determine accurately by hand estimation. The fineness of the sand particles within a sandy loam is important when assessing its susceptibility to erosion. Resistance to erosion is lowest for small non-cohesive grains, particularly silt and fine sand-sized particles with low clay content.

Particle size distribution is one of the major soil properties governing soil erodibility and is one of the crucial factors required to assess soil erodibility in terms of the K-factor of Wischmeier and Smith (1978). The K-factor is a lumped parameter that represents an integrated average annual value of the soil profile reaction to the processes of soil detachment and transport by raindrop impact and surface flow.

2. Soil organic carbon/matter

Soil organic carbon also serves to bind individual soil particles into larger aggregates and is important in maintaining the aggregate stability.

By keeping the aggregates in soil stable (by combining with soil minerals), it promotes infiltration, the movement and retention of water, helps develop and stabilize soil structure, cushions the impact of wheel traffic and cultivators, and reduces the potential for wind and water erosion). Generally, organic matter (OM) can hold up to 20 times its weight in water and can, therefore, directly affect soil water retention, which makes soil more resistant to drought and erosion, as well as indirectly through its positive effects on soil structure. The texture of a soil strongly influences SOM storage, with coarse textured soils being particularly vulnerable to SOM decline. Furthermore, the decline of SOC levels has been highlighted in numerous legislative reports and scientific papers as contributing to a decline in soil quality and can result in increased soil erosion, loss of nutrients and an increased susceptibility to compaction.

3. Bulk density

The natural rate of soil erosion is accelerated by increased soil bulk density (BD) resulting from vehicular traffic-induced compaction. A healthy soil bulk density is important in terms of sustainable soil productivity and environmental well-being. High BD values indicate a poorer environment for root growth, reduced aeration and undesirable changes in hydrologic function, such as reduced water infiltration. Since erosion will not occur without surface runoff, soil infiltration rate is important in relation to erosion. The higher the BD in surface or sub-surface layers, the lower will be the total porosity and hence the greater the risk of surface runoff.

Surface compaction along tramlines and wheelings can trigger erosion problems in winter cereal crops. In well-graded loam and sandy loam soils, the susceptibility to compaction can be very high because smaller particles can fit into spaces between larger particles, thus providing the ideal proportions of particles of different sizes to achieve the densest packing arrangements. In clayey soils, BD normally ranges from 1.2 to 1.5 ton m^{-3} and in sandy soils from 1.6 to 1.9 ton m^{-3}. Irrespective of soil textural group, arable soils consistently have a higher BD than other land uses.

4. Aggregate stability

Aggregate stability is one of the most complex and dynamic soil properties affecting principal physical and hydraulic soil characteristics, such as infiltration rate, hydraulic conductivity and erodibility. Crop management practices such as application of organic fertilizers, liming, incorporation of stubble and min-till or no-till cultivation, can improve aggregate stability. Aggregation is essentially the flocculation and cementation of individual soil particles to form aggregates. The primary soil properties influencing aggregation and aggregate stability are texture, clay mineralogy, soil organic matter (SOM), cations, sesquioxides and calcium carbonate. Clay flocculation promotes soil aggregation and structural stability.

The general consensus is that the clay fraction has a positive effect on structural stability compared to the silt and sand fractions. Cations such as Fe^{3+}, Al^{3+}, Mg^{2+} and Ca^{2+} serve to: (1) stimulate the precipitation of compounds that act as bonding agents for primary soil particles and (2) form bridges between clay and SOM particles resulting in aggregation. It was shown that Ca^{2+} ions were more effective than Mg^{2+} in aggregating soil clays and that if soils are prone to surface sealing, it is beneficial to manage them to high Ca:Mg ratios. High concentrations of Al and Fe oxides and hydroxides, often referred to as cementing agents, have the effect of increasing aggregate stability. The presence of Al and Fe oxide in soils also has a favourable effect on soil structure. Evidence of soil structural improvement is provided by increased aggregate stability, permeability, friability, porosity, and hydraulic conductivity. In general, Al oxides have a greater stabilizing effect than spherical Fe oxides on structure because of their platy morphology.

Water is the main cause of aggregate breakdown in most soils, either directly by rainfall or by surface runoff. Water-stable aggregation on the soil surface is therefore important when considering the inherent erodibility of a soil and its susceptibility to soil structural decline.

There are four main mechanisms for aggregate breakdown:

(1) slaking;
(2) differential swelling;
(3) mechanical; and
(4) physicochemical dispersion.

Slaking is the spontaneous disintegration of a soil aggregates which have insufficient strength to withstand the stresses induced by rapid water intake. Differential swelling depends on the same properties as slaking and produces similar micro aggregates, but normally occurs in soils with higher clay contents. Mechanical breakdown is a result of the kinetic energy imparted to the soil by rain drop impact. Physicochemical dispersion is the complete breakdown of aggregates into primary particles because the attractive forces holding the particles together are lessened by wetting.

4.0 CONCLUSION

In this unit, we explained the main processes of soil erosion, factors of water erosion, factor affecting water erosion and major soil properties controlling soil erosion at field-scale. We also learnt that erosion process occurs when the detached and transported soil particles by rain are deposited as sediment. This is because the level area causes a decrease in the velocity which results in deposition.

5.0 SUMMARY

The interactive effects of precipitation, vegetation, topography and soil properties factors determine the magnitude and rate of soil erosion. For example, the longer and steeper the slope, the more erodible the soil, and the greater the transport capacity of runoff under an intense rain. The role of vegetation on preventing soil erosion is well recognized. Surface vegetative cover improves soil's resistance to erosion by stabilizing soil structure, increasing soil organic matter, and promoting activity of soil macro- and micro-organisms. The effectiveness of vegetative cover depends on plant species, density, age, and root and foliage patterns.

6.0 TUTOR-MARKED ASSIGNMENT

1. List with examples the main processes of soil erosion.
2. State the factor affecting water erosion
3. List and briefly explain the major soil properties controlling soil erosion at field-scale.

7.0 REFERENCES/FURTHER READING

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UNIT 3 ECONOMIC IMPORTANCE OF SOIL EROSION

CONTENTS

1.0 INTRODUCTION

Accelerated soil erosion causes adverse agronomic, ecologic, environmental, and economic effects both on-site and off-site. Not only it affects agricultural lands but also quality of forest, pasture, and rangelands. Cropland soils are, however, more susceptible to erosion because these soils are often left bare or with little residue cover between the cropping seasons. Even during the growing season, row crops are susceptible to soil erosion. The on-site consequences involve primarily the reduction in soil productivity, while the off-site consequences are mostly due to the sediment and chemicals transported away from the source into natural waters by streams and depositional sites by wind.

2.0 OBJECTIVES

At the end of the unit, you should be able to:

- Explain on-site Problems of erosion
- Highlight Off-site problem of erosion.
- State the impact of gully erosion.
- Explain Some of the Erosion-induced Soil Degradation Processes
- Discuss different kinds of erosion.

3.0 MAIN CONTENT

3.1 On-site Problems

The primary on-site effect of erosion is the reduction of topsoil thickness, which results in soil structural degradation, soil compaction, nutrient depletion, loss of soil organic matter, poor seedling emergence, and reduced crop yields. There is potential for soil biota to be transported by the same erosive mechanisms. This subsequent loss may exacerbate soil susceptibility to wind erosion, since it has been demonstrated that biota are important in aggregating soil. Removal of the nutrient-rich topsoil reduces soil fertility and decreases crop yield. Soil erosion reduces the functional capacity of soils to produce crops, filter pollutants, and store C and nutrients. One may argue that, according to the law of conservation of matter, soil losses by erosion in one place are compensated by the gains at another place. The problem is that the eroded soil may be deposited in locations where either no crops can be grown or it buries and inundates the crops in valleys.

3.2 Off-site Problems

Water and wind erosion preferentially remove the soil layers where most agricultural chemicals (e.g., nutrients, pesticides) are concentrated. Thus, off-site transport of sediment and chemicals causes pollution, sedimentation, and silting of water resources. Sediment transported off-site alters the landscape characteristics, reduces wildlife habitat, and causes economic loss. Erosion also decreases livestock production through reduction in animal weight and forage production, damages water reservoirs and protective shelterbelts, and increases tree mortality. Accumulation of eroded materials in alluvial plains causes flooding of downstream croplands and water reservoirs. Soil erosion also contributes to the projected global climate change. Large amounts of C are rapidly oxidized during erosion, exacerbating the release of CO_2 and CH_4 to the atmosphere.

Wind erosion causes dust pollution, which alters the atmospheric radiation, reduces visibility, and causes traffic accidents. Dust particles penetrate into buildings, houses, gardens, and water reservoirs and deposit in fields, rivers, lakes, and wells, causing pollution and increasing maintenance costs. Dust storms transport fine inorganic and organic materials, which are distributed across the wind path. Most of the suspended particles are transported off-site and are deposited hundreds or even thousands of kilometers far from the source. Airborne fine particulate matter with high diameters PM10 and PM2.5 pose an increasing threat to human and animal health, industrial safety, and food processing plants. Finer particles float in air and are transported at longer distances than coarser particles. Particle size of the deposited erotic material decreases with increase in distance from the source area. In the Sahara, a region in Africa with one of the highest wind erosion rates, dust emissions range between 400 and 700 Tg per year and are prone to increase with the projected change in climate.

A number of changes in physical, chemical, and biological processes occur due to the accelerated soil erosion. These processes rarely occur individually but in interaction with one another. For example, compact soils are more prone to structural deterioration (physical process), salinization (chemical process), and reduced microbial activity (biological process) than un-compacted soils. Some processes are more dominant in one soil than in another. Salinization is often more severe in irrigated lands with poor internal drainage than in well-drained soils of favorable structure.

3.3 Impacts of Gully Erosion

In Nigeria, the impacts of gully erosion are enormous and similar to that obtainable elsewhere in the world and they include:

i) **Loss of Farmland**: A vast area of farmlands has been lost due to the menace of gully erosion while others are at their various stages of destruction leading to drastic decrease in agricultural productivity and ultimately food shortage that can lead to famine.

ii) **Treat to Vegetation**: The gully erosion in Nigeria has resulted in loss of vegetation as its continuous expansion encroaches into areas that are hitherto forest leading to falling of trees and exposure of more surface areas to gully activities. The phenomenon if allowed to continue and remains unchecked may ultimately lead to climatic changes locally or globally.

iii) **Effect on Properties**: Several properties whose value cannot be quantified accurately here have been destroyed and others are under treat by this menace especially houses and other properties located on the floodplain. About 10 houses have been lost in a single event of gully erosion in Auchi area of Edo State. Besides, it was reported recently that over 450 buildings are lost in Edo State of Nigeria as a result of erosion. On a separate note, Committee on Erosion and Ecological matter recently discovered 15 gully sites in Bida, Niger State of Nigeria. Apart from untimely evacuation from these gully sites, infrastructural facilities such as pipelines, utility cables, roads and houses also suffer from these hazardous events.

iv) **Effect on Life**: Many lives have been lost as a result of the problem of gully erosion. Some either fell into these gullies and sustained various degrees of injury or died. Some instances have also been reported where people are drowned in some of the gully sites. About 23 people have been reported in the past few years to have lost their lives in a single event of gullying activities Inibori, Ugbalo, Ewu-Eguare, Idogalo and Oludide communities of Edo State, Nigeria. Millions of people have been displaced and evacuated their homes following the gully incidences. The gully erosion in Oko community in Anambra State has created a deep gully and wide crater, threatening to sweep away the homes of about 826 families as this channel is continuously expanding at an alarming rate.

v) **Isolation of Villages and Towns:** Gully erosion has resulted in the separation of adjacent villages and towns as it may involve collapse of the bridges linking them together. This has had negative impacts on such areas since some facilities such as schools, hospitals and water supplies shared by the affected neighbouring communities may become inaccessible. Transportation of farm produce has also been affected and this also often leads to loss of agricultural products especially the perishable ones. Traders who also go to these areas for their trade are also cut off from their normal day-to-day business.

vi) **Bad Land:** Gully erosion has given rise to infertile and barren land that may need to be reclaimed. This usually brings untold hardship to the inhabitants if the land is still inhabitable but has been severely affected. Anambra State has lost over 30 percent of her land, and over 40 percent of the total area of land and homes are being threatened by the menace according to the Anambra State Ministry of Environment.

3.4 Some of the Erosion-induced Soil Degradation Processes

a. Physical Processes Increase in:

- Surface sealing
- Crusting
- Compaction
- Deflocculation
- Sand content

Decrease in:
- Topsoil depth
- Soil structural stability
- Macroporosity
- Plant available water capacity
- Water infiltration

b. Chemical Processes

Increase in:
- Acidification
- Salinization
- Sodication
- Water pollution

Decrease in:
- Cation exchange capacity
- Nutrient storage and cycling
- Biogeochemical cycles

c. Biological Processes

Decrease in:
- Biomass production
- Soil organic matter content
- Nutrient content and cycling
- Microbial biomass, activity,and diversity

Increase in:
- Organic matterdecomposition
- Eutrophication
- Hypoxia
- Emission of greenhouseGases

3.5 Kinds of Erosion

Water Erosion

On a global scale, water erosion is the most severe type of soil erosion. It occurs in the form of splash/inter rill, rill, gully, tunnel, stream bank, and coastal erosion. Runoff occurs when precipitation rates exceed the water infiltration rates. Both raindrop impact and water runoff can cause soil detachment and transport. Unlike wind erosion, water erosion is a dominant form of erosion in humid, and sub-humid, regions characterized by frequent rainstorms. It is also a problem in arid and semiarid regions where the limited precipitation mostly occurs in the form of intense storms when the soil is bare and devoid of vegetal cover. One of the spectacular types of water erosion is the concentrated gully erosion which can cause severe soil erosion even in a single event of high rainfall intensity. Excessive gully erosion can wash out crops, expose plant roots, and lower ground water table while adversely affecting plant growth and landscape stability. Gullying is a major source of sediment and nutrient loss. It causes drastic alterations in landscape aesthetics and removes vast amounts of sediment. Sedimentation at the lower end of the fields in depressional sites can bury crops, damage field borders, and pollute water bodies. Gullies dissect the field and exacerbate the non-point source pollution (e.g., sediment, chemicals) to nearby water sources. Gullies undercut and split croplands and alter landform features and watercourses.

Overland flow occurs either when precipitation exceeds infiltration capacity (infiltration excess overland flow), or when soil pore spaces are full as a result of groundwater flow or interflow (saturation excess overland flow. The onset of overland flow depends on antecedent soil water, hydraulic conductivity of soil, and precipitation rate and volume. Initiation of overland flow is typically associated with ponding and sheet flow, developing into complex patterns, influenced by micro-topography and local obstacles. Hydrological flow is typically laminar and selective detachment, entrainment, transport and down slope deposition of fine soil particles occurs. Rills can form as a result of convergence of overland flow, or occasionally by sapping mechanisms (flow of groundwater out of banks on hill slopes), into concentrated micro-channels (dimensions 2–250mm wide and deep). Confined flow causes scour of rill beds, often accompanied by collapse of steep side-walls that generates sediment of non-specific particle size for transport.

Wind Erosion

Wind erosion is a widespread phenomenon, especially in arid and semi-arid regions. It is a dominant geomorphic force that has reshaped the earth. Wind erosion is caused by the combined effect of high wind velocity, loose surface-soil particles and insufficient soil surface protection. Through surface creep, siltation and suspension, soil particles can be eroded. Most of the material carried by wind consists of silt-sized particles. Deposition of this material, termed as “loess”, has developed into very fertile and deep soils. The thickness of most loess deposits ranges between 20 and 30 m, but it can be as thick as 335m (e.g., Loess Plateau in China). Extensive deposits of loess exist in northeastern China, Midwestern USA, Las Pampas of Argentina, and central Europe. Excessive wind erosion due to soil mismanagement has, however, caused the barren state of many arid lands. Anthropogenic activities set the stage for severe wind erosion by directly influencing soil surface conditions through deforestation and excessive tillage. Wind erosion is prominent but not unique to arid regions. High winds, low precipitation ($\leq$300mm annually), high evapotranspiration, reduced vegetative cover, and limited soil development are the main drivers of wind erosion in arid and semiarid regions. Rates of wind erosion increase in the order of: arid>semiarid>dry subhumid areas>humid areas. Unlike water, wind has the ability to move soil particles up- and down-slope and can pollute both air and water. While arid lands are more prone to wind erosion than humid ecosystems, any cultivated soil that is seasonally disturbed can be subject to aeolian processes in windy environments.

Wind erosion not only alters the properties and processes of the eroding soil but also adversely affects the neighboring soils and landscapes where the deposition may occur. Landscapes prone to wind erosion often exhibit an impressive network of wind ripples (<2m high). Formation of sand dunes in deserts or along beaches is a sign of excessive wind erosion. Sand dunes can be as high as 200m in desert regions of the world (e.g., Saudi Arabia). The smaller sand dunes often migrate and form larger sand dunes. There are fast moving as well as slow drifting dunes.

4.0 CONCLUSION

At end of this unit, we explain economic importance of soil erosion which covers on-site problems of soil erosion, off-site problems erosion, impacts of gully erosion, some of the erosion-induced soil degradation processes and kinds of soil erosion. We also learnt that a number of changes in physical, chemical, and biological processes of soil occur due to the accelerated soil erosion. These processes rarely occur individually but in interaction with one another. For example, compact soils are more prone to structural deterioration (physical process), salinization (chemical process), and reduced microbial activity (biological process) than un-compacted soils. Some processes are more dominant in one soil than in another. Salinization is often more severe in irrigated lands with poor internal drainage than in well-drained soils of favorable structure.

5.0 SUMMARY

The primary effect of erosion is the reduction of topsoil thickness, which results in soil structural degradation, soil compaction, nutrient depletion, loss of soil organic matter, poor seedling emergence, and reduced crop yields. There is potential for soil biota to be transported by the same erosive mechanisms. This subsequent loss may exacerbate soil susceptibility to wind erosion, since it has been demonstrated that biota are important in aggregating soil. Removal of the nutrient-rich topsoil reduces soil fertility and decreases crop yield. Soil erosion reduces the functional capacity of soils to produce crops, filter pollutants, and store C and nutrients. One may argue that, according to the law of conservation of matter, soil losses by erosion in one place are compensated by the gains at another place. The problem is that the eroded soil may be deposited in locations where either no crops can be grown or it buries and inundates the crops in valleys.

6.0TUTOR-MARKED ASSIGNMENT

1. Outline the physical, chemical and biological processes of erosion induced degradation process
2. State the impact of gully erosion
3. List and explain three kind of erosion

7.0 REFERENCES/FURTHER READING

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UNIT 4 TYPES OF SOIL EROSION

CONTENTS

1.0 INTRODUCTION

There are several components of soil erosion by water, most commonly divided into four categories, inter rill, rain splash, rill, sheet and gully erosion.

2.0 OBJECTIVES

At the end of the unit, you should be able to:

- Define inter-rill erosion with example
- Explain Rain-splash erosion
- Explain sheet erosion
- Explain Rill erosion
- Discus gully erosion
- Highlight types of gullies erosion
- Outline the Relationship between Soil Erosion and Agricultural Productivity

3.0 MAIN CONTENT

3.1 Inter-rill erosion

As soon as it starts, runoff promptly develops diminute rills, and that portion of runoff that flows between rills is called sheet or inter rill erosion. This type of erosion is mostly due to shallow flow. Some particles are carried away in runoff flowing in a thin sheet and some concentrate in small rills. Inter rill is the most common type of soil erosion. Splash and inter rill erosion make up about 70% of total soil erosion and occur simultaneously although splash erosion dominates during the initial process. Inter rill erosion is a function of particle detachment, rainfall intensity, and field slope.

3.2 Rain-splash erosion

The kinetic energy in raindrops initiates the erosion process on impact with the soil surface. Large soil aggregates are dispersed and small particles splashed over a distance of several tens of centimetres. The soil particles that are splashed downhill travel further than those that move up hill, causing a net downslope transport of soil. Rain splash erosion is particularly important on steep slopes without vegetation. A thick vegetation cover intercepts virtually all the kinetic energy of the rainfall. However, the protective effects of vegetation are not always as simple; the interception process in a forest may increase the erosive power of the drops. Another influence on rain splash erosion is the resistance of the soil to dispersal. High organic content and moderate amounts of clay and calcium promote the development of stable soil aggregates whereas silt and sand are dispersed more easily. In some cases rain splash erosion can account for 50 to 90 times the runoff losses.

3.3 Sheet Erosion

When rainfall intensity exceeds the infiltration capacity of the soil, there is a net accumulation of water on the land surface that runs downslope as an irregular sheet (Fig. 1). The depth and velocity of the water increases downslope until the force applied to the soil by the water is sufficient to overcome the resistance of the soil to erosion. The amount

of erosion depends on the water depth and hillslope gradient. A common scenario is for erosion to increase with distance as the gradient steepens downslope and then for erosion to decrease, or even for some deposition to occur on the gentle footslopes. The sheet of water is not uniform, and contains tiny streams and threads of water that are slightly deeper and faster than average. They move back and forth across the hillslope during a storm and with rainsplash are responsible for most of the erosion and soil transportation.
Fig 1. Sheet erosion progressing to rill erosion

3.4 Rill erosion

The concentration of overland flow, caused by surface irregularities and variations in topography, leads to rills (channels) (Fig. 2). Concentration of runoff in these channels creates an increase in the efficiency and intensity of soil removal. Rill erosion is more dominant on shorter, steeper slopes while interill erosion is more important on longer, gentler inclines. Rills erode downward until they reach the soil layer of low susceptibility to erosion. After that the rills widen by lateral erosion. If the subsoil is also susceptible to erosion, rills eventually transform into gullies.

Fig. 2 Rill erosion damaging ridges in cowpea field

3.5 Gully erosion

Gullies are larger channels, which cannot be removed by tillage operations. Gully erosion creates either V- or U-shaped channels (Fig. 3). The gullies are linear incision channels of at least 0.3m width and 0.3m depth. Gullies are primarily formed by concentrated runoff converging in lower points of the field. Thus, erosion occurring in these channels is known as concentrated flow erosion. Undulating fields cause runoff to concentrate in natural swales as runoff moves downslope in narrow paths in the form of channelized flow. Continued gully erosion removes entire soil profiles in localized segments of the field. As gullies grow, more sediment is transported. Gullies are normally back filled with soil from neighboring fields which reduces the topsoil depth. However, The amount of soil exported by a gully is small in comparison to other erosion processes, estimates range from 1 -2%, but the process can cause a large amount of damage to an individual tract of land and have local significance.

Gullies can develop through multiple mechanisms and are less common than rills, but where locally formed can erode soil at greater rates than rills. Gully dimensions are highly variable, but are typically 0.5–30m deep and again particle size of eroded sediment is non-selective. Soil can also be lost in agro ecosystems through mass movements, in the form of rotational and transitional landslides. Such features are usually localized and tend to be associated with the steepest ground (>20) with relatively little vegetation cover and with significant variations in water table height). Although localized, landslides can result in massive and non-selective soil losses downslope.

Fig. 3 Early stage of gully erosion

3.6 Types of gullies erosion

There are two types of gullies: ephemeral and permanent.

- Ephemeral gullies are shallow channels that can be readily corrected by routine tillage operations.

- In contrast, permanent gullies are too large to be smoothed by regular tillage or crossed by machinery traffic and require expensive measures of reclamation and control.
- Ephemeral gullies following removal tend to reform in the same points of the field if not controlled. Even if gullies are repaired by tillage, soil is already lost as the eroded material is transported off-site
- In permanent gullies erosion, it resulted to division of field into two or more at high intensity and at this stage it is expensive to control

3.7 Relationship between Soil Erosion and Agricultural Productivity

The relationship between soil erosion and agricultural productivity is complex and involves many different factors. By altering soil properties, erosion has direct effects on crop production. Erosion can decrease rooting depth, soil fertility, organic matter in the soil and plant-available water reserves. Thus, the exposed soil remaining will be less productive in a physical sense. These effects may be cumulative and not observed for a long period of time. Erosion may also affect yields by influencing not only the soil's properties but also the micro-climate, as well as the interaction between these two. In soils with edaphologically inferior subsoil and a shallow rooting depth, crop yield will decline as surface soil thickness is reduced by erosion. Furthermore, fertilizer cannot compensate for surface soil loss. Soil mismanagement can readily lead to irreversible soil degradation and loss of the Natural resource base. Symptoms of accelerated erosion often remain masked by the effects of improved technology such as fertilizer application. However, the longer it takes to recognize these symptoms, the more difficult it becomes to restore soil productivity.

In the tropics the soil's nutrient reserves are often concentrated in the thin surface horizon. Soils generally are infertile, and exposed subsoil is often unsuitable for root growth. In addition, drought adversely affects crop growth on eroded soils, even in humid and sub humid regions.

On these shallow, infertile tropical soils, productivity may decline more rapidly with less soil loss than on more fertile soils in temperate regions. This is not to say that all soils in the tropics have low levels of soil loss tolerance. Some soils of recent origin, for example, Andisols and Inceptisols, are highly productive. They feature edaphologically favorable subsoil characteristics. Erosion causes lower yield reductions on these soils than on old, highly weathered, and leached Alfisols, Ultisols, or Oxisols. Erosion inevitably reduces soil productivity. How much reduction occurs therefore, depends upon soil profile characteristics, the crop grown, soil management, and microclimate. In soils with edaphologically favorable subsoil, a loss of surface soil represents a loss of N and other nutrients. Although erosion increases production .costs on these soils, it causes little or no productivity loss. Fertilizer can compensate for most or all topsoil losses.

Unfortunately, quantifying the effects of erosion on crop production presents many difficulties. First of all, the extent to which erosion affects crop production will vary depending on the type of crop, the type of soil, the micro-climate, local topography and the management system. Thus, the extent to which quantification of the relationship can be transferred between sites may be very limited. Secondly, even supposing that collecting vast quantities of location-specific data presented no problems, it is still extremely difficult to determine the influence of any singlefactor on crop yields. Any attempt to measure the effect of erosion on yields will be almost impossible to control for other effects, such as variations in precipitation. These difficulties are particularly acute when one considers that the time frame involved (typically at least a few growing seasons) can result in many such uncontrollable variations. In addition, the interaction among the various factors affecting crop production is only poorly understood.

4.0 CONCLUSION

At the end of the unit, we explain types of soil erosion such as inter-rill erosion with example, rain-splash erosion, sheet erosion, rill erosion and gully erosion. We also learnt kind of gullies erosion (ephemeral and permanent) and relationship between soil erosion and agricultural productivity.

5.0 SUMMARY

Unfortunately, quantifying the effects of erosion on crop production presents many difficulties. First of all, the extent to which erosion affects crop production will vary depending on the type of crop, the type of soil, the micro-climate, local topography and the management system. Thus, the extent to which quantification of the relationship can be transferred between sites may be very limited.

6.0 TUTOR-MARKED ASSIGNMENT

1. List and explain briefly types of erosion
2. Outline the Relationship between Soil Erosion and Agricultural Productivity

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UNIT 5 SOIL PRODUCTIVITY RELATION AND MODELING

CONTENT

1.0 INTRODUCTION

There is a need for information on both gross and net erosion rates from agricultural land, so that the sediment delivery ratio (SDR), or proportion of the sediment mobilized by soil erosion that is transported towards local watercourses, rather than being deposited close to the original source, can be determined. Therefore, soil productivity relation and modeling was developed in order to achieve this.

2.0 OBJECTIVES

At the end of this unit you should be able to:

- Outline the Variables and Functions in Relation to Modeling
- Measuring and Quantifying Soil Erosion on Arable Land
- State the Erosion Modeling
- Differentiate between Empirical Models and Conceptual Model
- Explain the Physically-Based Model
- Discuss the Universal Soil Loss Equation

3.0 MAIN CONTENT

3.1 Variables and Functions in Relation to Modeling

A comprehensive farm-level soil conservation model should therefore include the following variables and functions:

a. Functional relationships which capture the impact of farm management choices (the control variables) on soil attributes (the state variables). These are the state equations in an optimal control framework.
b. State variables which reflect changes in soil depth and other productivity related soil characteristics.
c. Erosion-productivity linkages which relate changes in soil characteristics to crop yields.
d. Crop yield functions which incorporate both soil productivity and management variables so that substitution possibilities between soil and other inputs are explicitly included in the model.

3.2 Measuring and Quantifying Soil Erosion on Arable Land

Traditional monitoring techniques used to establish soil erosion rates have the inherent flaw of failing to determine the fate of eroded sediment and, therefore, given no indication of the impact of measured erosion rates on surface water quality. It is particularly difficult to assemble information on the spatial distribution of erosion and deposition rates within the landscape, and on the associated SDRs using traditional monitoring techniques.

Much of the information available on erosion rates has been collected from flume and erosion plot studies; however, these only provide information on the net rate of soil loss from the bounded area, as represented by the flux of sediment across its lower boundary. As such, plot studies typically overestimate erosion rates by failing to encompass major catchment sediment stores. These stores get larger as catchment area increases because the fraction of less steep slopes, like valley bottoms where sediment deposition occurs, also increase. It is for these reasons that the representativeness of plot results in terms of the wider landscape is often questioned. As the scale at which erosion is being studied increases from flume-to-plot and up to field- and catchment-scale, the parameters influencing this erosion change and, therefore, so must methods used to measure erosion. The use of sediment fingerprinting and composite fingerprints to determine the provenance of eroded sediment is one preferable method at larger scales.

3.3 Erosion Modeling

Soil erosion modelling is used as predictive and simulative tool for soil loss process. Soil detachment, transportation and deposition are the process being taken into account for erosion models rely upon the concept of transport capacity, which defined as the maximum amount of sediment that flow can carry without net deposition occurring. Erosion models have been widely used as the most feasible approaches to

generate the data on erosion hazard to be used in soil and land conservation planning, especially for agricultural land protection.
Generally three main types of erosion models are widely used in predicting soil loss as are:

1. Empirical
2. Conceptual and
3. Physically-based model.

Erosion models are usually defined with using ordinary differential equation by describing special change. The three models mentioned above have a number of similarities to each other's and they are deterministic in structure. These models are based on four main factors which including; climate, topography, vegetation cover and soil. One different thing among the models is how the erosion processes modify the surface during the erosion event. Another difference is whether these models seek to describe continuous simulation of the process or predicting only for single erosion event.

However, there is limitation in accurate estimation of soil erosion for two reasons, first reason is the high uncertainty of the model and second one is related to the special and temporal variability. The conclusion models is not recommended to use and even model is calibrated, it is not sure that the model will have a good predictive quality if the event is varied outside the range of calibration events, but special resolution is not seemed to play a role. On the other, the input data of the model probably is the most important reason of why more complex physically-based erosion models probably is the most important reason of why more complex physically-based erosion models do not predict better than lumped regression-based models.

3.4 Empirical Models and Conceptual Model

This type of erosion model is based primarily on observation and is usually statistical in nature. Empirical models are based on inductive logic and generally applicable only to the condition that parameters are calibrated. The key focus of empirical model process is prediction of average soil loss, although some extensions are known as: black-box where only main inputs and outputs are studied, grey-box where the more detail on how system work is explained, and white-box: where the detail of how the system work is known. Models representing empirical models are: USLE, RUSLE, RMMF, etc. the problem with empirical models is that equation cannot be extrapolated beyond their data range confidently, either events or other geographical area.

Whereas **conceptual model** is a type of model which lies between physically-based and empirical model, it is based on spatially dumped forms of water and sediment yield, basically using the concept of the unit hydrograph.

3.5 Physically-Based Model

Concerning the off-site effect of erosion and identification of non-point source pollution, scientists have put efforts to develop the models which can predict the special distribution of runoff and sediment over the land surface. To accomplish such objectives, the empirical models have considerable limitations. On the other hand; they cannot be applied universally, they cannot be used on scales varying from individual fields to large catchments. Therefore, the physically-based methods become important.

Physically-based or process-based models are functionally based on the mathematical equations that describe the erosion process. They are intended to represent the essential mechanisms controlling erosion. The advantage of the physically-based models is that they can represent a synthesis of the individual component which is related to erosion, including the complex interactions between various factors and their special and temporal variations.

To date, there has been several physically-based models developed for soil erosion prediction, many of them are represented ro the small area or plot scale, but there are few models developed for regional or large scale for soil loss assessment. The representative models that included in the physically-based method are: ANSWER, CREAM, WEPP, PESERA, etc. one has to keep in mind about high data demand of physically-based models which will define whether the model is applicable in a given situation.

3.6 The Universal Soil Loss Equation

The Universal Soil Loss Equation (USLE) is an empirically derived, ‘grey box’, soil loss prediction methodology, developed at the National Runoff and Soil Data Centre in co-operation with Purdue University. The model can estimate the erosion that will occur, given specific input values and it can predict the erosion that might occur, given the anticipated conditions. The USLE was developed as a method of estimating or predicting average annual soil loss from inter-rill and rill erosion. On the basis of extensive field experiments conducted in the Midwestern United States, Wischmeier and Smith (1958) revised the equation and developed another parametric equation that became known as the Universal Soil Loss Equation,

A =RKLSCP
where ***A*** is average annual soil loss,
R is erosivity of rainfall,
K is soil erodibility,
L is slope length,
S is slope gradient,
C is cropping management and
P is conservation practice.

USLE is based on more than 25 years of research covering 10,000 plot-years of data from natural-runoff plots and the equivalent of 1000 plot-years of data from field plots using rainfall simulators. Following its definition in 1958 all variables involved have been standardized and their potential and limitations assessed. The USLE only measures soil loss due to rill and interill erosion. Gully erosion is excluded and deposition of eroded material (and hence a net erosion figure) are not included. Since the development of USLE, other researchers have attempted to address its limitations, modifying the equation and extending its use.

- The Modified Universal Soil Loss Equation (MUSLE) was developed in order to estimate sediment yield from individual runoff events in small agricultural watersheds. R was replaced with $R\ w = 9.05 \times VQp^{0.56}$

Where ***V*** is the volume of runoff in m^3,
Qpis the peak discharge rate in m3 per second.

the use of C factors also incorporated for a specific time of year.

- The Revised Universal Soil Loss Equation (RUSLE) is a computer-based model that employs new relationships to estimate the six factors. However, as with the USLE, channel erosion and deposition are not considered.
- The Areal Non-point Source Watershed Environmental Response Simulation (ANSWERS) model was developed to simulate surface runoff and erosion in mainly agricultural watersheds. Three erosion processes are considered detachment by raindrop impact, detachment by overland flow and soil transportation by overland flow. Several inputs are required but they do include the USLE K factor and the USLE CP factor. ANSWERS also provide a means to model deposition as well as erosion of the soil.
- The Agricultural Non-Point Source (AGNPS) model), is an event based model that simulates runoff, sediment and nutrient transport for agricultural watersheds ranging from a few hectares

to about 20,0000 hectares. Within the model, upland erosion is estimated with a modified version of the USLE (Young *et al*, 1989).

- The Chemicals, Runoff and Erosion from Agricultural Management Systems (CREAMS) model also uses USLE factors and was designed to estimate storm sediment yield from small agricultural watersheds.
- The Water Erosion Prediction Project (WEPP) is a watershed-based model that was developed by the United States Department of Agriculture – Agriculture Research Service (USDA-ARS) to improve on the USLE. Currently it has mainly been tested on Rangeland areas in the USA.

Despite these developments the USLE is still widely used, as the amount of data required for inputs is small (6) in comparison to some of the other models (e.g. over twenty for the WEPP).

4.0 CONCLUSION

At the end of this unit, we explain the variables and functions in relation to erosion modeling for measuring and quantifying soil erosion on arable land. We also learnt empirical models and conceptual model, physically-based model and universal soil loss equation.

5.0 SUMMARY

Erosion model is based primarily on observation and is usually statistical in nature. For instance, empirical models are based on inductive logic and generally applicable only to the condition that parameters are calibrated. The key focus of empirical model process is prediction of average soil loss, although some extensions are known as : black-box where only main inputs and outputs are studied, grey-box where the more detail on how system work is explained, and white-box: where the detail of how the system work is known. Models representing empirical models are: USLE, RUSLE, RMMF, etc. the problem with empirical models is that equation cannot be extrapolated beyond their data range confidently, either events or other geographical area.

Whereas **conceptual model** is a type of model which lies between physically-based and empirical model, it is based on spatially dumped forms of water and sediment yield, basically using the concept of the unit hydrograph.

6.0TUTOR-MARKED ASSIGNMENT

1. State the variables and functions in relation to modeling
2. Differentiate between empirical models and conceptual model
3. Universal Soil Loss Equation: *A =RKLSCP;* State the meaning of the alphabet as use in the equation

7.0 REFERENCES/FURTHER READING

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MODULE 3 SOIL CONSERVATION AND MANAGEMENT

UNIT 1 MEANING OF SOIL CONSERVATION

CONTENTS

1.0 INTRODUCTION

Soil conservation has been described as “the positive task of devising and implementing systems of land use and management so that there shall be no loss of stability, productivity, or usefulness for the chosen purpose. Through this process soil resources are protected from being exposed to agents of erosion which results to soil degradation. A good conservation measure enhances agricultural productivity and sustainability. Therefore the concept, measures, benefits and policies were discussed in the main content.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- Explain the meaning of soil conservation
- Outline the control measures for soil conservation
- State benefits of soil and water conservation
- Highlight conservation policies of land and soil

3.0 MAIN CONTENT

3.1 Meaning of Soil Conservation

It is the prevention and reduction of the amount of soil lost through erosion. It seeks to increase the amount of water seeping into the soil, reducing the speed and amount of water running off. Conservation is a concept that has been broadly defined as " prolonging the useful life of resources." unless there is a commitment by people to look after their natural resources, not only for themselves but for future generations as well, the concept becomes meaningless. Applied to land, the objective of conservation is to work out how to satisfy people's aesthetic and physical needs from the land without harming or destroying its capacity to go on satisfying those needs in the future. Soil conservation has been described as "the positive task of devising and implementing systems of land use and management so that there shall be no loss of stability, productivity, or usefulness for the chosen purpose".

3.2 Control Measures of Soil Conservation

This emphasizes the use of land according to its capability in order to keep it permanently productive therefore any overall strategy for effective control measures should address the following:

The reduction of erosion to a level where soil loss can be replenished by natural soil development

1. The improvement of the physical structure of the soil
2. To increase or maintain the level or organic matter
3. To control and make the best use of available water
4. To maintain the fertility level by reducing nutrient loss or improving fertilization practices.

3.3 Benefits of Soil and Water Conservation

The benefit of soil and water conservation for agricultural sustainability includes;

1. Conserving water makes it available for crops, livestock and domestic use over a longer period
2. Controlling soil erosion improves crop and pasture yields.
3. Conservation measures improve the supply of fuel and forest products.
4. They increase the value of the land.
5. Terraces make cultivating steep slopes easier.
6. More and better livestock fodder is available.

3.4 Conservation policies of land and soil

Policy instruments adopt land-use plans based on scientific research as their foundation, as well as local knowledge and experience, and capacity classifications of land use. In this context, agricultural policies and land reforms are essentially aimed at:

1. Improving soil conservation - including the introduction of farming methods and sustainable forestry to ensure long-term land productivity.
2. Fighting against erosion caused by the misuse and mismanagement of land that can cause a loss of soils and surface vegetation; and
3. Fighting against pollution caused by agricultural activities, including aquaculture and animal husbandry.

Conservation policies relating to non-agricultural forms of land use (relating to public works, mining, waste disposal, etc.) are not too dissimilar to policies that relate to agricultural uses - in that they aim to establish standards and practices for preventing or mitigating erosion, pollution and other forms of land degradation.

4.0 CONCLUSION

At the end of this unit, we explain the meaning of soil conservation, control measures for soil conservation, benefits of soil and water conservation and conservation policies of land and soil. We also learnt that soil conservation involves the positive task of devising and implementing systems of land use and management so that there shall be no loss of stability, productivity, or usefulness for the chosen purpose.

5.0 SUMMARY

The objective of conservation is to work out how to satisfy people's aesthetic and physical needs from the land without harming or destroying its capacity to go on satisfying those needs in the future. Therefore in order to achieve this successfully, conservation policies relating to non-agricultural forms of land use (relating to public works, mining, waste disposal, etc.) are not too dissimilar to policies that relate to agricultural uses - in that they aim to establish standards and practices for preventing or mitigating erosion, pollution and other forms of land degradation.

6.0 TUTOR-MARKED ASSIGNMENT

1. Outline the soil conservation measures
2. State the benefit of soil conservation

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UNIT 2 AGRONOMIC SOIL CONSERVATION MEASURES

CONTENT

1.0 INTRODUCTION

Agronomic measures are agricultural practices carried out during crop production which include mulching and crop management. Appropriate application of them would result to effect surface covers that might reduce erosion cause by water and wind. Some of the agronomic practices that enhance soil conservation are mulching, cover cropping etc.

2.0 OBJECTIVES

At the end of this unit, you should be able to;

- Explain mulching as a measure of soil conservation
- Define cover cropping with example
- Explain improve fallowing
- Outline multiple cropping
- Highlight planting pattern/time as a measure of soil conservation

3.0 MAIN CONTENT

3.1 Mulching

Mulch is a layer of dissimilar material placed between the soil surface and the atmosphere. Different types of material such as residues from the previous crop, brought-in mulch including grass), perennial shrubs, farmyard manure, compost, byproducts of agro-based industries, or inorganic materials and synthetic products can be used for mulching.

Mulch’s impact in reducing the splash effect of the rain, decreasing the velocity of runoff, and hence reducing the amount of soil loss has been demonstrated in many field experiments conducted on several Nigerian research stations. This high amount of material might be available in the humid and semi-humid agro-ecological zones but not in the semi-arid regions of Nigeria where climatic conditions restrict the production of sufficient mulching material. Other reasons that reduce the amount of residues are bush fire and termites. The complete removal of crop residues from the field for use as animal fodder, firewood, or as construction material is another factor that makes this soil conservation technology less applicable. A possible solution might be mulching with brought-in organic material.

In general, mulching is likely to be a useful erosion control technology in most parts of Nigeria as this method both reduces soil loss and enhances soil productivity and crop yields. Soils with shallow surface horizon, a high sand content and soils located in semi-arid areas will benefit from this technology as the water holding capacity will be improved. Hence, mulching should be integrated into the existing farming systems of smallholders.

3.2 Cover Cropping.

Cover crops such as the legumes *P. phaseoloides, M. pruriens, Centrosema pubescens, Stylosanthes guianensis,* and *Phaseolus aconitifolius* or the grasses *Pennisetum purpureum, Brachiaria ruziziensis,* and *Paspalum notatum* are plants that grow rapidly and close. Their dense canopy prevents rain drops from detaching soil particles and this keeps soil loss to tolerable limits, so cover crops play an important role in soil conservation as shown in Fig. 4.

Fig. 4 Soybean field as cover crop

Cover crops also positively influence physical soil properties such as the infiltration rate, moisture content, and bulk density. They increase the organic matter content, nitrogen (N) levels by the use of N_2-fixing legumes, the cation exchange capacity, and hence crop yields. Another benefit of cover crops is the suppression of weeds, such as speargrass (*Imperata cylindrica*) or witchweed (*Striga hermonthica*) which are common in Nigeria. Farmers benefit from cultivating cover crops as soil loss is reduced and physicochemical soil properties are improved. However, one of the problems of cover crops can be the intensive growth of several cover crop species that might result in competition with food crops for growth factors. This problem can be combated by choosing compatible crops and by controlling the cover crop by timely cutting.

3.3 Improved Fallowing

Improved fallows of short periods with selected tree or herbaceous species remain important as the long fallow periods that were part of the traditional shifting cultivation system for encouraging soil regeneration are no longer possible in most Nigerian locations. For example, it was showed that fallows with Guinea grass (*Panicum maximum*) provide much organic matter to the soil. Shrubs of woody plants such as pigeon pea (*Cajanus cajan*) are advantageous in improving the physical soil conditions due to the penetration of their rootlets into deeper soil layers. Leguminous fallows with *Leucaena leucocephala*, *M. pruriens,* or *P. phaseoloides* are known especially for increasing the N content and changing the quantity of available P fractions in the soil. An improved fallow favours soil microbiological parameters.

3.4 Multiple Cropping

Multiple cropping involves different kinds of systems depending on the temporal and spatial arrangement of different crops on the same field. It has been traditionally practiced and is still very common in Nigeria. Agroforestry is a collective name for a land use system in which woody perennials are 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. The potential of agroforestry as an erosion control measure attributed to its capacity to supply and maintain a good soil surface cover by the tree canopy and the pruning material. Another potential is the effect of a runoff barrier when trees are planted across the slope. As the intensive rooting by the woody perennials also improve the structure and infiltration rate of the soil, the amount of runoff and hence soil loss are reduced by alley cropping. The reduction of soil erosion by alley cropping obviously depends on the spacing between the hedges and the species. The age of the perennials is also important as most species become effective sediment traps about two to three years after planting. It was generally assumed that the intensive rooting of the species in different parts of the soil avoids competition for nutrients and water and that trees act as a nutrient pump within the plant and soil system. Alley cropping has been regarded as a promising methodology for soil fertility management in the tropics as the regular adding of pruned plant material enhances the organic matter content of the soil. In general, alley cropping is regarded as a system with potential to improve the physical, chemical, and biological soil properties and to increase farmers' income through additional products such as fuel wood or timber. However, the crop yield response is uncertain and variable due to the competitive effects of the different cultures for light, water, and nutrients. Yields also can be reduced by a combination of incompatible species, lack of micronutrients, increase of pest and diseases, missing information on planting pattern, or wrong crop management. As the demand for labour is high in tree-based systems and as the restoration effect on the soil requires many years, alley cropping is not likely to be a suitable soil conservation technology for farmers in Nigeria.

3.5 Intercropping

Intercropping systems including different kinds of annual crops planted in alternating rows also reduce soil erosion risk by providing better canopy cover than sole crops and a good example is 2 rows maize and 2 rows soybean (2 rows cereal and 2 rows legume) as presented in Fig. 5. In Nigeria, numerous investigations have been conducted on intercropping of cereals such as maize (*Zea mays*), sorghum (*Sorghum bicolor*) or millet (*Pennisetum glaucum*) with herbaceous grain legumes or root and tuber crops with other annual crops to improve soil productivity and crop yields. For exampleit was shown that sole groundnut improved the soils' bulk density at the 0 to 10 cm depth (1.26 g cm^{-3}) better thansole maize (1.34 g cm^{-3}). The cultivation of legumes also resulted in better stability of soil aggregates in the topsoil, which generally reduces the erodibility of the soil. Incorporation of legume in intercrop results in increase soil nitrogen which increases vegetation growth. The studies on intercropping systems indicate that multiple cropping generally contributes to erosion control. The increased coverage of the soil surface and the enhanced stability of soil aggregate reduce the erosivity of the rain and the erodibility of the soil. As the productivity of soils cultivated with different crop species is also increased, this measure is likely to be adopted as a soil conservation technology in the tropics.

Fig.5 Maize-soybean intercropping system (2 rows maize:2 rows soybean)

3.6 Planting Pattern/Time

Planting pattern, plant density, and time of planting also play an important role in soil conservation. Crops planted at close spacing or at a certain time provide a higher canopy during periods with high rainfall intensities and hence protect the soil from erosion.. Plant densities affect soil loss by influencing the height of crops and extend of surface coverage.

It can be concluded that diverse crop management practices have various beneficial effects as erosion is reduced, the physical, chemical, and biological soil properties are improved, and crop production is increased. Additional advantages are a decreased risk of total crop failure and the suppression of weeds. As product diversification and higher crop yields help to ensure both subsistence and disposable income, polyculture is of huge economic value for the farmers

4.0 CONCLUSION

At the end of this unit, we explain various agronomic practices that enhance soil conservation such mulching, cover cropping, fallowing, multiple cropping and planting pattern/time.

5.0 SUMMARY

Agronomic measures are agricultural practices carried out during crop production which include mulching and crop management. Appropriate application of them would result to effect surface covers that might reduce erosion due to water and wind. Some of the agronomic practices that enhance soil conservation are well discuss in all the units.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain cover cropping as a measure of soil conservation
2. Differentiate intercropping and multiple cropping with example
3. Define cropping pattern/time

7.0 REFERENCES/FURTHER READING

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UNIT 3 SOIL MANAGEMENT STRATEGIES FOR SOIL CONSERVATION

CONTENT

1.0 INTRODUCTION

Soil management strategies is known as Conservation tillage which is describes as the method of seedbed preparation that includes the presence of residue mulch and an increase in surface roughness as key criteria. The practices therefore range from reduced or no-till to more intensive tillage depending on several factors, such as climate, soil properties, crop characteristics, and socio-economic factors.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- Define minimum tillage
- Explain no-tillage
- Discuss ridge tillage and
- Explain ridge tying

3.0 MAIN CONTENT

3.1 Minimum Tillage

Minimum tillage describes a practice where soil preparation is reduced to the minimum necessary for crop production and where 15% to 25% of residues remain on the soil surface.

3.2 No-Till

No-till or zero-tillage is characterized by the elimination of all mechanical seed bed preparation except for the opening of a narrow strip or hole in the ground for seed placement. The surface of the soil is covered by crop residue mulch or killed sod.

No-till and mulch farming are sustainable management technologies for the humid and sub-humid tropics, whereas rough plowing, tied ridging, and mulching are appropriate techniques for the semi-arid area. Reduced and zero-tillage systems contribute to long-term maintenance of the soil structure as pores from root growth and the activity of the soil fauna and the soil aggregates from the previous years are less or not at all disturbed

3.3 Ridge Tillage and Ridge Tying

Ridge tillage is the practice of planting or seeding crops in rows on the top, along both sides or in the furrows between the ridges which are prepared at the beginning of every cropping season. Tied ridging or furrow diking includes the construction of additional cross-ties in the furrows between neighboring contour ridges.

Most smallholders in Nigeria still perform soil preparation manually by using hoes. Larger farms use plows and harrows pulled by tractors, which results in the complete inversion of the top 20 to 30 cm of the soil. Hence, ridging is very common all over Nigeria, whereas tied ridging is primarily conducted in the semi-arid northern part of the country to conserve both soil and water in individual basins.

Tillage operations affect the infiltration capacity and hydraulic conductivity of soils which has an impact on the amount of runoff and, hence, of soil loss. The more favorable moisture and temperature conditions in plots with reduced or no tillage also have beneficial effects on the activity of the soil fauna, such as earthworms. These soil organisms reduce compaction and crust formation, construct macro pores, and contribute to an improved soil structure by the formation of stable aggregates. These processes improve the infiltration rate for rainwater and reduce the erodibility and, hence, the erosion of the soil. Also, the maintenance or increase of the organic matter by conservation tillage is a basic ingredient in maintaining soil productivity and the stability of systems.

4.0 CONCLUSION

At the end of this unit, we explain various soil management strategies of soil conservation which includes minimum tillage, no-tillage, ridge tillage and ridge tying. We also learnt that tillage operations affect the infiltration capacity and hydraulic conductivity of soils which has an impact on the amount of runoff and, hence, of soil loss. The more favorable moisture and temperature conditions in plots with reduced or no tillage also have beneficial effects on the activity of the soil fauna, such as earthworms.

5.0 SUMMARY

Conservation tillage operations are necessary in locations with unfavorable climatic conditions or problematic soils. Water harvesting is important in arid and semi-arid areas with erratic and small rainfalls. The construction of ridges or tied ridges with a series of small basins is a useful technology for the collection and storage of rainwater in dry areas.

6.0 TUTOR-MARKED ASSIGNMENT

1. Define mulching
2. Explain no-tillage
3. Describe ridge tillage

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UNIT 4 MECHANICAL STRATEGIES FOR SOIL CONSERVATION

CONTENT

1.0 INTRODUCTION

Mechanical methods, including bunds, terraces, waterways, and structures such as vegetative barriers or stone lines installed on farm also can break the force of winds or decrease the velocity of runoff to reduce soil erosion.

2.0 OBJECTIVES

At the end of this unit, you should be able to;

- Define terraces as a means of soil conservation
- Explain waterways in soil conservation
- Explain structures use in conservation
- Outline the challenges of soil conservation

3.0 MAIN CONTENT

3.1 Terraces

Contour bunds made of earth or stones or terraces that consist of an excavated channel and a bank or ridge on the downhill side for cultivating crops are permanent erosion control technologies. The first are installed across slopes of low gradients, the latter at right angles to the steepest slope in hilly areas. These measures have been considered to be useful in preventing gully erosion, the most spectacular type of erosion. Permanent structures of these kinds are effective soil conservation technologies as excessive soil loss and silting up of the fields are reduced. However, high labor intensity, time-consuming regular inspections, high consumption of scarce farmland, and the large amounts of construction material required are factors that stop farmers from installing or maintaining terraces.

3.2 Waterways

Waterways such as cut-off drainage are permanent structures that aim to collect and guide excess runoff to suitable disposal points. They are constructed along the slope, often covered with grass to prevent destruction, and primarily installed in areas with high rainfall rates. The implementation of waterways probably needs special knowledge of the water regime of the area.

3.3 Structures

Structural barriers made of stones or vegetation installed along contour lines is another mechanical erosion control measure. As they operate as filters, they may not reduce the runoff amount but retard its velocity and hence encourage sedimentation, increase infiltration, and facilitate the formation of natural terraces). Vegetative barriers are usually constructed as single lines or in the form of strips of several meters wide. Vetiver (*Vetiver zizanioides*), a perennial grass with a deep and fibrous root system is mostly used in northern Nigeria and it is recommended as an appropriate soil conservation technology for semi-arid zones as it withstands denudation, fire, drought, and flood. In general, mechanical measures are effective soil conservation technologies as they reduce soil loss. But as the installation and maintenance is usually labour-intensive, these structures are not likely to be adopted by farmers.

3.4 Challenges of Soil Conservation

This involves the following;

1. Fragmented land ownership makes it difficult for farmers to invest optimally in soil conservation.
2. Conservation structures need a lot of labour to build and maintain.
3. Crop production in semi-arid areas involves many risks, including flooding. This makes it difficult for farmers to realize the full benefits of conservation.
4. Many farmers lack the skills to design and build conservation structures, sub-standard and poorly constructed structures often results.

5. Land tenure systems determine the ownership of the structures and influence farmers' interest in conservation and in maintaining the structures.
6. Irregular rainfall reduces the effectiveness of vegetative erosion-control practices.

4.0 CONCLUSION

At the end of this unit, we explain the mechanical methods of soil conservation which includes; bunds, terraces, waterways, and structures such as vegetative barriers. We further explained that stone lines installed in the farm also can break the force of winds or decrease the velocity of runoff water to reduce soil erosion.

5.0 SUMMARY

In general, mechanical measures are effective soil conservation technologies because they effectively reduce soil loss either due to wind or water erosion factors. But as the installation and maintenance is usually labour intensive, these structures are not likely to be adopted by farmers because of the following challenges; fragmented land ownership, labour to build and maintain, skills to design and build conservation structures, land tenure systems and irregular rainfall pattern (climate change)

6.0 TUTOR MARKED ASSESSMENT

1. Describe terrace and waterways as mechanical means of soil conservation
2. Outline the challenges of soil conservation

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UNIT 5 EXTENSION APPROACHES IN SOIL CONSERVATION

CONTENTS

1.0 INTRODUCTION

To discuss approaches that addresses various areas in reference to conservation concerning soil resources and controlling soil erosion at large. This involves activities that relates to farmers participation, education and training, extension services, technical assistance and provision of incentive to the farmers for agricultural sustainability. Activities that encourage farmers and students to be involves in any soil conservation project being carried out in their communities are the emphasis and these will consequently enhance soil productivity.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- Explain farmer participation approach in soil conservation
- Discuss briefly education and training of farmers
- Highlight the stages of extension services in soil conservation
- Explain technical assistance
- Explain the two kinds of incentives

3.0 MAIN CONTENT

3.1 Farmer Participation

Farmer participation is the key to the success in any soil conservation programme. Regardless of how technically sounds any plan or measure to be applied is, it cannot be successfully carried out without the support and participation of the farmer. Any soil erosion control programme must, therefore, contain adequate provision for such activities as discussion, meetings, interviews, training and demonstration of various practices and methods.

However, the results may be less perfect, but the farmer will be able to observe and see closely to what he can hope to achieve on his plot of land. Soil conservation plots should be able to demonstrate:

- The effectiveness of different soil conservation measures under locally resources, crops available and land uses.
- The benefits of soil conservation in terms of improved soil environment, labour saved in cultivation and increased productivity. Thus, without the latter, the farmers will not be interested. This would be achieve by clearly and sequentially present the figure for cost and returns to the famer at the beginning and at the end of the programme.

3.2 Education and Training of farmers

Education and training of local farmers should start without delay as soon as an area is identified for soil erosion control. Such education includes village meetings, exhibitions, field visits and the showing of slide movies. Whoever is responsible for this assignment should bear in mind that soil conservation measures may require a drastic change in land use-possibly a change in the terrain itself (e.g by terracing). It is rarely a simple matter like introducing new types of fertilizer or crop varieties. Therefore, this may require a special training to selected people within a community such as village heads, lead farmer, contact farmers, farmers group or active members of youth clubs. Basic requirements for contact farmers are those of the age between 20 to 45; of physically active, and good attitude; have good level of education and who have access to piece of land that can be used for demonstration purposes.

3.3 Extension Services

The effectiveness of farmer education and training depends largely on the competence of the local extension officers and on the quality of the agencies which support them. Since extension staffs in Nigeria have little formal training in soil erosion control, short courses should be arranged for their benefit. After receiving such training, they should be encouraged to partake in all the stages of an extension cycle. These stages are;

1. **Motivation stage:** Using normal mass education techniques to generate farmer awareness and interest in soil erosion issues and to promote participation in the programme. This is primarily the responsibility of the extension agency (EAs) with some help from the relevant research institute (RIs).
2. **Technical assistance stage:** Actual planning, design, layout and installation of soil erosion control measures on the farms. This is undertaken jointly by extension agency (EAs) and research institute (RIs) in cooperation with the farmers.

3. **Follow-up stage:** Assistance to farmers by the EAs in obtaining loans for improved seeds and other farming inputs and in marketing their produce and by RIs in the maintenance of conservation structures and practices.

3.4 Technical Assistance

Technical assistance to a farmer involves many activities. Once the farmer is motivated, the task of technical assistance involves farm interviews, farm planning, conservation layout and installation, maintenance, production. Supporting services and marketing have to follow. For farmers to be successfully given assistance means helping them to increase their production and income. To offer soil conservation measures that only aimed at protecting the soil will often attract a farmer's cooperation.

3.5 Incentives

Financial incentives in support of technical assistance are usually needed to encourage farmers to adopt soil conservation measures. Farmers involved in conservation work are likely to have reduced income in the initial stages of conservation treatment because

- Production is lost or delayed
- Additional labour is needed construction
- Inputs, time and effort are needed to restore soil quality, following soil disturbance and subsoil exposure
- Some actual loss in production area is likely. The early losses should be covered by later gains, but this take time and the losses should attract government compensation when they occur.

Incentives may two kinds:

1. **Direct incentives:** Among direct incentives, cash subsidies are commonly paid in recognition of work performed or as daily wages, food, farm implements, fertilizers, herbicides and

insecticides are provided as incentives in kind or in quantities, which again recognize daily labour input or amounts of work accomplished.

2. **Indirect incentives:** There are also many types of indirect incentives which include provision of technical assistance. Others include exemption or deductions from tax on income or property; farm credits; security of land tenure for farmers squatting on government land; provision of marketing services and other infrastructural development.

4.0 CONCLUSION

In this unit, we explain the various extension approaches for soil conservation measures which includes farmer participation approach, education and training of farmers, extension services, technical assistance and provision of incentives.

5.0 SUMMARY

In summary we discuss all the approaches that would address various areas in reference to conservation concerning soil resources and controlling soil erosion at large. This involves activities that involve farmer’s participation, education and training, extension services, technical assistance and provision of incentive to the farmers for agricultural sustainability. In order to achieve this the activities require that farmers and students to be encourage to be involves in any soil conservation project being carried out in their communities and these will consequently enhance soil productivity.

6.0 TUTOR MARKED ASSESSMENT

1. Discuss briefly education and training of farmers
2. Highlight the stages of extension services in soil conservation
3. Explain technical assistance for soil conservation measure
4. Explain the two kinds of incentives with good examples

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