NATIONAL OPEN UNIVERSITY OF NIGERIA

SCHOOL OF EDUCATION

COURSE CODE: ESM 204

COURSE TITLE: ENVIRONMENTAL HARZARDS AND NATURAL DISASTER MANAGEMENT

Course Code ESM 204

ENVIRONM ENTAL HARZARDS AND NATURAL DISASTER MANAGEMENT

COURSE GUIDE

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TABLE OF CONTENTS

Introduction

Environmental Hazards and Natural Disaster Management is a two credit course. It will be available to all students to take towards the core module of their B.Sc (Hons) in Environmental Studies/Management. It will also be appropriate as one-off course for anyone who wants to be acquainted with the Natural and Environmental Disasters or/and does not intend to comp lete the NOUN qualification.

The course is designed to contain ten units, which involve fundamental concepts and issues on Environmental Hazards and Disasters Management across the World and how to control and manage these disasters. The material has been designed to assist students in Nigeria by adapting the examples to our local communities. The intention of this course therefore, is to help the learner to be more familiar with Disaster Management.

There are no compulsory prerequisites for this course, although basic prior knowledge in geography, biology and chemistry is very important in assisting the learner through this course.

This Course Guide tells you in brief what the course is about, what course mater ials you will be using and how you can work your way through these materials. It gives suggestions on some general guid elines 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 infor mation on tutor-marked assignments is found in a separate booklet.

What you will lea rn in this course

The basic aim of Environmental Hazards and Natural Disaster Management is to acquaint learners with the basic concepts of Environmental Hazards and Natural Disaster Management for the enhancement of Environmental Resources Management in Nigeria. During this course, you will learn about Natural disasters such earthquakes, volcanic eruption, Snow Avalanche and other environmental hazards that may be experienced in the Nigerian environment. Some common environmental hazards in Niger ia such as flood, drought, desertification, landslide and acid rain will be d iscussed in this course.

The course will g ive you general overview of the process of the occurrence of some of these hazards, causes, consequences and management of these environmental hazards.

Course Aims

The aim of the course can be summarized as follows: this course aims to give learners a clear conceptualisation of the basic issues surrounding the causes, effects and control management of environmental hazards in Niger ia and around the world.

This will be achieved by aiming to:

- Introduce you to the basic concepts of environmental hazards.
- Outline common environmental disasters in Nigeria.

Explain the causes of some environmental disaster
Discuss common consequences of environmental hazards.
State management techniques that will aid the management of the environment.

Course Obj ectives

To achieve the aims outlined above, the course sets overall objectives. Added to this, each unit also has specific objectives. The unit objectives are always included at the onset of each unit; you are expected to read them before you start working through the unit. You may wish to make reference to them during your course of study of the unit to guide your progress. Cultivate the habit of always going back to check the unit objectives after completing a unit.

The essence of this is to ensure that you have done what is required of you by the unit.

Outlined below are the broad objectives of the course as a whole. When you meet these objectives, you should have achieved the aims of the course as a whole.

When you have successfully comp leted this course, you should be able to:

1. Explain the concept of environmental hazard s.
2. State the difference between environmental hazard s and natural disasters.
3. Outline some environmental hazards in Nigeria.
4. Mention basic problems associated with environmental hazards in Nigeria.
5. Relate the causes of environmental hazards in Niger ia.
6. Discuss on the methods of controlling environmental hazards in Nigeria and other parts of the World.

Working through This Course

To end this course you are expected to read the study units and some other materials and resources made available to you by NOUN. These will work together in facilitating your learning. You are expected to undertake all practical exercises outlined in each unit.

Course mat eria ls

Major components of the course are:

1. Course Guide
2. Study units
3. Other sources

Study unit s

There are ten study units in this course, as follows:

Unit 1: Introduction to Environmental Hazards and Disasters

Unit 2: Earthquake

Unit 3: Floods

Unit 4: Drought and Desertification: Concepts and Causes

Unit 5: Impact of Drought and Desertification

Unit 6: Volcanic Hazards (1)

Unit 7: Volcanic Hazards (2)

Unit 8: Landslide

Unit 9: Snow Avalanches

Unit 10: Acid Rain

Each study unit consists of about three hours of work and includes specific objectives, directions for study, references, commentaries on some terms, other resources and summaries of major issues and ideas.

The units direct you to work on exercises relate to the required readings . Together with tutor-marked assignments, these exercises will assist you in achieving the stated learning objectives of the individual units and of the course.

Assessment

There are two aspects to the assessment of the course. First, are the tutor-marked assignments, second, there is a written examination.

At the end of the course you will need to sit for a final written examination.

Tut or-marked assignment s (TMAs)

There are five tutor-marked assignments in this course. You are encouraged to answer all of the questions, or as directed by the course coordinator/facilitator

Course overview

This table br ings together the number of units and the tutor- marked assignments in this course

Unit	Title of Unit	TMA
2	Earthquake	1
4	Drought and Desertification: Concepts and Causes	2
5	Impact of Drought and Desertification	3
9	Snow Avalanches	4
10	Acid Rain	5

How to get the most from this course

In distance and open learning, the study units rep lace the university lecturer. This is one of the greatest benefits of open learning; you can read and work through specially designed study mater ial 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 set books or other material, and when to undertake an exercise or a practical step. As a lecturer might give you an in-class exercise, your study units provide exercises for you to do at appropriate points.

Each of the study units has a similar for mat. 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 r ealise what you should be able to do by the time you have completed the unit. These objectives are to be used as study guide.

On completion of a unit, go back and ascertain if you have achieved the objectives. If you have made a habit of doing this you will sig nificantly improve your chances of passing the course.

The main body of the unit guide you through the course contents.

Some units require you to undertake practical exercise.

The following is a practical strategy for working through the course. When you need help, don t hesitate to call and ask your tutor to provide it.

1. Read this course Guide thoroughly
2. Organize a stud y schedule. See the course overview for more details.
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 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 mater ials. Information about what you need for a unit is given in the over view at the beginning of each unit.
6. Work through the unit. The content of the unit itself has been arranged to provide a sequence for you to follow.
7. Review the objectives for each study unit to confir m that you have achieved them. If you feel unsure about any of the objectives, review the study material or consult your tutor.
8. 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 pace your study so that you keep yourself on schedule.
9. When you have submitted an assignment to your tutor for mark ing, do not wait for its return before starting on the next unit. 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 assig nment. Consult your tutor as soon as possible if you have any questions or problems.
10. 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)

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Table of Contents

UNIT 1: INTRODUCTION TO ENVIRONMENTAL HARZARDS AND DISASTERS

Table of Contents

1.0 Introduction

Welcome to yet another exiting and interactive learning on the environment. I want you to realise that you belong to the privileged few that have the opportunity to acquire knowledge and skills that can reshape our best out of this class that is devoted to Environmental Hazards.

Environmental hazards may be considered as a special type of environmental problem that demands special attention that is why environmentalist at the National Open University of Nigeria has devoted an entire course to this global environmental problem that is threatening the existence of humanity.

This first chapter is the first of a series of ten designed to stimulate your intellectual appetite; hence it will introduce you to environmental hazards.

2.0 Objectives

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

- Explain the concept of environmental hazards
- Mention four types of environmental hazards
- State two effects of natural hazards on the development of a building facility in a site prone to any named environmental hazards

3.0 Environmental Hazards: A Conceptual Background

Environmental hazards may be likened to Environmental resources as both evolve from the Earth s natural systems but I want you to understand that environmental hazards are more of a negative resource. So it is a clear fact that in every sense that environmental hazards are an element of the environmental problems currently capturing so much public attention. They cause the alteration

of natural ecosystems; heighten the effects of those ecosystems degradation, thus reflecting the human induce d damage done to the environments, and many times affecting a la rge human population.
Traditionally almost eve ry environmentally related book on natural hazards paints the picture of a chronicle of death and destruction, a similar accounting of damage avoided is almost never included. But the effects of the disaster cause d by natural hazards can be greatly reduced by action taken in advance to reduce vulnerability to them. Industrialized countries have made progress at reducing the impacts of hurricanes, floods, earthquakes, volcanic eruptions and landslides (OAS, 1990).
For instance, Hurricane Gilbert, recor ded as being the most powerful hurricane ever recorded in the Weste rn Hemispher e, was said to be responsible for 316 fatalities, though less forceful hurricane killed thousands of people earlier in the century. A combination of zoning restrictions and improved structures together with new prediction, monitoring, warning, and e vacuation systems made the difference. Latin America n and Caribbean countries have reduced loss of life from some hazards, principally through disaster preparedness and response; they now have the opportunity to reduce economic losses through mitigation in the context of development to a greate r extent than they have to date.
The disaste rs caused by environmental hazards generate a demand for enor mous amounts of capital to replace what is destroyed and damaged. The development community should address this issue because it affords, among all environmenta l issues, the most manageable of situations: the risks are readily identified, mitigation measures are available, and the benefits that accrue from vulnerability reduction actions are high in relation to costs.

3.1 The Toll of Environmental Hazards

Today the depressing regular ity of environmental disaste rs is making headline News of National and International print and elec tronic media. Each year one or more hurricane strikes the Caribbean region.

REFLECTION
If this is the experience in your city or town, what would be your reaction? Share your thoughts with at least two of your course mate.

The destructive ones noted in history include hurricane Gilbert in 1988 and Hugo in 1989, and Katrina in 2005 caused billions of dollars of damage. Flooding, too, occurs annually, but no reliable estimates are available of the cost in human live and property. Earthquakes and volcanic eruptions Ruiz in unpredictable with disastrous effects: the mudslide precipitated by the eruption of Volcanic Ruiz in Colombia in 1985 killed 21, 800 people, and earthquakes in Mexico (1985) and El Salvador (1986) together killed more than 10,000(OAS, 1990).

Landslides are limited in area. But occur so frequently that they account for hundreds of millions of dollars in damage every year. While not as spectacular, drought can be more harmful to agricultural production than hurricanes. After the 1971 drought, for example, banana production in Saint Lucia did not recover fully until 1976. Disaster aid, however, is scarce in the region for these types of pervasive, slow-onset hazard.

Over the past 30 years average annual costs of natural disasters to Latin America and the Caribbean were 6,000 lives, adverse effects on 3 million people, and US$1.8 billion in physical damage. Moreover, the impacts are increasing: during 1960s approximately 10 million people were killed, injured, displaced, or otherwise affected; the number for the 1970s was six times larger, and for the 1980s, three time larger.

In addition to the direct social and economic impact, natural disasters can affect employment, the balance of trade, and foreign indebtedness for years after their occurrence. After Hurricane Fifi struck Honduras in 1974, for example, employment in agriculture decreased by 70 percent. Funds intended for development are diverted into costly relief efforts. These indirect but profound economic effects and their drain on the limited funds now available for new investment compound the tragedy of a disaster in a developing country. Furthermore, international relief and rehabilitation assistance has been insufficient to compensate countries for their losses; during the period 1983 1988, reconstruction assistance amounted to only 13 percent of the estimated value of losses (OAS, (1990).

3.2 Environmental Hazards and Development

The losses are a concern not only for the countries in which they occur but also for international lending agencies and the private sector which are interested in protecting their loans and investments. The investments are often at risk of both environmental hazards and the side effects of development projects that exacerbate these hazards. For example, excessive erosion and siltation reduces the useful life of large multipurpose dams.

Many smaller dams in the region also experience these types of damage: accelerated erosion caused by a hurricane filled half the storage capacity of a reservoir in the Dominican Republic virtually overnight. As a result of these concerns, one important lender, the Inter-American Deve lopment Bank, is studying the process of evaluating dam projects on the grounds that more realistic methods of estimating life expectancy and cost-benefit ratios will have to be introduced if the problem of erosion and estimating life expectancy and cost-benefit ratios will have to be introduced if the problem of erosion and siltation cannot be resolved satisfactorily for any pr oject.

While the development efforts of the past have brought economic advancement to many parts of the world, they have also brought unwise or unsustainable uses of the natural resources base. Indeed, in recent years, the United Nations specialized conferences on the human environment, desertification, water manageme nt, deforestation, and human settleme nts all point to environmental degradation brought about by development, and the corresponding reduction in the capacity of an ecosystem to mitigate natural hazards. Nevertheless, development agencies often continue to operate as though their activities and natural disasters were separate issues.

REFLECTION

As Gunnar Haman points out in Prev ention is Better than Cure:

When a disaster has occurred, development agencies have regarded it as a nuisance and tried to avoid becoming involved; or even worse, the risk of existing or new potential hazards has been over-looked in the planning and implementation of some development activities, it is now being observed that intensive development may be the cause of many new disast ers in poor countries.

Until quite recently, in fact, many practitioners believed that development efforts themselves would spontaneously provide solutions to problems posed by natural hazard.

Environmental deficiencies generated by the conditions of underdevelopment and natural disasters pose grave problems and can best be remedied by accelerated development through the transfer of financial and tec hnological

assistance as a suppleme nt to the domestic effort of the development countries (OAS, (1990).
In the intervening eighteen years enormous amounts of financial aid and sustained technical assistance have been provided, but far from reducing the effects of natural disasters, development has contributed to disaster vulnerability in areas where the presence of hazards was not properly assessed.
While the link between natural disasters and development has bee n demonstrated repeatedly, governments and lending agencies do not yet systematically integrate the consideration of natural hazards into project preparation. Past losses and the vulnerability of infrastructure have reached such levels that in some areas development assistance consists almost entirely of disaster relief and rehabilitation.
When loan proceeds are routinely programmed for reconstruction, little remains for reconstruction needs have brought about a reassessment of economic development programs in Bolivia, Colombia, Ecuador, El Salvador, Guatemala, Nicaragua, Peru, the Paraguay River Basin, and several Caribbean island countries.
There is a growing awareness that natural hazard management is a pivotal issue of development theory and practice. The United Nations declare d the 1990s as the International Decade for Natural Disaster Reduction (IDNDR) and called on developing countries to participate actively in reducing disaster vulne rability. The Organization of American States (OAS) has endorsed the IDNDR and made natural hazard management a priority technical assistance area.

3.3 Perspectives on Prevention and R econstruction of Natural Hazards

A key element to be addressed in this decade is the distribution of resources between disaster prevention and post-disaster efforts. Prevention, which includes structural measures (e.g., making structures more hazard-resistant) and non-structural measures (e.g., land-use restrictions), is a cost-effective means of reducing the toll on life and property.
Post-disaster relief and reconstr uction measures are important for humanitarian reasons, and may include improvements that are designe d to prevent or mitigate future disasters. This is increasingly the case in projects funded by development financing organizations. Nevertheless, post-disaster measures are disproportionately costly for each life save d and each building reconstructed costs of jobs and production associated with disasters. It is useful in this regard to distinguish between hazard management and disaster management. Both include the comple te array of pre-event and post-event measures, but they differ in their

focus. Disaster management is concerned with specific events that destroy lives and property to such an extent that international assistance is often needed (Hogan & Marandola, 2007).

Hazard management addresses the potentially detrimental effects of all natural hazardous events, whether or not they result in a disaster; it is the more inclusive of the two terms, seeking to incorporate consideration of natural hazards in all development actions, regardless of the severity of the impact. It thus concentrates more on the analysis of hazards, the assessment of the risk they present, and the prevention and mitigation of their impact, while disaster management tends to concentration more on preparedness, alert, rescue, relief, rehabilitation, and reconstruction.

Despite the clear economic and humanitarian advantages of prevention, it is relief and reconstruction measures that typically enjoy political and financial support. Donor nations quickly offer sophisticated equipment and highly trained personnel for search and rescue missions. Politicians of a stricken nation gain more support from consoling disaster victims than from requesting taxes for the un-dramatic measures that would have avoided the disaster.

Short-term efforts to address immediate needs usually take precedence over long term disaster recovery and prevention activities, particularly given the visibility attached to the relied phase of disaster by the mass media. It is not surprising. Therefore, to find that of all funds spent on natural hazard management in the region, more than 90 percent goes to saving lives during disasters and replacing lost investment; less than 10 percent goes to prevention before disasters.

The situation is similar with respect to science and technology as opposed to basic information on the location, severity, and probability of events-the data that provide the basis for prevention measures. A sound balance must be sought between obtaining additional scientific information and applying existing information to institute mitigation measures resting chiefly on economic and political organization and process.

3.4 Reducing the Impact of Natural Hazards

There are information and techniques designed to minimize the effects of even the most sudden and forceful of hazardous events and prevent than causing a disaster. But in some instances the situation itself cannot be avoided, construction measures and location decisions can help save lives and avoid damage. In some instances, such as flooding, the integration of hazard mitigation

measures into development planning and investment projects may make it possible to avoid the hazards entirely.
Mitigation measure is better seen as a fundamental investment, essential to all development projects in high-risk areas, and not as a luxury that may not be affordable. The vulnerability of many places around the world to hurricanes, earthquakes, volcanic eruptions, flooding, or drought is widely recognized. Environmental planners should not ask the question whether these events will happen, but what may occur when they do.
The normal single-sector planning technique can no longer maximize the benefits of mitigation methods and may, in fact, increase the risk exposure of people and their property. Since the orthodox development project often represents an isolated intervention into complex and long- standing natural and socioeconomic processes, an advance in one area may not be accompanied by needed change in another. When natural events subsequently exert pressure, the fruits of the project may be lost to a disaster caused by the deterioration of the natural and human environment related, in turn, to the project itself (Hogan & Marandola, 2007).
Environmentally Integrated development planning, relatively implies, a multicultural approach. It accounts both for a change in associated sectors that share a defined physical space and for the changing relationships between sectors as the result of an intervention. Underlying the integrated approach is the assumption that change is organic and that an initiative in one sector affects the region as a whole.

Exercise 1.1
State two reasons, why Natural hazard considerations should be introduced at the earliest possible stage in a facility development process.

If a location designed for a housing estate is in an earthquake zone, this should be considered before it is planned for urban development. If a piece of land is considered for agricultural project is subject to flooding, that should be taken into consideration in the formulation of the project. If environmental hazard risk is noticed on time in any planning process, lesser unnecessary projects will be carried forward simple on their own momentum.
Mitigation measures must be applied early, and non-structural mitigation, the most cost-effective mechanism, requires particularly early recognition of the need for land-use restrictions. As in environmental impact audit conducted on a project

already formulated, an after-the-fact natural hazard assessment has much less value than an evaluation conducted in time to impact the original formulation of the project.

4.0 Conclusion

You must have discovered by now that it a clear fact and in every sense that environmental hazards are an element of the environmental problems currently capturing so much public attention. They cause the alteration of natural ecosystems; heighten the effects of those ecosystems degradation, thus reflecting the human induced damage done to the environments, and many times affecting a large human population.

This call for the attention of all and sundry to take urgent steps that will educate and equip citizenry on how to handle environmental hazards.

5.0 Summary

Environmental hazards may be likened to Environmental resources as both evolve from the Earth s natural systems but I want you to understand that environmental hazards are more of a negative resource. But the effects of the disaster caused by natural hazards can be greatly reduced by action taken in advance to reduce vulnerability to them. Industrialized countries have made progress at reducing the impacts of hurricanes, floods, earthquakes, volcanic eruptions and landslides.

6.0 References and Other Resources

Hogan, D.J. & Marandola, E. (2007). Vulnerability of Natural Hazards in population-Environment Studies. Background Paper to the Population-Environment research network (PERN) Cyberseminar on Population and Natural Hazards, 5-19 November.

OAS, (1990). Disaster, Planning and Development: Managing Natural Hazards to reduce Loss. Organization of America States. Washington, D.C.

Other Resources

Lauwerys, J. A (1970).Man s Impact on Nature. New York. The American Museum of Natural History.

Nest (1991). Nigeria s Threatened Environment: A National Profile. Ibadan Nest.

UNIT 2: EARTHQUAKE

Table of Content s

1.0 Introduction

I like to invite you to a discussion on another environmental hazard it is called **earthquake. Earthquakes are one of the commonest environmental hazar ds that** are still challenging the survival instinct, capacity for survival and adaptive techniques of humans to subdue the environment for comfort.

The occurrence of friction between rocks on either side of a fault prevents the rocks from slipping easily or when the rock under stress is not already fractured, some elastic deformation will occur before failure. When the stress at last exceeds the rupture strength of the rock a sudde n moveme nt occurs to release the stress. This experience may be simply described as earthquake or seismic slip.

2.0 Objectives

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

- Explain what an ear thquake is.
- Describe a magnitude number
- Mention seve n ways earthquakes may be categorise d
- Differentiate between ground failure and earthquake

3.1 Seismic Waves

Earthquakes simply demonstrate that the earth is consistently a changing system.

They general depict a built up stress in the lithosphere which occurs along its, planar breaks in rock where there is displaceme nt of the side relative to the other.

Often, the stress results into faults or breaks, at other times, it causes slipping along old, sting faults. When movement along faults occurs gradually relatively smoothly, it is called cree p. Creep- is termed as seismic slip, meaning fault displacement without significant earthquake activity-can be inconvenient rarely causes serious damage.

When friction between rocks on either side of a fault presents the rocks from slipping easily or when the rock under stress is not already fractured, some elastic deformation will occur before failure. Whe n the stress at last exceeds the rupture strength of the rock (or the friction along a pre-existing fault), a sudden movement occurs to release the stress. This is earthquake, or seismic slip. With the sudden displacement and associate d stress release, the rocks snap back elastically to their previous dimensions; the behaviour is called elastic rebound.

Faults come in all sizes, from microscopically small to thousands of kilometres long. Likewise , earthquakes come in all sizes, from tremors so small that eve n sensitive instruments can rarely detect them, to massive shocks that can level cities. (Indeed, the seismic movement of creep is actually character ized by many micro-earthquakes, so small that they are typically not felt at all.) The amount of damage associated with earthquake is party a function of the amount of accumulated ene rgy release d as the earthquake occurs.

The point on a fault at which the first movement or break occurs during an earthquake is called the earthquake, or hypocenter. In the case of a large earthquake s focus, for example, a section of fault may be kilome tres long and may slip, but there is always a point at which the first movement occurred, and this point is the focus (Montgomery, 2006).

Deep- focus earthquakes are those with focal depths over 100 km, which distinguishes them from shallow-focus earthquakes. The point on the earth s surface directly above the focus is called the epice ntre. When news accounts tell where an earthquake occurred, they re port the location of the epicentre.

When an earthquake occurs, it releases the store d-up energy in seismic waves that travel away from the focus. There are several types of seismic waves. Body waves (P waves and S waves) travel through the interior of the ear th. P waves are compression waves. As P waves travel through matter, the matter is alternately compressed and expanded. P waves travel through the earth, much as sound waves travel through air. S waves are shear waves, involving a side-to side motion of molecules.

Seismic surface waves are somewhat similar to surface waves on water. This means that they cause rocks and soil to be displaced in such a way that the ground surface ripples or undulate. Surface waves also come in two types: Some cause vertical ground motion, like ripples on a pond; other cause horizontal sharing motions. The surface waves are, large in amplitude- amount of ground displacement-than the body waves from the same earthquake. Therefore, most of the shaking and resultant structural damage from earthquakes is caused by the surface waves.

3.1 Magnitude and Intensity

All of the seismic waves represent energy release and transmission; they cause ground shaking among people associated with earthquakes. The amount of ground motion is related to the magnitude of the earthquake. Magnitude is most commonly reported in countries using the Richter magnitude scale, named after geophysicist Charles F. Richter, who developed it.
Montgomery (2006) says that a magnitude number is assigned to an earthquake on the basis of the amount of ground displacement or shaking that it produces near the epicentre. The amount of ground motion is measures by a seismograph, and the size of the largest (highest-amplitude) seismic waves on the seismogram is determined.
The value is adjusted for the particular type of instrument and the distance of the station from the earthquake epicentre (because ground motion naturally decreases with increasing distance from the site of the earthquake) so that different measuring stations in different places will arrive at approximately the same estimate of the ground displacement as it would have been measured close to the epicentre value is assigned.
The Richter scale is logarithmic, which means that an earthquake of magnitude 4 causes ten times much ground movement as one of magnitude 3, one hundred times as much as one of magnitude 2.

3.2 Occurrence and Severity of Earthquakes

Table 2.1

Descriptor	**Magnitude**	**Number per Year**	Approximate Energy Release (ergs)
Great	8 and over	1 to 2	Over 5.8x102 3
Major	7-7.9	18	2-42 x 102 2
Strong	6-6.9	120	8-150 x 1020
Moderate	5-5.9	800	3-55 x 101 9
Light	4-4.9	6200	1-20 x 101 8
Minor	3-3.9	49.000	4-72 x 101 6
Very mirror	<3	(mag. 2-3 about 1000/day) (mag. 1-2 about 8000/day)	Below 4 x 1016

Source: Frequency data and descriptors from National Earthquake Information Centre.

Different observers in the same spot may assign different intensity values to a single earthquake. Nevertheless, intensity is a more direct indication of the impact of a particular seismic eve nt on e vent on humans in a given place than is magnitude. The extent of damage at each intensity levels is, in turn, related to the maximum ground velocity and acceleration experienced. Thus, even in uninhabited areas, intensities can be estimate if the latter data have bee n measured (Montgomery, 2006).

Several dozen intensity scales are in use worldwide. The most widely applie d intensity scale in the United States is the Modified Mercalli Scale.

3.3 Ground Motion

Ground shaking and movement along the fault are obvious hazards. The offset between rocks on opposite sides of the fault can break power lines, pipelines, building, roads, bridges, and other structures that actually cross the fault. In the 1906 San Francisco earthquake , maximum relative horizontal displacement across the San Andres s fault was more than 6 meters. Fault displacement aside, the shaking produced as accumula te energy is release through seismic wave causes damage to and sometimes complete failed of buildings, with the surface waves especially shear surface waves- responsible for most of this damage. Shifts of even a few tens of centimetres can be devastating, especially to structures made of weak mate rials or inadequately reinforced concrete.

When shaking continues, damage may become progressively worse. Such effects, of course, are most severe on or very close to the fault, so the simplest strategy would be not to build near fault zones. However, many cities have already developed near major faults. Sometimes, cities are rebuilt many times in such place. The ancient city of Constantinople- now Istanbul-has been levelled by earthquakes repeatedly throughout history. Yet there it sits.

Short of moving whole towns, what else can be done in these cases? Power lines and pipelines can be built with extra slack where they cross a fault zone , or they can be designed with other features to allow some give as the fault slips and stretches them. Such considerations had to be taken into account when the Trans Alaska Pipeline was built, for it crosses several known, major faults along its route(Montgomery,200 6).

Designing earthquake resistant buildings is a developed challenge and is a relatively new idea that has developed mainly in the last few decades. Engineers have studied how well different types of building have withstood real earthquakes. Scientists can conduct laboratory experiments on scale models of skyscrapers and other building, subjecting them to small-scale shaking designe d to simulate the kinds of ground movement to be expecte d during an earthquake.

On the basis of their findings, special building codes for earthquake-prone regions can be developed.

This approach, however, presents many challenges. There are a limited number of records just on how the ground does move in a severe earthquake. To obtain the best of such records, sensitive instruments must be placed near the fault zone. *Earthquakes are generally followed by many aftershocks earthquakes that are* weaker than the principal tremor. The main shock usually causes the most damage, but when aftershocks are many and are nearly as strong as the main shock, they may also cause se rious destruction.

The duration of an earthquake also affect how well a building survival is. In reinforced concrete, ground shaking leads to the formation of hairline crac ks, which then widen and develop further as long as the shaking continues. A concrete building that can withstand a one-minute main shock might collapse in an earthquake in which the main shock lasts three minutes. Many of the California building codes, used as models around the world, are designed for a 25-second main shock, but earthquake main shock can last ten times that long.

A final point to keep in mind is that even the best building codes are typically applied only to new construc tion. When a major city is located near a fault zone, thousands of vulnerable older buildings may already have been built in high-risk areas. The cost to redesign, rebuild, or even modify all these, buildings would be staggering. Most legislative bodies are reluctant to require such efforts; indeed, many do nothing even about municipal buildings built in fault zones.

3.4 Ground Failure

Landslide can be a serious secondary earthquake hazard in hilly areas. Earthquakes are one of the major events that trigger slides on unstable slopes. The best solution is not to build in such areas. Even if a whole region is hilly, detailed e ngineering studies of rock and soil properties and slope stability may make it possible to avoid the most dangerous sites.

Ground shaking may cause a further problem in areas where the ground is ver y wet in filled land near the coast or in places with a high water table. This problem is infestation. When wet soil is shaking by an earthquake, the soil particles may be jarred apart, allowing water to seep in betwee n them, greatly reducing the friction betwee n soil particles that gives the soil strength, and causing the ground to become somewhat like quicksand. When this happens buildings can just topple over or partially sink into the liquefied soil; the soil has no strength to support them. The effe cts of liquefaction were dramatically illustrated in Niigata, Japa n, in 1964. One multi-storey apartment building tipped over to settle at an angle of 30 degrees to the ground while the structure remained intact! (Montgomery, 2006).

Liquefaction was likewise a major cause of damage from the Loma Pieta earthquake and the Kobe earthquake. Telltale signs of liquefaction include sand boils, formed as liquefied soil bubbles to the surface during the quake. In some areas prone to liquefaction, improved underground drainage systems may be installed to try to keep the soil drier, but little else can be done about this hazard, beyond avoiding the areas at risk. Not all areas with wet soils are subject to liquefaction; the soil or fill plays a large role in the extent of the danger.

3.5 Tsunamis and Coastal Effects

Coastal areas, especially around the Pacific Ocean basin where so many large earthquakes occur, may also be vulnerable to tsunamis. There are seismic sea waves, sometimes improperly called tidal waves, although they have nothing to do with tides. When an undersea or near- shore earthquake occurs, sudde n movement of the sea floor may set up waves travelling away from that spot, like ripples in a pond caused by a dropped pebble.

Contrary to modern movie fiction, tsunamis are not seen as huge breakers in the open ocean that topple ocean liners in one sweep. In the open sea, tsunamis are only unusua lly broad swe lls on the water surface. As tsunamis approach land, they develop into large breakers waves, just as ordinary ocean waves become breakers as the undulation waters touch bottom near shore.

The breakers of tsunamis, however, can easily be over 15 meters high in the case of large earthquake. Several such breakers may crash over the coast in succession; between waves, the water may be pulling swiftly seaward, emptying a harbour or bay, and very quickly speeds of 1000 kilometres/ hour (600 miles/ hour) are not uncommon speeds and tsunamis set off on one side of the Pacific may still cause noticeable effects on the other side of the ocean.
A tsunamis set off by a 1960 earthquake in Chile was still vigorous enough to cause noticeable effects on the other side of about 7-meter-high breakers when it reached Hawaii some fifteen hour later, and twenty five hours after the earthquake, the tsunami was detected in Japan (Montgomery,200 6).
Given the speeds at which tsunamis travel, little can be done to warn those near the earthquake epicentre, but people living some distance away can be warned in time to evacuate , saving lives, whe never a major earthquake occurs in the Pacific region, sea- le vel data are collected from a series of monitoring stations around the Pacific. If a tsunami is detected, data on its source, speed, and estimated time of arrival can be determine d.

3.6 Fire

A secondary hazard of earthquakes in cities is fire, which may be more devastating than ground movement. In the 1906 San Francisco earthquake, 70% of the damage was due to fire, not simple building failure. As it was, the flames were confined to a 10-square-kilometer area only by dynamiting rows of building around the burning section. Fires occur because fuel lines and tanks and power lines are broken, touching off flames and fuelling them. At the same time, water lines also are broken, leaving no way to fight the fires effectively (Montgomery, 2006).

4.0 Conclusion

Earthquake is one of the commonest environmental hazards that humans are yet to subdue. Thus earthquakes are still challenging the survival instinct, capacity for survival and adaptive techniques of humans to subdue the environment for comfort.

5.0 Summary

Earthquakes simply demonstrate that the earth is consistently a changing system. They general depict a built up stress in the lithosphere which occurs along its, planar breaks in rock where there is displacement of the side relative to the other. When the stress at last exceeds the rupture strength of the rock a sudden movement occurs to release the stress. This experience may be simply described as earthquake or seismic slip.

The amount of ground motion is relate d to the magnitude of the earthquake. A magnitude number is assigned to an earthquake on the basis of the amount of ground displacement or shaking that it produces near the epicentre. All earthquakes may be categorise d as;

- Major
- Strong
- Moderate
- Light
- Minor
- Very mirror

Landslide can be a serious secondary earthquake hazard in hilly areas. Earthquakes are one of the major events that trigger slides on unstable slopes. The best solution is not to build in such areas.

6.0 Tutor Marked Assignments

Two earthquakes on the Richter scale have a magnitude of 4 and 3 respectively.

1. How will you cate gorize/ describe each of t hese earthquakes based on table 2.1?
2. What is the amount of energy each earthquake had released and what is the combined amount of ene rgy that was released by these two earthquakes?

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UNIT 3: FLOODS

Table of Content s

1.0 Introduction

The problem of flood is real and the consequences of this hazard have been continually felt in most of our communities. Among these four major Natural Hazards in Nigeria, flooding stands out as the most disastrous in Nigeria in term of life and properties loss in view of studies reported by Nest (1991), Ojo (1991), Ologunorisa & Adeyemo (2005) and Ojo (2007).

The outcomes from these studies are an indication that flooding should be given adequate attention in terms of awareness, perception, expe rience, coping and manageme nt strategies. This is what this unit strives to focus on.

2.0 Objectives

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

- Define d the term flood
- Mention the types of flood
- Discuss on the causes of flooding
- List the benefits of flooding
- Explain the negative effects of flooding

3.0 Flood: A Conceptual Clarification

The daily usage and in common environmental literature, a flood may be referre d to as a comparatively high flow of water that over-tops the natural or artificial banks in any reach of stream. It is also regarded as an over flow or inundation that comes from a river or other body of water and causes or threatens damage or simple as a deluge or inundation (see Ojo, 2007).

Flood can also be defined as the highest values of the stage or discharge of a stream during the water year. This common view implies the distinction betwee n floods of the same magnitude, but there might have been in existence also several different inundations or none at all. If there are several inundations in a year, the greatest one will be a flood but a flood need not be an inundation, even a dry year has a flood.

It is necessary to state here that these definitions do not contradict themselves. The latter is necessary only because of the technical exigency of including at least one flood for every year in the computation of flood magnitudes and their probable fre quencies of occur rence. A year for while a rare flood is recorded for instance, will transform logarithmically to affinity which induces computational problem.

Exercise 3.1

1. In your own words describe what you understand as flood.
2. Find out from 4 of your classmate their perception of what constitutes as flood.
3. Find out from 3 people in your community their perception of what constitutes as flood.
4. Compare your perceptive and that of others with the definition and explanation of flood give n in section 3.0 above.

3.1 Types of Flood

Ologunorisa (2006) mentioned that flood have been divided into: River Floods and Coastal Floods.

3.1.1 River Floods

They are caused by precipitation acting either directly by rainfall, or indirectly by snow or ice melt, and those resulting from dam collapse and earth slides. Floods resulting from melting of snow and ice, with or without an additional increment from rainfall, are a major component of hydrological region in the high latitude areas a Canada, the United States and Russia, and parts of Europe and at high attitudes in the major mountain areas of Europe and Asia. Such floods normally occur only once a year.

In view of the markedly varying flood response to different rainfall conditions, many attempts have bee n made to classify rainfall floods on the basis of the storm event itself. Thus, Ward recognize d two types, of river floods related to different causal factors:

(1) Flash floods, and

(2) Long rain floods.

Flash floods are often the results of convection storms; while long rain floods are associated with several day convention or even weeks of low intensity rainfall and are the most common cause of major flooding.

The characteristics of long rainfall floods can be classified into four types.

These are:

- Flash floods of few hours duration;
- Single e vent floods of longer duration;
- Multiple even floods and
- Multiple event floods.

It should be noted that apart from the four discussed above, another type calle d flood poundage occur on surface depression on urban and other surfaces.

3.1.2 Coastal Floods

They are of three kinds:

(i) Those caused by me teorological disturbances such as hurricanes and other disturbances at sea (Typhoons , cyclones, tsunamis, e tc).

(ii) Those caused by seismic disturbance such as submarine earthquakes, landsides and other disturbances of the sea.

(iii) Lakeshore floods. The combination of the different types of floods accounts for 40 percent of the world s natural disasters. Earthquakes are but over-estimated while droughts are unde r-estimated probably because it is a non-event hazard. Apart from the high frequency of flood occurrence, most of the overflow of river or seas. For example, flood- prone lands comprise about 5 percent of the area of the Unite d States, more than 10 percent of the Hwang Ho basin in China, almost all of the Netherlands and nearly all of the Southern part of Vietnam.

There is therefore an imperative need for a proper and comprehensive understanding of floods, if the safety of flood plain occupancy and coastal areas are to be guaranteed Ologunorisa (2006).

3.2 Causes of Floods

Climatologists have discussed seventeen factors which may influence runoff and hence floods in any stream. These they divided under three broad categories vies:

- Climatic factors such as precipitation,
- Interception and physical factors; and
- Channel characte ristics, including types and efficiency.

(1) Climatic factors, these are:

(a) Precipitation form: such as rain (rainstorm floods), snow (snow melt floods due to ice jams, floods due to glaciers, floods due to earth-slide; types of precipitation, intensity, duration, time distribution, area distribution, fre quency of occurrence, direction of storm moveme nt, antecedent precipitation and soil moisture.

(b) Interception vegetation species, composition, age and density of stands, season of the year, size of stor m.

(c) Evaporation and (d) Transpiration.

(2) Physiographic Factors which include:

(a) Basin characte ristics such as size, shape slope, orientation, elevation, stream density.

(b) Physical factors such as land use and land cover surface infiltration condition, soil type, geological conditions such as the permeability and capacity of ground water formation.

(c) Topography factors such as the presence of lakes and swamps.

(d) Artificial drainage.

(3) Channel characte ristics including:

(a) Carrying capacity suc h as size and shape of cross sections, shape roughness, length, tributaries, types and efficienc y.

(b) Storage capacity such as breakwater.

The effects of all these factors are fairly accurately known except for the effect of land use. Among many physiographic factors that affect the runoff of any area, one of the important is land use and land manageme nt. Some environmentalists have agree d that it is largely the human that apparently increased severity of all these factors and in them alone insufficient.

Ologunorisa (2006) says that few scholars have discussed the causes of the most dangerous floods of all. That is coastal floods. A hurricane for instance causes damage by the direct action of wind on property, by the accompanying heavy rainfall that causes river to flood. Hence the damage is from three sources, each potentially destructive in its own right, collectively, they are catastrophic.

Floods may also be caused by the encroachment of hydraulic structures and cities on floodplains and coastal lands and by blocking of river channels. The Ogunpa river flood in Ibadan on August 30 1980 for instance was wholly due to the blocking of the river channel with waste deposited by the residents of Ibadan (Ojo, 2007). Eve ntually, it was as if the river decided that it had created the channel and should therefore have the right of way . The entire channel was cleared in one swift flood along with over 2oo residential building, over 200 livers and inestimable property.

3.3 Beneficent Effects of Floods

Of all the extreme events, none is more paradoxical than floods. That is because it is the most frequently occurring natural hazard that causes the greatest damage as well as the most beneficial effect. It is probably safe to attribute the rise and growth of the early loosely refers to the period when man settled and embarke d on cultivations of agriculture. Naturally, these early settlement (later to the Nile, Tigris, Euhrates , Indus and Hwange Ho.

All these rivers have over the years build expensive and fertile instruments possessed ideally suited to tilling with the crude instruments possessed by the early man. Since the beginning of recorded time, humans have always had an affinity for floodplains and riversides. This is because there is lack of road and rail networks, and hence greeter affinity for floodplains and riversides.

Perhaps, the best example of the benefits of floods and floodpla ins is prese nted by the river Nile and its valley. It covers and fertilizes large area of land. This resulted in the early occupancy and subsequent rise of civilization, in the Nile valley. The Nile valley indeed has been a human anthill since ve ry ancient time. Today, the Nile valley with about 900 persons per square kilometres is one of the most densely settled, parts in the African continent. Farming is so comple tely reliant on flooding to ensure that the River floods, the rive r channel is artificially narrowed in some stretches by the construction of levees. These hold back the excess flood-water after the flood has rec eded. This dependence has given rise to such popular saying like Egypt is the Nile and the Nile is Egypt , No Nile, no Egypt , and the the Nile gives life to the Egyptian desert .

Also some farmers along the lower zones of floodplains have adopte d their crop pattern, to annual overflow and they would be disappointed if flooding were to fail. Here than are examples where floods are not only beneficial, but also desirably necessary for the substance of life. Other examples of floodplains giving rise to civilization are the early West African Empires of Ghana, Mali and Songhai who are most value possessions were the Region of present day Bamako. The Nok cultures also developed on the floodplains of the Niger.

Today, the Ganges delta and the Hwang Ho floodplains are some of the most densely settled parts of the world while valuable forest resources continue to be harvested on the Amazon floodplains.

A list of other advantages of the floodplains are:

the fact that floodplains soils are normally more fertile and easier to till than those of upla nds,

the flat lands characteristics of floodplains are less costly to build on,

the moderate gradie nts are favourable for highways and railroads construction and the abundance of water for various purposes attract huma n occupancy of the floodplains.

It is important to note that sites on riverbanks have always been attractive locations for towns because they act as a focus for routes at bridging points. Towns tended to develop first on bluffs or terraces close to the river. Consequent expansion forces them to spread out on the floodplains, e.g London, Paris and Washington D. C. In Nigeria, examples of such towns include Makur di, Jebba, Lokoja and Onisha (Ologunorisa, 2006).

Floods may also have other beneficial uses if they can be properly controlled and managed. The excess floodwater, for instance, may be held in reservoirs and used to provide water for homes and industry in the dry season and generate hydro-electric power. For example, the Naser Dam in Egypt and the Hydro- Electric power works at the Kainji Dam in Nigeria rely on high floodwater to be efficient.

The floodwater may also be used to r educe stream pollution and provide opportunity for fishing and recreation, and agric ultural expansion schemes.

3.4 The Negative Effects of Flood

Flood has been known to cause damage to lives, landed prope rty, household property, business, traffic, drains, surface and underground water. For an in-depth comprehe nsion of flood effects, it is preferable to review a few catastrophic floods. The causes of floods are essentially the same differentiate d only in magnitude and the diversity of the victims (especially in their nature and response capa bility).

On August 31st, 1980, the Ogunpa River flowing through the city of Ibadan over flow its banks and all features e ncroach on its floodplains. Over 2000 persons perished in that flood (see Oyo State Year Book, 1981, P.2). The series of flood which hit the city of Kano between August 6 and 13, 1986 culminating in the collapse of the Baguda dam and is estimated to have claimed at total of over 100 lives.

No discussion of the loss of lives will be complete without mention of the Hwang Ho River (Translated from Chinese to mean Yellow River). This amazing river is responsible for more human deaths than any other individual feature of the world s surface. In 1887, a massive flood on this river killed over 2 million people (by drowning or star vation). In 1931, the worst flood ever claime d a total death toll of 3,700,000 people. Hence within a time span of only 44 years, the yellow River had depleted the Chinese population of by million people or more, which is about the population of the e ntire Niger Delta. No wonder then that the river is more popularly referred to as Chinese sorrow .

In 1970, a cyclone initiated a flood in the coastal areas surrounding the Bengal in Bangladesh whic h killed about 225,000 people, crops worth about 63 million dollars were destroyed and 280,00 herds of cattle were washed away (Burton, et al, 1978). These weather events range d from hurricane in the Ame ricas to heavy rains resulting in flash floods and avalanches in the other parts of the globe. India had the worst disasters with 3,320 dead resulting from cyclones, tornadoes, rain floods, snow, rain and typhoons and snows. Nigeria (14) and republic of Benin (7) the way African countries listed ranked low not necessarily due to the mild nature of rainstorms which reliable records can be complied. WMO (1997) has confirmed that the 1995 figures were very close to 8,300 The number of countries which reported weather-related deaths was also similar 44 in 1996 and 42 in 1995. It is important to note that the largest fatalities are associate d with floods resulting from rain.

The most striking feature of these severe rain events is the amount per day which in India was about 12,00mml-1 for 12 consecutive days in August 1996 while in China falls totalled 70,000mmd-1 (also in August, 1996). In the case of China, live lost within demolished houses have not been full accounted for but about 2 million houses collapsed and 2,000 boats sank (Adefolalu, 2000).

Adefolalu (2000) further observes that the story in other parts of the wor ld was not different, as most fatalities had to do with flooding arising from heavy rains. The case of United States of America deserves special mention if only to highlight that the low number of deaths (292) was not as a result of mild storms, snowstor ms, or weak hurricanes and tornadoes but to the efficiency and high level of sophistication of early warning system (EWS) and the accuracy of the NEW-CASTING Techniques which connect over 1,000 Radar network to the Global

Telecommunication System (GTS) from which India houses derive their 30-minute forecasts of the weather.

Further, the underground shelter system allows for immediate evacuation of people rather than transporting them over long distances at great danger. It is noteworthy that only, 24 fatalities accompanie d 1,200 tornadoes in 1996-a figure that was 5 less than in 1995 and less than 30% of the average annual deaths, (82). These go to prove that in terms of ave rting death, the United State of America is far ahead of the whole world in their EWS and public enlightenment/sensitization campaigns on extreme weather events.

Despite their ranking as numbers 1 and 2 world population, China and India tend to lead in rating catastrophic losses of life in weather-related event. Nigeria has a fair rating of 1 out of every 7.7 million at risk of dying in any major weather disaster. This, of course, does not represe nt the total picture, as reports cannot be said to be complete due to lack of reliable (reporting) network. For instance, air disaster and multiple road accidents occurring in bad weather in 1996 would have changed the total figure if properly accounted for. However, the rate of fatalities in normally occurring severe weather events in Africa is amplified by the other rating for Egypt, Ethiopia and Malaga sy.

4.0 Conclusion

The reality of the terrible effects of flood hazards have clearly been shown in this unit and that the benefits are nothing to compare with relative to the negative conseque nces.

5.0 Summary

Flood is refer red to as a relatively high flow that over-tops the natural or artificial boundary of a water body. It is also regarded as an over flow or inundation that comes from a r iver or other body of water and causes or threatens damage or simple as a deluge or inundation . Flood can also be defined as the highest values of the stage or discharge of a stream during the water year.

Floods have been divided into: River Floods and Coastal Floods and we have two types of river floods related to different causal factors:

(1) Flash floods, and

(2) Long rain floods.

Flash floods are often the results of convection storms; while long rain floods are associated with several day convention or even weeks of low intensity rainfall and are the most common cause of major flooding.

There are four characteristics of long rainfall floods, these are:

- Flash floods of few hours duration;
- Single e vent floods of longer duration;
- Multiple even floods and
- Multiple event floods.

Coastal Floods are of three kinds:

1. Those caused by meteorological disturbances such as hurricanes and other disturbances at sea (Typhoons, cyclo nes, tsunamis, etc).
2. Those caused by seismic disturbance such as submarine earthquakes, landsides and other disturbances of the sea.
3. Lakeshore floods

There are seventeen factors which may influence runoff and hence floods in any stream. These are divided under three broad categories:

- Climatic factors such as precipitation,
- Interception and physical factors; and
- Channel characte ristics, including types and efficiency.

Of all environmental hazards, none is more paradoxical than floods. Simply because it is the most freque ntly occurring natural hazard that causes the greatest damage as well as the most beneficial effect. Perhaps, the best example of the benefits of floods and floodplains is presente d by the river Nile and its valley. History tells us that it covers and fer tilizes large area of land. This resulted in the early occupancy and subsequent rise of civilization, in the Nile valley.

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UNIT 4: DROUGHT & DESERTIFICATION: CONCEPTS AND CAUSES

Table of Content s

1.0 Introduction

Drought and desertification are becoming popular environmental problems in Nigeria today. This emerging popularity has made these twin environmental hazards essential for us to study in Nigeria and especially at the Open University. In this unit we shall study with clarity the concepts of drought and desertification. The causes of these e nvironmental hazards will be analyzed systematically and the root cases will also be traced in details.

I want to c hallenge you to disseminate the knowledge you will acquire in this to your families, friends and ne ighbours in other to help control these problems. I do hope you will take the advantage this unit has provided you.

2.0 Objectives

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

- Describe what is drought
- List the three major types of global drought
- Mention seven features of drought
- Describe what desertification is
- State five indicators of desertification
- Discuss on two basic causes of desertification

3.0 Drought: A Conceptual Review

Drought has been described as an extended and continuous duration of very dry weather (Jones, Robertson, Forbes, & Hollier, 1990). I want you to unde rstand clearly that this definition varies from country to count ry, since weather varies. In the UK, three types of drought are recognized:

(a) total drought is a period of 15 or more consecutive days with a rainfall below 0.2mm;

(b) partial drought has a duration of 29 successive days with an a mean rainfall of 0.2 mm or less per day;

(c) a dry spell has a duration of 15 or more successive days, dur ing which the rainfall does not exceed 1 mm per day.

But in the United States, a dry spell is a period;

1. Of 14 days without measurable rainfall.
2. A period with an experience of insufficient water supply to meet usual domestic, agricultural and industrial demands. Drought takes place under many climatic regimes and may vary in severity from the minor and short-lived summer restrictions on washing cars and watering gardens in southern and easter n England to catastrophic events such as the development of the Dustbowl in the American Midwest during the 1930s and the large-scale crop failures during the Ethiopian famine of 1985.

Drumlin, an elongated hummock of uncertified glacial all deposited and molded below an incensed. Drumlins may be up to 36 mm length 60 m in height and the parallel to the direction of the former ice flow with their steeper blunt end facing upstream. Drumlins usually occur in clusters or swarms, giving rise to a basket-of eggs topography. The sands and gravels in drumlins are often extracted for construction and industrial purposes.

There is no generally accepted definition of drought, but understand that it is generally accepted that the menace is characterized by moisture deficiency, when the demand for water for particular water use system excee ds the supply available from various sources.

Droughts have been recorde d as recurrent phenomena in Nigeria in general and more specifically in the Sudano-Sahelain regions, whic h are the areas of West Africa characterized by droughts and desertification.

As in most parts of the world, precipitation is the most significant avenue of water supply-demand component of most of the water use syste ms. Therefore, are closely associated with droughts and with many definitions of droughts.

Globally, there are three basic types of drought;

- meteorological drought,
- agricultural drought and
- hydrological drought.

The metrological drought is usually said to take place when there is a prolonge d absence or deficiency or inadequate distribution of precipitation.

REFLECTION

Have you ever had this experience of metrological drought in your community? If yes, what was your survival strategy? If no was your answer make inquiry from people or individual from your community who you hope to have had such an experience at one time or the other.

It is often defined as a percentage of the long-term average rainfall in a given location. There are many variations of this definition and this makes meteorological drought apparently difficult to identify with any degree of accuracy.

Compared to meteorological droughts, agricultural droughts have been observe d to take place when there is insufficient moisture available at the appropriate time to mee t evaporative demand by crops, vegetation, pastures and other agricultural systems; as a result, yield and/or absolute production decline (Ojo, 2007).

Crops requires varying moisture needs through their growth and development periods, and therefore, the timing of rain is essential in rain-fed agricultural regions in determining whether there will be a good harvest or a poor one. Hydrological drought takes place when the water needs of plants cannot be met by available precipitation.

Some of the features of drought were articulate d by Ojo (2007) are:

(a) Low rainfall and high rainfall variability.

(b) High evaporation and potential evapotranspiration rates

(c) Generally persistent negative rainfall anomalies

(d) Occasional torrential rains resulting in floods

(e) Rapidly high erosive runoff especially on steep terrains

(f) Sparse vegetation cover

(g) Too little moisture for rain fed cultivation throughout the year

Drought is no doubt an inevitable and often devastating phenomenon. In gene ral, droughts have occurred throughout the available historical record of climate in West Africa. Severe droughts that have affected parts of West Africa in the Sahel region where highlighted by Ojo (2007) spanning from1445-1452, 1538, 1557-1588, 1681-1687, 1738-1756 and 1828-1839.

The droughts of the 1730s to the 1750s were recorde d to have killed 50% of the population of Timbuktu and other parts of the Niger bend and resulted to famine in places like Senegal, Gambia, Mali, Mauritania, Burkina Faso, Benin, Chad and parts of northern Nigeria especially Bornu and Kano regions.

The droughts between 1972 and1973 were also severe , although they were comparatively less than the 1983-84 in scope. In 1984, the Food and Agricultural Organization (FAO) me ntioned that about 250 million inhabitants in 22 countries in Africa, including northern Nigeria, were affected by food crisis as a result of the persistent droughts of 1972-73.

So it clear that drought have occurred in many parts of West Africa and that certainly includes our country Nigeria. This experience have occurred in varying degrees of severity and duration throughout human history, and many regions of the African continent have experienced considerable distress arising from drought occurrences, mass migration, famine and cessation of economic activity in many countries.

3.1 Desertification: A Conceptual Review

Desertificat ion, just like drought, is not simple to define; however, most definitions have generally reflecte d some degree of land degradation processes. Globally the term desertification, since its adoption by the United Nations Conferences on Deser tification (UNEP, 1977), has swallowed up a number of related terms such as desert encroachme nt, the advancing Sahara , desiccation, desertization. The term has also been use d to describe the dogmatization due to burning, c learing and erosion of forest a nd savannah zones of West Africa.

The United Nations Environment Programme (UNEP, 1977) described desertification as land degradation in arid, semi-arid and dry humid areas as a basic consequenc e of human activities. Another version of his definition was developed at the UN Conference on Environment and Deser tification (UNCED, Rio de Janeiro, June 1992), which says that desertification is land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors including climatic variations and human activities.

This new ve rsion definition has been internationally discussed and approved at the UNCED as the operational standard for Agenda 21. Therefore it is general accepted that desertification may take many forms but it usually refers to widespread land degradation in the dry lands, which is the re duction of biological productivity of dry land ecosystems, including rangeland pastures and rain fed and irrigated croplands, as a result of the acceleration of certain natural physical, chemical and hydrological processes.

These processes usually include;

- erosion and deposition by wind or water,
- salt accumulation in soils,
- groundwater or surface runoff,
- reduction in the ability of soils to transmit and store water for plant growth.

The severity of desertification in West Africa, however, varies significantly from one country to another, and even in the Sudano- Sahelian regions of Nigeria, the degree of desertification varies from one state to another. In general, the main features of desertification include:

a) A reduction in the amount of the soil covered by the vegetation. Specifically, the amount of bare soil increases and vegetation may be reduced to isolated patches.

b) A consequent rise in the reflective capacity (albedo) of the surface for solar radiation, since arid and semiarid soils are lighter-coloured than most plants, even with grey foliage so usual in these climates.

c) A considerable and permanent loss of perennial plants, especially woody shrub and trees

d) Considerable soil erosion and impoverishment, because of removal of fine minerals and organic materials by wind and because of rapid oxidation of the remaining water and soil carbon. Gully and sheet erosion of soils by occasional heavy rainfalls appears to accumulate the eroded materials on valley floors or in basins.

e) Overgrazing and inadequate forage in relation to vegetative resources (Ojo, 2007).

3.2 Indicators of Desertification

Desertification is often the consequence of stress disturbance on the environment which may be natural or caused by human. Ecosystems which do not alter in the presence of stress and/or disturbances are described as stable. Alterations here are varied from those associated with regular seasonal stresses. When ecosystem remains stable from year to year it is said to be stable. Such an ecosystem is expected to return to its original state after a disturbance or stress or to maintain equilibrium (oduwaiye , 1999).

Stability here can be viewed from two angles;

(1) Structural stability: if the species composition remain more or less the same and

(2) Functional stability: if ecosystem characteristic biomass production and nutrient cycling rates unchanged.

The following are the indicators of deser tification.

(a) The disappearance or permanent degradation of the vegetation

(b) Soil erosion by wind

(c) Dune formation or reactivation

(d) Desiccation of the soil profile and more controversially

(e) Lowering of the ground water table.

However Grumblatt in his pilot study on Evaluation of FAO/UNEP provisional methodology for assessment and mapping of desertification provided the following scheme (partly reproduced) which can be used in collecting data.

I. Physical

(i) Climate

- **(a) Rainfall**
- (b) Temperature
- (c) Wind speed, Direction, Frequency
- (d) Sunlight duration
- (e) Sand storm/ dust storm frequency

(ii) Soils

(a) Surface rockiness

(b) Texture

(c) Opinion wate r

(d) Permeability

(e) Alkalinity

(f) Water erosion

(g) Wind erosion

II Biologica l

(i) Vegetation

- (a) Herbaceous ca nopy cover
- (b) Herbaceous biomass
- (c) Percent bare ground
- (d) Species composition
- (e) Vegetation type winds

III Socio/Economic

Human population
(a) Density of permanent structures.

3.3 Causes of Desertification

The basic causes of dese rtification as articulated by Oduwaiye (1999) are;

- drought and
- human activities which include grazing by livestock, wood cutting, cultivation and burning.

1. Drought

Drought is commonly regarded as one of the causes of desertification. But it is known this is the only possible when there is prolonged drought. Although drought usually leads to the loss of several plant species.

Drought is known to be a periodic eve nt even in arid and semi-arid climates where periods of rainfall failure are interposed with years of abunda nt rainfall. Drought however only gives more force to instability create d through other manageme nt practices e.g. overgrazing of available fragile lands during wet years.

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2. Human Activities

(a) Grazing by Livestock: This human activity may contribute in different ways to desertification. These include:

(i) The substitution of annual for perennial grasses which will perhaps reduce the plant cover available to protect the soil in the long dry season.

(ii) Damaging of soil structure in the vicinity of wells as a result of trampling by cattle.

(iii) Destruction of seedling.

(b) Wood Cutting: Humans especially in poor nations are used to wood cutting to produce fuel wood or construction timber. This impairs natural regene ration of woody species and a great proportion of the soil surface nutrients content are exposure after woodcutting. This will also result in more run-off and soil surface compaction leading to deterioration.

(c) Cultivation: Yearly cultivation without adequate fertilization impoverishes the soil structurally in quality- wise. It also increases the possibility of remobilization by wind.

(d) Burning: Burning affects biological product ivity by

(i) destroying grass and herb growth

(ii) favouring fire resistant species over fire-tende r ones

(iii) stimulating fresh shoots, particularly of grass
(e) Other activities by human There activities include urban development, and road construction.

4.0 Conclusion

These semis twin-Drought and desertification are dry devils that are becoming popular environmental problems in Nigeria today. This emerging popularity has made these twin environmental hazards essential for study in Nigeria and especially at the Open University.

We have studied with clarity the concepts of drought and desertification. The causes of these environmental hazards have been analyze d systematically and the root causes also traced in details.

I want to c hallenge you to dissemina te the knowledge you have ac quired in this unit to your families, friends and ne ighbours in orde r to help control these problems. I do hope you have taken the advantage this unit has provided you.

5.0 Summary

Drought has been described as an extended and continuous duration of very dry wealth. This definition varies from countr y to country, since weather varies.

In the UK, three types of drought are recognized:

(a) total drought is a period of 15 or more consecutive days with a rainfall below 0.2mm;
(b) partial drought has a duration of 29 successive days with an a mean rainfall of 0.2 mm or less per day;
(c) a dry spell has a duration of 15 or more successive days, dur ing which the rainfall does not exceed 1 mm per day.

Globally, there are three basic types of drought;

- meteorological drought,
- agricultural drought and
- hydrological drought.

Some of the features of drought were articulated as:

(a) Low rainfall and high rainfall variability.
(b) High evaporation and potential evapotranspiration rates
(c) Generally persistent negative rainfall anomalies
(d) Occasional torrential rains resulting in floods
(e) Rapidly high erosive runoff especially on steep terrains
(f) Sparse vegetation cover

(g) Too little moisture for rain fed cultivation throughout the year

Desertification was described as land degradation in arid, semi-arid and dry humid areas as a basic consequence of human activities.

Another version of his definition was developed at the UN Conference on Environment and Desertification (UNCED, Rio de Janeiro, June 1992), whic h says that desertification is land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors including climatic variations and human activities.

The following are the indicators of deser tification.

(a) The disappearance or permanent degradation of the vegetation

(b) Soil erosion by wind

(c) Dune formation or reactivation

(d) Desiccation of the soil profile and more controversially

(e) Lowering of the ground water table.

The basic causes of dese rtification as articulated are;

- drought and
- human activities which include grazing by livestock, wood cutting, cultivation and burning.

6.0 Tutor Marked Assignment s

1. Discuss with examples four features of desertification
2. Make an outline of five evidences of desertification.
3. Explain two human activities that have c ontributed to desertification in Nigeria.

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UNIT 5: IMPACTS OF DROUGHTS AND DESERTIFICATION

Table of Content s

1.0 Introduction

Welcome to what may be regarded as the second part of the previous unit where we discussed on drought and desertification- concepts and causes. We do hope you found the previous unit worthwhile and that you have indeed shared with others the knowledge you have so far acquired.

In this unit we shall move further to discuss on the impact that the consequences of drought and desertification has resulted into and ways of ameliorating some of these impact.

2.0 Objectives

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

- Mention five major impacts of drought and desertification.
- List six basic socio- economic impacts of drought and desertification in Nigeria.
- Mention three ways by which human contributes to desertification.
- Explain how grazing leads to desertification.
- Discuss on how desertification becomes reversible.

3.0 Major Impact of Drought and Des ertification

It is essential for you to first understand clearly that it is virtually impossible to separable, perhaps almost like a Sieme ns twin, the impact of droughts from that of desertification. Consequently, discussions on the two hazards will not be separate d in this unit.

The impact of drought and desertification in the drought prone and decertifie d areas of Nigeria are serious on many sectors such as:

- the physical a nd ecological environment
- agriculture and livestock production and management
- water resources and water resources management
- Health
- ecosystems and
- forests and forestry.

Related to the above listed impacts of droughts and desertification are:

- Loss of biodiversity, rapid deterioration of the ecosystems,
- Loss of ecological stability, soil erosion and loss of soil fertility, silting of reservoirs and change in hydrological regimes.

REFLECTION: The Punch Newspaper, 30th January, 2006

One disturbing manifestation of the effect of droughts and desertification is the progressive shrinking of Lake Chad, which is one of Nigeria s important landmarks and best-known cultural heritage. The lake which is the remnant of an inland sea was estimated to have covered an area of 400,000km about 6000 years ago.

Newly released satellite images by the National Space Research and Development Agency of Nigeria (NASRDA) show that Lake Chad has completely withdrawn from Nigeria and is now located in Chad Republic.

As a follow up to this story, experts have predicted that the lake may dry up completely by 2010 if the current rate of retreat is not controlled. This will have serious of socio-economic, socio-cultural and socio-political implications on the communities that benefits from the lake.

The Chad Basin Development Commission is made up of four countr ies:

- Chad
- Cameroon
- Nigeria and
- Niger.

These nations must rise quickly and that on time to rescue the situation before it is too late to cry over spilled milk.

Do you realise that we are talking about estimated 20 million people living in these four countries whose means of livelihood-subsistence agriculture-is totally dependent on the lake is currently at risk of severe hunger and famine?

Recent studies have also shown that far mers on the Nigerian side of the lake are moving along with the water as it recedes. The implication of this is that we now have some Nigerians living in Chad Re public but still believe that they are within Nigeria (Ojo, 2007).

DISCUSSION POINT

Can the gradual migration of Nigerian farmers at the Lake Chad generate borde r disputes in the next decade?

Do you foresee another Bakassi on our hands in the near future because of the impact of drought and desertification?

3.1Socio-Economic Impacts

Basic socio- economic impac ts of drought and desertification include:

(a) Unemployment

(b) Rapid drop in agricultural activities and produc tion with its release in the rural labour force from farming activities. This labour force move to urban locations.

(c) The dynamics migration from rural areas places more pressure on jobs and facilities in the urban centres. Such movements are characteristic of the Sudano-Sahelian regions, from where migrants move southwards to urban centre such as Lagos in search of better living conditions. The economic and social conseque nces of these movements are substantial.

(d) The feedback mec hanisms in drought and desertification systems exacerbate their own effects.

(e) The consequences of drought and desertification sometimes leads to political problems (including conflicts and possibly wars) which often lead to a lot of suffering and death.

(f) Decrease in quality of living as a consequence of the decline in quality of the rural communities. This decline in rural communities is apparently due to lack of water supply, un-sustained availability of fuel energy and inadequate income generation.

(g) Famine and death.

Exercise 5.1

1. List six basic socio- economic impacts of drought and desertification in Nigeria.
2. Discuss your personal experience on any one or as related to you through an individual or any means.

Other socio-economic impacts of drought and desertification in Nigeria are listed below:

a. Migration: An alarming rate of rural-urban movement as a result of serious food shortages and rural unemployment (example is the experie nce at the Gidan Kaura village in Gada Local Governme nt Area of Sokoto state).

b. Demand on few facilities: In affecte d are as, only women, old men and little kids are left in a pathetic state of inadequacy of such amenities as housing, food, medicine etc.

c. Social Vices: The urban centres are littered with loiterers and beggars with high incidence of crime and truancy among idle immigrants from affected communities.

d. Famine and Malnutrition: Reduction in food production and subse quent nutrient, intake of both human and animals result in high mortality among both populations.

e. Industrials Raw Materials: The 1972 drought in Sokoto State has bee n the onset of an irregular and inadequate supply of industrial raw materials such as cotton, cotton seed and tanning materials.

3.2 Control of Desertification

There are short and long-term techniques for the control of desertification. These techniques as outlined by Olagunju (1999) are articulated below:

3.2.1 Short Term Techniques

These techniques give a cushion effect within a shor t period of establishment. Examples include:

(1) Preservation of Existing Forest

The currently existing vegetation in gazetted forest reserves and other wooded areas should be adequately policed and le gislations against indiscriminate felling of tree, bush-burning and overgrazing must be wells enforced while those on the protection of planted trees should be enacted.

There is also need to evolve systematic manageme nt practices for sustaining adequate supply of goods and services from the forests. Moreover, apart from increasing the number of grazing rese rves, there is also need to establish and implement grazing reserve laws and by-laws to improve the pasture.

(2) Enrichment of Soil Nutrient

Steps must be take n to encourage the use of manure and fertilizers to improve growth rate of the existing vegetation.

(3) Alternative Energy Sources

The utilisation of gas cookers, kerosene stoves, and solar energy appliances for domestic use will reduce the demand on the forests. For example, the purchase of 42,000 ke rosene stoves by the Sokoto State Government for resale to Civil servants at subsidized rates is an example in the right direction.

3.2.2 Long-Term Techniques

There are techniques whose effects show up after a long period of establishment. Examples include:

(1) Yearly Planting of Trees

This activity is better backed up by Government policies. This is one potent method for educating the populace on the dangers of an environment devoid of trees.

Importantly, the gene ral public should be mobilized to make forestation a personal programme knowing full well that a restore tree-cover in the environment is for their personal benefit.

(2) Sand Dune Fixation

This is the planning of grasses on the dunes to reduce movement of sand particles followed by the introduction of tree species.

(3) Community/ Individual Wood lots Programme

This is idea for the provision of more trees in the environme nt for the benefits of fuel wood, poles, fodder and shad, fruits, gums and resins, and other commercial products.

(4) Farm- Forestry Practice

The farm forestry involves the distribution of seedlings to farmers free of charge to plant on their farms, protect and nurture to maturity. Moreover, the use of in situ conserva tion where existing trees are protected from destruction to protect the soil from wind erosion (as wind breaks) and serve as fodder and shade for man and animals.

(5) Shelter belts Establishment

The Arid zone Forestation Programme, Ecological `Disaster Relief Programme, Forestry II Project, the State Forestry Services, Drought and Desertification Control and State Environmental Protection Programmes have established conventional shelterbelts. These programmes have proved to be some of the most effective way of protecting the soils. For example, the 65 gazzetted forest reserves and 200-km of shelter belts in Sokoto State still exists and is protective.

(6) Integrated Rural Development

With irrigated shelterbelts, other welfare services like the provision of water for the rural people and their livestock (in boreholes) exist, to improve the living standard of affected communities.

3.3 Irreversible Desertification

Desertification ends up into irreversible loss of biological productivity when there is destruction or alteration of soil profile which is itself the result of thousands of years of soil forming processes in which case, the soil will not be able to support plant growth which leads to reduced productivity.

Such soil degradation includes Lateritsation and Compaction which facilitates sheet wash by running water, sand accumulation which may develop into dunes. These situations can be checked through the planting of grass (e.g vetiver), shrubs and trees (Oduawaiye, 1999).

3.4 The importance of Remote Sensing in Desertification Control

To monitor and solve the challenges of desertification, there is need to collect data about the target environment. Remote Sensing has proved very useful in this area.

Lilles and Kiefer (1979) defined remote sensing as the science and art of obtaining information about an object, area or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area or phenomenon. The device is used to collect data about environment without coming in contact with the environment under study.

4.0Conclusion

The reality of desert encroachment in Nigeria is not an issue for debate but a call for concern, awareness and concrete actions that will help reduce the negative impacts of droughts and desertification.

It is essential for you to first understand clearly that humans are the major cause of these environmental hazards whose effects are virtually impossible to separate.

5.0 Summary

The impact of drought and desertification in the drought prone and decertifie d areas of Nigeria are serious on many sectors such as:

- the physical a nd ecological environment
- agriculture and livestock production and management
- water resources and water resources management
- Health
- ecosystems and
- forests and forestry

There are short and long-term techniques for the control of deser tification. These techniques are:

Short Ter m Tec hniques

- Preservation of Existing Forest
- Enrichment of Soil Nutrient
- Alternative Energy Sources

Long-Term Techniques

- Yearly Planting of Trees
- Sand Dune Fixation .
- Community/ Individual Wood lots Programme
- Farm- Forestry Practice
- Shelte r belts Establishment
- Integrated Rural Deve lopment

6.0 Tutor Marked Assignment

1. Mention t hree ways by which human contributes to desertification
2. How does grazing lead to desertification?
3. Is desertification reversible?

8.0 References and Other Resources

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UNIT 6: VOLCANIC HAZARDS (I)

Table of Content s

1.0 Introduction

As we commence yet another unit on environmental hazards our goal is make this unit easy for you to comprehend.

The environmental hazard for consideration is volcanic hazar d and it will be discussed in two parts as units 6 and 7.

This sixth unit will review fundamental issues on volcanic hazards and relate some real life experience of the hazards volcanoes have caused in terms of life and properties.

We like to sound a note of caution that some real life stories and incidences may disturb you if you are emotional.

2.0 Objectives

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

- Discuss on the three volcanic tec tonic se ttings
- List six substances that are ejected during a volcanic er uption

3.0 Volcanic Tectonic

There are about 500 active volcanoes in the world. In an average year, around fifty erupt. Since only about 5 per cent of eruptions result in human fatalities, the relative infrequency of hazardous volcanoes events is one of their most dangerous features.

Traditionally, volcanoes have been classified as active dormant or extinct but in 1951 Mt Lamington erupted in Papua New Guinea killing 5,000 people although considered extinct. To be prudent, all volcanoes which have erupted within the last 25,000 years should be regarded as at least potentially active.

Like earthquakes, the distribution and behaviour of volcanoes is controlled by the global geometry of plate tectonics, and active volcanoes in every continent, except Australia (Smith, 1991).

They are found in three tec tonic settings:

1. Subduction Volcanoes

   They are located in the subduction zones of the earth s crust where one tectonic plate is thrust consumed beneath another.

   They comprise about 80 per cent of the world s active volcanoes and are the most explosive type with the typical form of a stratulern, composed of alternating layers of ash and lava.

2. Rift Resumes

   They occur where tectonic plates are dive rging. They are generally less explosive and more effusive, especially when they occur on the deep ocean floor.

3. Hat spill Roleames

   They exist in the middle of tectonic plates where a crustal weakness allows molten material to penetrate from the earth s interior. The Hawaman islands in the middle of the Pacific plate are a good e xample.

3.1 Primary Volcanic Hazards

They are associate d with the products eje cted by the volcanic eruption. The most explosive volcanic eruptions are accompanie d by pyrodastic flows, sometimes called nies ardents or glowing clouds. These flows result from the frothing of molten magma in the vent of the volcano. The gas bubbles them expand and burst explosively to fragment the lava.

Eventually, a dense dead of lava fragments is ejected to form a turbulent mixture of;

- hot gases
- pyroclastic material
- volcanoes fragments
- Cystals
- ash
- pumice
- glass and shards

These eventually then flows down the flank of the volcano. Pyroclastic bursts flow downhill because, with a heavy load of lava fragments and dust, the flow is appreciably denser than the surrounding air.

Such clouds may be literally red hot (up to 1,0000C) and may be ejected many tens of kilometres into the atmosphere. However, they pose the biggest hazar d when they are directed laterally by explosive blasts (Pelean type) and remain close to the ground. These directe d blasts are capable of advancing in surges at speeds beyond 30 ms1. In historical eruptions, pyroclastic flows have travelled some 30 10 km from the source. Very little can survive in the path of a pyroclastic surge and flows e ruption.

During the twentieth century the Mont Pelee disaster on the island of Martinique the town of St Pierre, some 6 km from the centre of the explosion. The Island suffered a surge temperature around 7000C borne by a blast travelling at around 33 ms, such surges can melt

- plastic
- metal and
- glass.

The surge itself is usually preceded by an air blast with sufficient force to topple some buildings. Air fall replied comprises all the fragmented material which is ejected by the volcano and subseque ntly falls to the ground.

Volcanic gases are released by explosive eruptions and lava flows. The gaseous mixture commonly includes

- water vapour
- hydrogen
- carbon monoxide
- hydrogen sulphide
- sulphur dioxide
- sulphur trioxide
- chlorine and
- hydrogen chloride in variable proportions.

Measurement of the exact gas composition is made difficult by the high temperatures near an active vent and by the fact that the juvenile gases interact with the atmosphere and each other, thus constantly altering their composition and proportions

Carbon monoxide has caused deaths because of the toxic effects at very low concentrations but most fatalities have been associated with carbon dioxide releases.

Carbon dioxide is dangerous because of the following feat ures:

- it is a colourless
- odourless gas
- density about 1.5 times greater than air
- accumulates in low-lying places

- Commonly found at topographic hollows
- Sometimes detected at basements of house
- Not easily detected
- Once inhaled, it can cause death in 10 -15 minutes at atmosphere concentrations as low as 10 per cent by volume.

REFLECTION

You may wish to consider this awful experience in 1979. About 142 people evacuating from a village in Indonesia due to the presence of lava, at night tried to escape from the threatened er uption simply walked into a dense pool of volcanically released carbon dioxide and were immediately asphyxiated.

Learn wisdom from this experience.

3.2 Ground Deformation

Ground deformation occurs as often as volcanoes grow from within by magma intrusion and as new layers of lava and pyroclastic material accumulate on the surrounding slopes. The deformation is not in itself a hazard but it provides a destabilizing process by over -steepening hill slopes

Such structural failures of a volcano have occurred worldwide, on average, four times per century over the last 500 years, although few deaths have occurre d major structural instability is most likely on large polygenetic volcanoes (Smith, 1991).

Lather is volcanic mudflows with the following characteristics:

- at least 50% sediment
- has sand grain size or smaller
- occur widely on the flanks of volcanoes
- Also occur in wet tropics
- the term is of Indonesian origin
- present the greatest threat to human life, after Iron privoclastic surge
- lather may occur in associate with any volcanic event
- large quantities of water are present on the steep sides of a volcano.
- Sometimes this water forms iron violent electrical rainstorms
- most destructive events have been linked to the rapid melting of snow and ice
- pyroclastic flows cause mean-descent lava fragme nts to fall over a wide area of snow and ice

REFLECTION
For example, about 5,500 people were killed in a mudflow following the erumpent of the Kelut volca nic Lava, in 1919.

The water mixes with soft ash and volcanic boulder to produce a debris-rich fluid, sometimes at high temperatures, which then pours down the mountainside at speeds which commonly a ttain 15 ms and may reach in excess of 22ms.
The lather threat is prominent along the volcanic chain of the northern Andes. Andean volca noes result iron in the Pacific Ocean floor (Nazea plate) descending beneath the continent of South America plates. There are at least twenty active volcanoes in the resulting mountain area which extends for 1,000 km and straddles the equator from central Colombia in the north to southern Ecuador in the south.
The highest peaks exceed 5,000 m in altitude and are permanently snow capped.
Many of the mountain tops are structurally very week due to the action of hot gases over time. Lathers have caused several historic disasters.

DISCUSSION POINT
Cotopaxi in Ecuador has erupted at least fifty times since 1738. During an eruption in 1877, so much ice and snow was melted that e normous lathers, were released about 160 km long. This was discharged simultaneously to the Pacific and Atlantic drainage basins.
What is the possible effect of this discharge on the aquatic organism?
Discuss your response with your colleague s in class.

The worst volcanic disaster in the world since the eruption of Mont Pelee occurred is a result of lathers following the 1985 eruption of the Nevado del Ruiz volcano in Colombia. Nevado del Ruiz (5,200m) is the most northerly active volcano in the Andes. It has generated large lathers in the past, notable in 1595 and 1815, and additional settlement has taken place in the surrounding valleys over the last century.

Fresh major volcanic eruption did not take place until one year later. This caused large-scale, rapid melting and a huge lather rushed down the Lagunillas valley sweeping up tree, buildings and everything else in its path. Some 50 km downstream it overwhelmed the town of Armero. Over 5,000 buildings were destroyed by a deposit of mud 3-8 m deep and almost 22,000 people lost their lives within a few minutes. Some of the survivors were trapped up to shoulder height in the ash slurry for two days before being rescued.

Exercise 6.1

From the above paragraph about 22,000 lives were lost in this volcanic eruption.
On the bases of this data search the internet using any search engine such as goggle scholar to obtain;

1. The number of lives lost in volcanic eruption in;

- 2000
- 2001
- 2002
- 2003
- 2004

2. Identify the countries where each incident occurred and rank each Country based on the number of occurrence.

3. Make a list of the Continents of the world and rank them on the bases of volcanic eruption.

4.0 Conclusion

Volcanic eruption is real and it is a very serious environmental hazard although the hazard is alien to our nation, there are many nations around the world that are plagued by the fear of the possibility of volcanic eruption. Others live in the fear and trauma of seeing a beloved one perish in an eruption.
Irrespective of the experience volcanic eruption releases gases that are dangerous and hazardous to human health, life and properties. This hazard cannot easily be controlled but humans can avoid living in volcanic zones.

5.0 Summary

We have learnt in this unit that:
Lather is volcanic mudflows with the following characteristics:

- at least 50% sediment
- has sand grain size or smaller

- occur widely on the flanks of volcanoes
- Also occur in wet tropics
- the term is of Indonesian origin
- present the greatest threat to human life, after Iron privoclastic surge
- lather may occur in associate with any volcanic event
- large quantities of water are present on the steep sides of a volcano.
- Sometimes this water forms iron violent electrical rainstorms
- most destructive events have been linked to the rapid melting of snow and ice
- pyroclastic flows cause mean-descent lava fragme nts to fall over a wide area of snow and ice.

  Carbon dioxide re leased from volcanic vent is dangerous because of the following features:
- it is a colourless
- odourless gas
- density about 1.5 times greater than air
- accumulates in low-lying places
- Commonly found at topographic hollows
- Sometimes detected at basements of house
- Not easily detected
- Once inhaled, it can cause death in 10 -15 minutes at atmosphere concentrations as low as 10 per cent by volume.

8.0 References and Other Resources

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UNIT 7: VOLCANIC HAZARDS (II)

Table of Content s

1.0 Introduction

This is the second part on the series on volcanic eruption. This unit will treat issues related to lather slides and debars avalanches. Essential environmental control techniques for diverting and controlling lava flows such as bombing, the use of artificial barriers and water sprays will be discussed.

2.0 Objectives

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

- Explain the relationship between lather slides and volcanic eruption.
- State three methods for the control and diversion of lava flow.
- Discuss on any four ways of forecasting and warning on volcanic eruption.

3.0 Lather Slides and Debars Avalanches

They are a common feature of volcano-related ground failure. They are particularly associated with eruptions of deictic magma, which is siliceous with a relatively high viscosity and has a large content of dissolved gas.

The experience of volcanic eruption at Mt. St Helens that took place in May, 1980 is worth discussing. Mt St Helens is one of at least seven active subduction volcanoes in the Cascade Range of the Pacific Northwest, USA.

The e xperience began with swarms of small earthquakes (M = 3.0) and minor ash eruptions gave the first signs of a major event and were followe d by ground uplift on the north flank of the volcanic cone. Over a two-month period the uplift continued at a rate of about 1.5 m per day. More than one month before the main eruption the bulge was nearly 2 km in diameter and had swe lled by as 100 m.

Large cracks were e vide nt in the cover of snow and ice. All this evidence was consistent with the injection of viscous magma under the volcano at shallow depth. On 18 May, when the bulge because 150m high, an ear thquake (M = 5.1) shook the walls of Mt St He lens summit crater and started many small avalanches. Then a huge slab of rock and ice on the over-steepened northern slope of the volca no broke away from the main cone along a crack across the upper part of the bulge. The earthquake triggered a debris avalanche containing 2.7 km of material and pressure in the shallow intrusion was further relieve d by an explosive eruption and massive ash cloud. Volca nic ash blankete d much of eastern Washington State, 57 people were killed and proper ty damage was estimated at USI billion (Smith, 1991).

3.1 Environmental Control

There is no known me thod of preventing volcanic eruption. Similarly, there is no known defe nce against the pyroclastic flows and comparatively little can be done to protect standing crops and exposed water supplies from air-fall tephra. Therefore, lava flows moving at comparatively slow speeds are the volcanic hazard over which most physical control can be exerted.

The first known attempt to divert a lava flow took place in Sicily in 1669, when iron bars were employed to try to stop an advancing flow from Etha reaching the town of Catania. A breach was opened in the flank of the flow which then began to take another direc tion. Unfortunately the new course threatened a neighbouring village and the attempt was abandoned.

Control of lava flows has also been attempted in Hawaii, mainly to protect the city of Hilo, which was reached by a flow in 1881 and is at risk from future events.

3.2 Methods of Diverting and Controlling Lava Flows

There are three possible methods, according to Smith (1999) for diverting and controlling lava flows:

3.2.1Bombing

The use of ground explosives can be useful in three situations.

- First, bombing of lava high on the volcano may cause the flow to spread there and halt the advancing lava front by depriving it of supply. This method was first tried with limited success in 1935 on a fluid lava stream advancing on Hilo, although some scientists believe that more mode rn techniques of aerial bombing could achieve better results.

- Second, control of how lava has been attempted by breaching the flow out locally and starve the advancing front of material. This method was tried on the flow of Mauna Los s 1942 eruption and in the 1983 eruption of Etna, when it prove d possible to divert some 20-30 % of the bloc ky flow from its natural channel.

- The third possibility, not yet trie d, is to bomb the walls of the cone at the vent so that the ve ry fluid lava there spills out over a relatively wide area and is unable to contribute to a definite stream. These methods involve an e lement of risk. Eve n when the topography is suitable, and are best attempted with good atmosphere visibility, which is unusual during volcanic eruption.

3.2.2 Artificial Barriers

It can be used to diver lava streams away from valuable property if the topography is favoura ble. Barriers must be constructed from resistant, large-calibre material, such as massive rocks, with a broad base and gentle slopes. The method is most appropriate for thin and fluid lava flows which e xert a relatively small amount of thrust. It is doubtful if diversion would work with more powerful blocky flows which may attain heights of 30 m or more.

Several diversion barriers have been pr oposed to protect Hillo, Hawaii. The topographic setting is favourable because flows can only approach the city through a narrow corr idor, allowing intercepting barriers to be locate d in advance of an eruption with a high degree of confidence. The walls suggested would be around 10 m high and the channels created by the barriers would be around 1 km

wide, which would hold the volume of lava resulting from any nearby eruptions in historic times.
This method has applications e lse-where. For example, in the Kralla area of Northern Icela nd, the land has been bulldozed to create two barriers to protect a village and a factory respectively from the free-flowing lava.

3.2.3 Water Sprays

This technique was first employed to control lava flows during the 1960 er uption of Kilauca, Hawaii, in a sponteous experiment by a local fire chief. The method was used on a large scale during the 1973 eruption of Eldfell to protect the town of Vestmananaeyjar on the Icelandic island of Heimacy. It has been estimated that 1 m of water will cool about 0.7 m of lava from 11000C when totally converted to stream.
On Heimacy, special pumps were shipped to the island so that large quantities of sea water could be pumped from the harbour. At the height of the operation, the pumping rate was almost 1 m s effectively chilling about 60.0000 m. of advancing lava per day. The exercise was expensive, lasting for about 150 day, but it appeared to be successful.
Some days after spraying started, the lava front slowed up into a solid wall some 20m in height. Measurements of lava temperature, made is specially drille d boreholes after the eruption was over, c onfirm that where water had not bee n applied, the lava te mperature was 500-7000C at a depth of 5-8 m below the surface. In the sprayed areas an equivalent temperature was attained until a depth of 12-16 m below the lava surface (Smith, 1991).

3.3 Vulnerability Modification Adjustment: Community preparedness

As with earthquakes, the cost of mentoring volcanic activity and pre-disaster planning is small compare d to the potential losses. Given the existence of a monitoring programme and effective preparation, some warning can usually be given to permit evacuation of the most dangerous areas before the eruption occurs. Until rece ntly, emerge ncy planning in volcanic hazard zones was not well developed in the LDCs.
Before the Nevado del Ruiz disaster in Colombia in 1985, there was no national policy in place for the systematic monitoring of volcanic hazards or for the manageme nt of such hazards. Police failures were compounded by de lays in hazard mapping and the unwillingness of the author ities to accept the economic and political costs of early e vacuation.

The length of time available for the alert phase differs widely. In some cases volcanic activity may start to increase months before a violent eruption; in other events only a few hours may be available. For effective evacuation, it is essential that the population at risk is clearly informed well in advance about the evacuation routes and the refuge points to which they should go. To some extent these directions will have to be flexible depending on factors such as the expecte d scale of the eruption, which might influence the pattern of lava flow, and the wind direction at the time, which will influence the pattern of ash fall.

Some local roads may be destroyed by earthquake-induced ground failures. Stee p sections of highway can become impossible with even small deposits of fine ash, which make asphalt very slippery. The e vacuation of densely populate d areas creates special problems of transportation, including the peak capacity of road networks and the balance of public a nd private vehicles available (Smith, 1991).

During the 1991 er uption of Mt Pinatubo, the total number of evacuees extended to well over 200,000 about three times more people than previously evacuated in any volcanic e mergency.

In some cases, off-shore evacuation may be necessary for;

- small volcanic islands
- coast of New Br itain island
- Papua New Guinea.

The existing road network, extending no more than 50 km from the caldera, could not guarantee safe landward evacuation during all eruptions whilst seabor ne evacuation was limite d by the absence of suitable wharf facilities for large ships.

In small-to moderate eruptions, it was suggeste d that the best option might be to shelter the population in an extensive system of tunnels which were excaudate in tephra deposits around Rebaul during the Japanese occupation of the area during the Second World War.

After evacuees have reached the refuge points, they require support services which include;

- medical treatment (especially for dust-aggravate d respiratory problems and burns)
- shelter
- food and
- hygie ne.

Volcanic emerge ncies may last for many months as eruptions are repeate d. This implies that the temporar y arrangements planned for refugees may have to function for some time, perhaps is that, depending on the prevailing wind conditions, ash fall has the potential to disrupt communities se veral hundreds of kilometres away.

For reside nts at these sites claimed any prior knowledge of ash fall hazard and warning messages were largely ineffectual in promoting a response. Hazar d mitigation specialists clearly have a difficult task in persuading such distant communities that they face a volcanic risk.

Increasing efforts are now made to encourage the local population in seismically active areas to become more involved with disaster prepare dness. Evidence from the western USA suggests that, whist residents do make responses from the long-term threats, there is little prioritization of the adjustments.

In the Philippines the Institute of Volcanology and Seismology has adopted a programme whereby residents are gives a training course and then encouraged to look for possible precursor y signs of volcanic activity. Such as crater glow, steam releases, sulphurons odour and dying vegetation (Smith, 1991).

In Ecuador about 3 million people live within the two main volcanic mountain ranges and are at some degree of risk from lather. The principal threat is the Chillos and Latacunga on lather deposits from the 1877 e ruption.

Again, public education programmes, including field trips and evacuation exercises involving 5,000 people in a simulated eruption scenario, have been use d to raise awareness and encourage better precautionary attitudes.

3.4 Forecasting and W arning

Major volcanic eruptions do not occur spontaneously. They are preceded by a variety of environmental changes which accompany the risk of magma towards the surface. The monitoring of these changes provides the best hope of developing reliable forecasting and warning systems. However, only twenty volcanoes worldwide are monitored by well-equipped local observatories whilst a further 150 have limited instrumentation, mainly seismometers (Smit h, 1991).

UNDRO (1985) classified the various unusual physical and chemical phenomena that have been observe d to occur before eruptions. Unfortunately, such phenomena do not always appear and the highly e xplosive volcanic eruptions are generally the most difficult to forecast.

The most reliable monitoring techniques are seismic and ground deformation measurements, although lather monitoring by automatic rain gauges and flow sensors on the upper slopes of volcanoes can provide some warning of this hazard.

3.4.1 Earthquake Activity

This occurs commonly near volcanoes, although it is not fully understood whether earthquakes trigger eruptions or vice versa. For predictive purposes, it is important to gauge any increase in activity in relation to local background leve ls. This means that it is essential to have good seismograph recor ds, preferably over many years for the volcano in question.

Immediately prior to an expecte d eruption these records will be suppleme nted by data from portable seismomete rs. There is some evidence from a percussive seismic signature whic h has been incorporated into a tentative earthquake swarm model for the prediction of volcanic eruptions.

The onset and subsequent peak of a swarm of high-frequency earthquakes reflects the fracture of local rocks as the magmatic pressure increases. This phase is followed by a relatively quiet period, when some of this pressure is relieved by cracking in the earth s crust, before a final tremor results in an explosive e ruption.

3.4.2 Ground Deformation,

This is sometimes a reliable percussive sign of an explosive eruption as magma moves towards the surface, but the relationships are complex and not easy to fit into a forecasting mode l. The method is also difficult to employ for the explosive subduction volcanoes because it erupts so infrequently that it is difficult to obtain sufficient comparative information. In rare cases, such as the 1980 event at Mt St Helens, the deformation is sufficiently large to be easily visible but it is usually necessary to detect movements with standard surve y e quipment or the use of tilt meters.

These instruments are very sensitive but can only record changes in slopes over short distances. The use of electronic distance measurement (EDM) techniques provides a more accurate picture of relative ground displace ment, although it is less usually available and requires a series of visible targets on the volcano. Global positioning system (GPS) measurements, obtained from satellites, are now also available to reveal the surface displacement of volcanoes.

3.4.3 Thermal Monitoring

Thermal Monitor ing as magma rises to the surface; it might be expected to produce an increase in temperature. But many volcanoes have erupted without any detectable thermal change. The temperature of hot springs and steam emission can be fairly easily monitored but it provides only an indirect picture of what is happening beneath the surface.

Also any small rise in surface temperature associated with a greater geothermal heat flux can be obscured by rainfall. There is also a problem of thermal inertia when heat conduc tion may be too slow for forecasting pur poses. Where a crater lake exists, thermal changes have been meaningful.

UNDRO (1985) cited the example of the Crater Lake on Taal volcano, in the Philippines, whic h increased in temperature from a consta nt 330C in June 1965 to read 450C by the end of July. The water level also rose during this period and, in September 1965, a violent eruption occurred.

Such observations can increasingly be suppleme nted by thermal imaging from satellites. Heat emission was one of the first volcanic features to sense remotely and it has proved a valuable means of haza rd assessme nt.

3.4.4 Geodetically Monitoring

This is any predictive interpretation of the chemical composition of the juvenile gases issuing from volcanic ve nts is a diffic ult task. Gas samples take only a short time, or distance, apart often shows considerable variation. It is, therefore, not usually possible to know how representative any changes in composition might be of more gene ral conditions in the volcano. Visual observations of steam emissions or ash clouds depend on meteorological conditions of well as volcanic activity, but volcanic plumes can be monitored by AVHRRs carried on weather satellites.

At present there is no fully reliable forecasting sche me available for volcanic eruptions although some success has been achieved. For example , a high-confidence forecast of the 1991 Mt Pinnatubo eruption allowed the evacuation of people from an area that, at maximum, covered a 40 km radius.

By the time the 1996-7 eruptions on the island of Montserat had destroyed the main town of Phymouth, all the residents had been evac uate to the safer, northern part of the island. But uncertainty ofte n leads to practical problems; this was well illustrate d by the events at La Soufriere, on the island of Guadaloupe, Lesser Antilles, in 1976.

Abnormal seismic activity over a twelve-month period eventually led to the evacuation of 72,000 people from around the volcano. This evacuation of around one-fifth of the population was one of the largest, and most costly, ever undertake n for a volcanic e mergency and lasted for ove r three months.

The managerial problems of responding to an uncertain volcanic hazar d prediction have also been apparent in the Cascade Range in the Pacific Northwest of the USA. Following steam discharges at least ten times above the normal level from Mt Baker, Washington, during March 1975, the US Geological Survey foresaw the possibility of a destructive mudflow or avalanche.

The US Forest Service closed public access to the Baker Lake Recreation Area in June 1975. The restrictions remained in force for nearly one year, during whic h time no hazardous event occurre d.

Subse quent survey of both residents and recreationalists shown a wide-spread belief that the author ities had over-reacted and over 70 per cent of residents claimed that they would ignore any future hazard warnings and respond to mandatory controls only.

In comparison, the 1980 eruption Mt St Helens was more accurate ly forecast but still took the author ities party by surprise. This was because the main explosion was not immediately preceded by any special abnormal phenomena and the explosive blast was directed laterally rather than vertically. As a result 57 people who had been allowed to enter the danger area were killed. Although the surrounding area was sparsely populated, it has been estimated that perhaps as many as 1,000 lives might have been lost if free access had been allowe d to residents and tourists.

4.0 Conclusion

The occurrence volcanic e ruption is real and it is a very serious environmental hazard that destroys life and properties although you may not appreciate the techniques for the control of this hazar d because it is alien to our nation.

There are many nations around the world that are plagued by the fear of the possibility of volcanic eruption. Others live in the fear and trauma of seeing a beloved one perish in an eruption.

Irrespective of the experience volcanic eruption releases gases that are dangerous and hazardous to human health, life and properties. This hazard cannot easily be controlled but humans can avoid living in volcanic zones.

5.0 Summary

In this unit you have learnt that lather slides and debars avalanches are common feature of volcano-re lated ground failure. They are particularly associate d with eruptions of deictic magma, which is siliceous with a relatively high viscosity and has a large content of dissolved gas. The experience of volcanic eruption at Mt. St Helens that took place in May, 1980 is worth discussing.

With regards to environmental control there is no known me thod of preventing volcanic eruption. Similarly, there is no known defe nce against the pyroclastic flows and comparatively little can be done to protect standing crops and exposed water supplies from air-fall tephra. Therefore, lava flows moving at comparatively slow speeds are the volcanic hazard over which most physical control can be exerted.

Three possible methods of diverting and controlling lava flows identified they are

- Bombing
- Artificial Barriers
- Water Sprays

The most important precursors of volcanic eruption are:

- Earthquake Activity
- Ground Deformation
- Thermal Monitoring
- Geodetically Monitoring

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UNIT 8: LANDSLIDE

Table of Content s

1.0 Introduction

The truth about life is that environmental hazards are inevitable because they are natural but may be naturally induced or artificially as a result of human interference on nature. However the type of hazard e xperienced in a particular location may be different from another.

The concept for discussion in this unit is not a familiar one with our environment so you may not have a deep appreciation of the hazar d as experienced by others except you have the capacity to put yourself in their shoes.

The truth is that landslides are real; you may wish to have a look at pictures to back-up our discussions in this unit.

2.0 Objectives

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

- Mention five types of landslide terrain
- Discuss on two major factors t hat determine the strength of the material during a landslide
- Outline five causes of La ndslide

3.0 CONCEPTUAL REVIEW OF LANDSLIDE

The down slope movement of large volumes of surface materials under gravitational influences is an important environmental hazard, especially in mountainous terrain. Rapid movements cause most loss of the life and damage; including human-induced land subsidence, have less potential to kill but can be costly.

Depending on the dormant material, these movements tend to be groupe d into *landslides (rock and soil) or avalanches (snow and ice). Mass movements may be* triggered by either seismic activity or atmosphe ric events. To that extent, this hazard lies at the interface betwee n endogenous and exogenous earth processes.

There can be few countries where mass movement processes do not exist, and the landslide risk is increasing worldwide as land hunger forces new development on to unstable slopes, it is an under-recognize d threat because the impacts tend to be frequent and small- scale, whilst the process itself is often attributed to other hazards, such as earthquakes and rainstorms. Mass moveme nts also add considerably to the wide range of hazards found in mountainous areas throughout the world Smith, 1991).

During the early 1970s, an average of nearly 600 people per year were killed by slope failures worldwide but, twenty years later, the figure ranked into several thousand. Perhaps as many as 90 per cent of these deaths occur on the Pacific ocean which is partic ularly susceptible to mass movements because of the varying combinations of rock type, steep te rrain, heavy typhoon rainfall, rapid land use c hange and high population de nsity.

The main cause of increased deaths has been the expansion of unregulated town settlements to unstable slopes in many Third World cities- for example, in Caracas. In Venezuela, the number of urban landslides increased from less than one per year in 1950 to reach about 35 per year in the 1980s.

The death toll from mass movements is still compara tively low in most MDCs. In the USA annual mortality runs at 25 50 people and it has been estimate d that, for landslides alone, some 22 per cent of the population are exposed to high hazard conditions while another 20 per cent are exposed to moderate hazards conditions. As with many other environmental hazards it is the urban area which is most vulnerable because of the large populations at risk (Smith, 1991).

3.1 LAND SLIDES TERRAIN

The term landslides cover most down slope movements of rock and soil debris that have become separated, from the underlying part of the slope by a shear zone or slip surface. The type of movement, which may include falling, sliding and flowing, de pends largely on the nature of the geologic environment, including material strength, slope configuration and water pressure. The truth is that slope failure will become an increasingly important hazard, especia lly in the LDCs.

Five types of landslide terrain have bee n identified:

1. *Areas subject to seismic shaking. Earthquakes can promote widespread* land sliding, which often occurs in thousands of individual slides, as in the 1950 Asian- India earthquake when over 50 billion m of material was displaced over an area of 15,000 km. Major landslides also occurred after the 1988 Armenian and 1990 lran earthquakes.
2. *Mountainous environment with high relative relief. High e nergy* terrain, such as the Himalayan or Andean mountain chains, produces perhaps one catastrophic rock fall per decade worldwide. These spectacular slope failures comprise huge masses of material (up to 100 x 106m) which, at least in the initial stages, travel near-vertically at high velocities over long run-out distances.
3. *Area of moderat e relied suffering sever e land degradation. Readily* erodible soils on slopes subject to land degradation caused by deforestation or overgrazing have the potential for gully expansion and land shipping. Over the centuries, about 100 villages in southern Italy have been abandoned because of this process.
4. *Areas covered with thick sheets of loss. Any mantling of an existing* ground surface with finely grained deposits, such as wind-blown loess or tephra, is likely to lead to a shear zone at the junction of the two materials and the formation of flow slides in the loose deposits. The loess plateau of central China is a classic location.
5. *Areas with high rainfall inputs. In areas which regularly experience* rainfall from monsoons or tropical cyclones, rock weathering can penetrate tens of meters below the ground surface. For example, in parts of Hong Kong weathered material has moved down slope or cover the bedrock to a depth of more than 20 m. throughout the humid tropics, these dee p and porous mantles are prone to landslides(Smith,1991).

3.2 Landslides: Strength of the Material

Landslides are down slope movements of rock and soil along slip surfaces. They are associated with a disturbance of the equilibrium which normally exists between stress and strength in material resting on slopes. The relationship between stress and strength in material resting on slopes and the density, strength cohesion and friction of the materials comprising the slope is exceeded by a down slope stress.

The strength of the material is the maximum resistance to shear stress and depends on:

1. Internal cohesion: This is produced by the interlocking, or sticking together, of granular particles, particularly in clayey soils and rocks, that enables the material to rest at an angle. Some materials, such as dry sand, are cohesion less. Cohesion is independent of the weight of material about the surface.
2. ***Internal friction: This is the resistance of particles of granular soil to*** sliding across each other. The friction components of granular soil to depend on the weight of material above the surface.

In turn, these factors will depend on

- the weight or loading on the slope
- the moisture conditionals
- the weight of material in the block
- the angle paralleled to the slope
- the driving force or shear.

Sliding is resisted by the shear strength which is derived from the cohesion of clay-rich materials and the static friction between the block will remain in place as long as the driving force does not exceed this combined shear strength. If the slope becomes steeper, the shear stress exerted on potential slip surface because the down slope component of gravity increase. If these stresses eventually exceed the shear strength along a critical slip surface, the mass above the surface will move down slope.

3.3 Types of Landslide

There are two main types of landslide:

3.3.1 Rotational slides

They exist as curved slip surfaces. The result is a pattern of scars and depositional features. Of which the most common is the spoon-shaped scar associated with shear failures along arcade plants. The slipped material will be deposited on the slope in either a hummocky or a lobate form depending on the water content.

This type of slope movement can cause a great deal of property damage if the slope has been built upon but warning can often be given for evacuation. A good example is the landslide disaster which affected the city of Ancona, central Italy, in 1982.

The major short-term cause was an increase in pore-water pressure associated with heavy rainfall in the previous month. Apart from losses to road and rail communications, 280 dwellings were damaged. Although the slide occurred in an area of known slope instability, no formed warning was given on this occasion. Nevertheless, about 4,000 people spontaneously evacuated their houses.

3.3.2 Translational slides

Translational slides have relatively uniform, planer surfaces of movement and are sometimes known as block glides and debris slides. Intersecting planner slip surfaces from wedges of rock, which are relatively common types of translational slide. The destructive landslide that hit the Vaiont dam in the Piave valley, northern Italy, in October 1963 was a combined natural and technological disaster.

The Vaiont dam, over 260 m high, the key construction in a chain of hydroelectric dams, was completed in 1960 across a narrow canyon set within a broader valley.

The slope of the upper valley were underlain by layered sedimentary rock dipping towards the valley floor and traversed by fractures parallel to the slope. The sedimentary sequence included limestones with inter-bedded clays which became significantly weaker when wet.

As the water stored in the reservoir backed up behind the dam, it entered pre-existing fractures and wetted the vulnerable layers. Following heavy rain and a minor earth tremor, the southern slope of the valley failed. A large volume of material collapsed into the reservoir and displaced some 200 x 106m3 of water, mud, rock and timber, which fell almost vertically over the dam into the valley below. Although the dam remained intact, several villages were destroyed with the loss of 1.189 lives.

Table 8.1 Classification of landslides

Type of movement	Type of material Bedrock	Engineering soils Predom course	Predom fine
Falls	Rock fall	Debris fall	Earth fall
Topples	Rock topple	Debris topple	Earth topple
Slides (a) rotational (b) translation	Rock slump Rock block slide Rock slide	Debris slump Debris block slide Debris slide	Earth slump Earth block slide Earth slide
Lateral spreads	rock spread	Debris spread	Earth spread

Flows	Rock flow (deep creep)	Debris flow (soil creep)	Earth flow
Complex	Combination of two or more principal types of moveme nt		

Source: Smith (1991)

3.4 Causes of landslides

Landslides result from a varie ty of events that may combine either to increase the driving force or to reduce the shear resistance on a slope. Factors that increase during forces on a slope may be either physical or human and include:

- An increase in slope angle which may occur if a stream erodes the bottom of a slope or if the slope is steepened by building work. Jones et al. (1989) have described how the cutting of a road into the basic of a slope during 1984, which left exposed faces 25 m high and colluviums standing at an angle of 550 unsupported by anything other than a 3 m masonry wall, led to the Catak landslide disaster in Turkey in which sixty- six people died in 1988.
- Removal of lateral support at the foot of a slope again caused e ither by natural mass wasting processes or by building activity.
- Additional weight placed on the slope by the dumping of waste or house construction. Residential development not only adds weight to the slope through the buildings themselves but also through excess water supplied from landscape irrigation and seepage from swimming pools and sewage affluent systems.
- Removal of vegetation by wildfires or through human activities such as logging, overgrazing or construction. Surface materials become looser because of the loss of soil binding by roots and the slope is also more exposed to the erosive action of surface water through the loss of plant cover.
- Local shocks and vibrations whic h can occur naturally from seismic activity or from the operation of heavy construction machinery.

Factors that lead to a re duction in the shear resistance on a slope are:

- An increase in pore pressure in the slope materials, especially along a slip surface. This is the most important single factor and explains the close relationship which exists between shallow-seated landslides debris flows, and rainstorms. Unfor tunately, the detailed interac tion of rain-water and soil behaviour is not fully understood and it remains difficult to predict landslides on a site-specific basis.

In unsaturate d material that is not totally dry, the internal voids or pore will be filled with gas fair and water vapour and some liquid water. If the slope the n experiences additional loading, perhaps as a result of building construction, the mineral grains will be able to slide into a more compact arrangement. Such compression increases the soil density and additional strength will result.

However, if there is resistance to a denser configuration due to water in the void space, and rapid surface loading occurs relative to the permeability of the soil, then the additional load is transferre d into the pore water causing an increase in the pore-water pressure. In turn, this reduces the friction component of strength and down slope movement may occur:

- An increase in slope angle, which often occurs when developed slopes are over-steepene d by cutting into the base, a process which increases the driving force. After land slipping on the slope the area has to be re-engineered to a safer 2:1 overall angle combined with restoration work includes improve d drainage, reverberation and strengthening of the toe of the slope.

  Studies have shown that, several decades ago, 25-30 per cent of landslides in southern California were related to construction activities. Improve d grading codes have reduced the amount of slope movement damage but there is still a general trend, in the Los Angeles area and else where, towards building on hill slopes which is driven by the decreasing availability of flat land sites and the fashion for houses with extensive views;
- Weathering processes, whic h promote the physical and chemical breakdown of slope materials. Certain clay materials, such as montmorillonite, expand when water is present and the behaviour of these expansive clays has been implicated in the failure of many southern Californian hillsides. In addition, other natural or soil piping developments on slopes will lead to weakness and the possibility of land sliding.

In most urban areas, landslides may be attributed to a combination of the above factors. One example is the 1979 Abbortsford landslide which created a slope failure covering 18 ha in a suburb of Dunedin, New Zealand, and severely damaged sixty-nine houses. In this case the failure was attributed to the removal of some slope support at the toe by excavation for building, the introduction of additional water to the site and the extensive removal of natural vegetable all superimposed on an unstable geological setting.

The progressive human invasion of landslide hazard zones is not confined to the developed world. The need for improve d transportation leading to new road construction in terrain with a high probability of slope movement throughout the LDCs. In these areas limited resources may lead to inadequate hazard protection.

For example, the 52 km long Dharan-Dhankuta road, completed in 1981, provide a key north-south link within Nepal be tween the Ganges lowlands to the sout h and the hill villages to the north. The road crosses the unstable Himalayan foothills of East Nepal and is surrounded by long, step valley side slope angled at 30-450. Engineering is difficult and expensive in such terrain and the road was built to a relatively low cost specification. The road has since proved difficult to maintain because of cut-slope failures and the blocking of culverts by debris.

3.5 Rock falls

These are moveme nts of debris (mainly rock) transported through the air. The y are the simplest type of rock movements and occur on steep faces where bedrock weakness exists such as joints be dding and exfoliation surfaces are present.

Rock falls are presume d to fall directly off cliff faces, rather than to slip along a joint or bedding plane, although both types of movement may occur. The presence of water in clefts and fissures is highly influential, especially in the mid-latitudes where regular freeze-thaw cycles progressively weaken the rock mass by increasing such openings.

Many of the largest rock falls are induced by earthquake but more spontaneous slope instability also occurs, especially in closely jointed or weakly cemented materials on slopes steeper than about 100. The greatest rock fall hazard exists when joint and bedding planes are inclined at a steep angle as the highly folde d rocks common in major mountain chains like the Himalayas, Andes and Rockies.

The Frank rockslide, which occurre d in Alberta, Canada, in 1903, was a classic example.

In this case the slide took place across bedding planes in a steep anticline formed in the well-jointed limestone of Turtle Mountain, which was subject to mining activity. Groundwater see ping into the joint dissolved the limestone and enlarged the fractures. During the winter this water froze and wedged the rock apart, further weakening the structure. The resulting debris destroyed the southern end of the small town of Frank killing about seventy people. The present town has since been relocate d about 2 km north of the original site.

3.6 Debris flows

These are down slope movements of fluidities soil and other material acting as a viscous mass. This occurs when loose slope materials become saturated, resulte d in a loss of cohesion and internal friction between the granular particles, as that an unstable slurry mixture is produced. Debris flows tend to be less deep-seate d slope failures than landslides. They are a major feature in the tropics, where the y are triggered by either the prolonged rainfall associated with slow-moving low pressure troughs or the more inte nse rainfalls, sometimes exceeding 100 mm h-1, created by tropical cyclones.

The high water content means that the slope mate rial moves faster and further from the original source than with landslides. Although the course of debris flows is often guided by stream channels, events mean that they te nd to claim more lives than landslides. Because of their high density, up to 1.5 to 2.0 times the density of water, debris flows have great destructive force and can remove large boulders and houses from their path.

Several tropical cities, such as Rio de Janeriro and Hong Kong, are at risk from both landslips have been associate d with property development involving earth cuts, fills and retaining walls during major rainstorms in the summe r months. In 1966, landslides produced in excess of 300,000 m3 of debris in the stress of Rio and more than 1,000 people died whe n many over-steepened for building construction, failed. One year later, fur ther storms hit Brazil and mudflows caused a further 1,700 deaths and the disruption of the power supply to Rio.

In February 1988 more debris flows in Rio de Jane iro claimed at least 200 lives and made 20,000 people homeless. Most of the victims were living in unplanne d squatter settlements erected on deforested hillsides. Such period in January 1982, some 500-600 mm of rain fell in the San Francisco Bay area and debris flows killed twenty-six people, ten of whole died in a block glide incident in Sanata Cruz County.

In most cases the flows followed stream course and began as flow-sides before turning into fluidized masses that were able to attain velocities of 10 ms. The flows occurred at night and most victims died in the homes, indicating the need for effective evacuated as well as better planning controls.

4.0 Conclusion

Environmental hazards have continued to challe nge the existence of humanity and especially the need to enjoy a comfortable life. In this unit we have discusse d in details on landslides the types, causes, rock fall and debris flow. It is important for you to accept this environmental hazard as a natural challenge to human survival, thus provoking our intellectual capacity and skill to control nature for the benefit and survival of the human race.

Landslides, rock fall and debris flow will continue to take place as long as humans exist on earth. The challenge is to check the excessiveness of t his environmental problem especially through technology that will be environme ntally sustainable.

5.0 Summary

In a nut shell what we have discussed in this unit is that down slope move ment of large volumes of surface materials under gravitational influences is an important environmental hazard, common in mountainous terrain. Rapid movements cause most loss of the life and damage; including human-induced land subsidence, have less potential to kill but can be costly. Depending on the dormant material, these movements tend to be grouped into landslides (rock and soil) or avalanches (snow and ice).

There can be few countries where mass movement processes do not exist, and the landslide risk is increasing worldwide as land hunger forces new development on to unstable slopes. Mass movements also add considerably to the wide range of hazards found in mountainous areas throughout the world.

We also learnt that, during the early 1970s, an average of nearly 600 people per year were killed by slope failures worldwide but, twenty years later, the figure ranked into several thousand.

Five types of landslide terrain were mentioned in this unit;

- Areas subject to seismic shaking.
- Mountainous environment with high relative relief.
- Area of moderate relied suffering severe land degradation.
- Areas covered with thick sheets of loss.
- Areas with high rainfall inputs.

Recall that the strength of the material in a landslide is the maximum resistance to shear stress and depends on:

- Internal cohesion
- Internal friction

In turn, these factors will depe nd on

- the weight or loading on the slope
- the moisture conditionals
- the weight of mate rial in the block
- the angle paralleled to the slope
- the driving force or shear.

There are two main types of landslide:

- Rotational slides
- Translational slides

Causes of landslides are;

- An increase in slope angle
- Removal of lateral support at the foot of a slope.

- Additional weight placed on the slope by the dumping of waste or house construction.
- Removal of vegetation by wildfires or through human activities such as logging, overgrazing or construction.
- Local shocks and vibrations

6.0 References and Other R esources

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Unit 9: SNOW AVALANCHES

Table of Contents

1.0 Introduction

Welcome to the ninth unit of this course. Our discussion will be centred on Snow and how the fall affects humans and the environment in general. We are aware that most of us in Nigeria have ne ver had a firsthand experience of what we are about to discuss in this unit. But it may be appropriate to say that most of us are aware of snow at least through motion pictures.

2.0 Objectives

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

- List three elements that the path of a snow avalanche follows
- Discuss on three types of snow avalanche motion.

3.0 Snow Avalanche: Europe and North American Exper ience

Just as it is with slope failures in rock and soil, a snow avalanche results from an unequal contest be tween stress and strength on an incline. The strength of the snowpack is related to its density and te mperature. Compared to other solids, snow layer has the unique ability to sustain large density changes. Thus, a layer deposited with an original density of 100kg m-3 may density to 400 km m-3 during the course of a winter , largely due to the weight of overlying snow, pressure melting and the recrystallisation of the ice. On the other hand, the shear strength decreases as the temperature approaches 00C. As the temperature rises further and liquid melt water exists in the pack, the movement of the snow blanket grows.

Snow avalanches are a special type of mass movement. They are common features of mountainous terrain throughout arctic and temperate regions wherever snow is deposited on slopes steeper than about 200. The USA alone surface 7-10,000 potentially damaging avalanches per year, although with only about 1 per cent harm on humans or property. In the past, most casualties were suffered either by travellers passing through the mountains or by miners located in permanent, but human sited, mining settlements.

The Andean countries are notable for avalanches related mining disasters. The worst avalanches disaster in the USA occurred in 1910 in the Cascade Ra nge of Washington, when three snowbound trains were swe pt into a canyon with the loss of 118 lives.

Historically, the avalanc he problem has always been more severe in Europe than North America because the population density is higher in Europe than North America because the population density is higher in the Alps than in the Rockies. Switzerland has a relatively large number of avalanche deaths amounting to some 20-30 fatalities per year.

Snow avalanche problems have risen in recent decades. This is mainly due to the greater use of alpine areas for winter recreation and the associated development of ski centres and other holiday resorts. For example , the town of Vail, Colora do, located at an elevation of 2,500 m. was founded as a resort community only in 1962. The construction of alpine facilities often required the removal of tumble from the surrounding slopes. If left intact, the trees would help to stabilize the snow cover and protect the new roads, railways and power lines which are invading these areas.

Avalanche problems in the Rockies beset the Canadian Pacific Railway and the Trans-Canada Highway together with sections of US Highway 2.The Trans-Canada Highway alone crosses nearly 100 avalanche tracks in the 145 km section betwee n Golden and Revel stoke in the vicinity of Roget s Pass and it has been estimated that at least one motor vehicle is under a major avalanche path at any given time.

Studies have shown that annual avalanche deaths had been on the increase in the United States since the early 1950s but there is some evidence that, in the winter sports area of North America and Europe, the annual loss of life may have reached a peak in the mid-1980s (Smith, 1991).

Most snow loading on slopes occurs slowly. This gives the pack some opportunity to adjust by internal deformation because of its plastic nature, without any damaging failure taking place. The most important triggers of pack failure te nd to be heavy snowfall. For a hazardous snowpack failure to occur there must be sufficiently stee p to allow the snow to slide.

Avalanche frequency is thus relate d to slope angle, with most events occurring on intermediate slope gradients of between 300-150. Angles below 200 are generally too low for failure to occur and most slopes above 600 rarely accumulate sufficient snow to pose a major hazard. Most avalanches start at fracture points in the snow blanker where there is high tensile stress, such as a break of ground slope at an over-hanging cornice or where the snow fails to bond to another surface, such as a rock outcrop.

3.1 Snow Avalanche Path

Whatever their individual characteristics, all avalanches follow an avalanc he path which compr ises three elements;

- the starting zone where the snow initially breaks away
- the track or path followed and
- the run out zone where the snow decele rates and stops.

Science avalanches te nd to recur at the same sites, the threat from future events can often be de tected from the recognition of previous avalanche paths in the landscape. Clues in the terrain include breaks of slope and eroded channels on the hillsides and evidence from damaged vegetation. In heavily foreste d mountains, avalanche paths can be identified by the age and species of trees and by sharp trim-lines separating the mature, undisturbed forest from cleared slope.

Once the hazard is recognized, a wide range of potential adjustments is available, some of which a re shared with landslide hazard mitigation.

In practice, avalanches result from two quite distinct types of pack failure:

1. loose snow avalanches occur in cohesion less snow where inter-granular bonding is very weak, thus producing be haviour rather like dry sand. Failure begins near the snow surface when a small amount of snow, usually less than 1 m3, slips out of place and starts to move down the slope. The sliding snow spreads to produce an elongate d, inverted V-shaped scar.
2. Slab avalanches occur where a strongly c ohesive layer of snow breaks away from a weaker underlying layer, to le ave a sharp fracture line or crown. Rain or high temperatures, followed by refreezing, can create ice-crusts which may well provide a source of instability when buried by underlying topography produces some upward deformation of the snow surface which leads to high tensile stress and the creation of associate d surface cracking of the slab layer. The

initial slab which breaks away may be up to 10,000 m2 in area and up to 10 m in thickness. Suc h large slabs release considerable amounts of energy and represent the most dangerous type of avalanche (Perla and Martinelli, (1976). When a slab breaks loose, it may bring down as mush 100 times the initially released amount of snow which is then deposed in a rather chaotic heap.

3.2 Character of Snow Avalanche Motion

The character of avalanche motion also depends on the type of snow and the terrain. Most avalanches start with a gliding motion but then rapidly accelerate on slopes greater than 300.

It is common to recognize t hree types of a valanche motion.

1. *Power avalanches are the most hazardous are formed of an aerosol of fine,* diffused snow behaving like a body of dense gas. They flow in deep channels and are not influenced by obstacles in their path. The speed of a powde r avalanche is approximately equal to the prevailing wind speed but, be ing of much greater density than air, the avalanche is much more destructive than wind storms. At the leading edge its typical speed is 20-70 m s-1 and victims die by inhaling snow particles.
2. *Dry flowing avalanches are formed of dry snow travelling over stee p or* irregular terrain with particles ranging in size from power grains to blocks of up to 0.2 m diame ter. These avalanches follow well-defined surface channels, such as gullies, but are not greatly influenced by terrain irregularities. Typical spee ds at the leading edge range from 15 60 m s-1 but can reach speeds up to 120 s-1 whilst descending through free air.
3. *Wet-flower, avalanches occur mainly in the spring season and are* composed wet snow formed either of rounded particles (from 0.1 m to several meters in diameter) or a mass of sludge. Wet snow tends to flow in stream channels and is easily deflected by small terrain irregularities. Flowing wet snow has a high mean density (300-400 kg m-1 compared to 50-150 kg m-3 for dry flows) and can achieve considerable erosion of its track, despite reaching speeds of only 5-30 m s-1.

Snow avalanche movements translate into extremely high external loadings on structures. Using reasonable estimates for speed and density, it can be shown that maximum direct impact pressures should be in the range of 5-50 t m2, although some pressures have been known to exceed 100 t m2 (Smith,1991).

Table 9.1 provides a guide to the relationships which exist between avalanc he impact pressures and the damage to man-made structures. In addition to the direct impact, avalanches may exert upward and downward forces some of which have been known to lift large locomotives, road graders and buildings.

The Galtur disaste rs in Austria, which occurre d in February 1999, were the worst in the Europea n Alps for thirty years and illustrated many of the features of massive powder avalanches. In this event, thirty-one people were killed and seve n modern buildings were demolished in a winter sports village previously thought to be located safely at least 200 m from the largest avalanche run out tracks.

However, a series of major storms earlier in the winter deposited nearly 4 m of snow in the starting zone. This previously unrecorde d de pth was further increase d in places by snow redistributed ove r the upper slopes by strong winds. By the time the highest level of avalanche warnings were issued, the snow mass in the starting zone had grown to approximately 170.000 tonnes. During its trac k down the mountain, at an estimated speed in exceed of 80 m s-1, the avalanche picke d up sufficie nt additional snow to double the original mass. By the time it reached the village the leading powder wave was over 100 m high and had sufficient energy to cross the valley floor and reach the village with destructive force.

Table 9.1 Relationships between impact pressure and the potential damage from snow avalanches

Impact (tones m2)	Potential damage
0.1	Break windows
0.5	Push in doors
3.0	Destroy wood-frame houses
10.0	Uproot mature trees
100.0	Move reinforced concrete structures

4.0 Conclusion

Snow avalanche are common in temperate countries and they are the result of an unequal contest between stress and strength on an incline. This natural hazard has continued to result into the loss of life and properties especially in Europe and North America. Houses and other important facilities are not expected to be built on the snow avalanche path to avoid loss of life and properties.

5.0 Summary

In this unit we have learnt that, snow avalanches are a special type of mass movement. They are common features of mountainous terrain throughout arctic and temperate regions wherever snow is deposited on slopes steeper than about 200. The USA alone surface 7-10,000 potentially damaging avalanches per year, although with only about 1 per cent harm on humans or property.

We also mention that whatever their individual characteristics, all avalanches follow an avalanche path which comprises three elements;

- the starting zone where the snow initially breaks away
- the track or path followed and
- the run out zone where the snow decele rates and stops.

Finally we stresse d that it is common to recognize three types of avalanche motion they are;

- Power avalanc hes are the most hazardous are forme d of an ae rosol of fine , diffused snow behaving like a body of dense gas.
- Dry flowing avalanches are formed of dry snow travelling over stee p or irregular terrain with particles ranging in size from power grains to blocks of up to 0.2 m diameter.
- Wet-flower, avalanches occur mainly in the spring season and are compose d wet snow formed either of rounde d particles (from 0.1 m to several meters in diameter) or a mass of sludge.

6.0 Tutor Marked Assignment

1. Outline three possible ways that the path of a snow avalanche is likely to follow.

2a. Discuss on three types of snow avalanche motion.

2b. Mention the most hazardous of the three types of snow motion discussed above

2c. Give two reasons why you conside r it as the most hazardous relative to the others.

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UNIT 10: ACID RAIN

Table of Content s

1.0 Introduction

This is the last unit in this course. Our concern in this unit is to disc uss on another environmental hazard- acid rain. Acid rain may be regarded as the most dangerous of all airborne pollutants.

Am sure most of our families and friends in the Niger-dealt can testify to this stateme nt based on their experience.

Unlike smog, it is invisible; unlike chlorofluorocarbons (CFCs) the damage is not in the uppe r reac hes of the atmosphere, but right here on earth. Acid rain serves as perhaps the best example of how pollution is formed and how it causes global environmental damage, as well as trans-boundary strife.

This unit explores the causes, effects and some way of pr eventing acid rain.

2.0 objectives

After completing this unit you should be able to:

- Discuss on the cause of acid rain.
- Outline three common gases that have potential of inducing acid rain.
- Describe the effects of acid rain on living and non-living components of the environment.
- Identify cities in Nigeria where acid rain could possible occur.
- Outline ways of ameliorating the problem of acid rain.
- Carry out an investigation to determine the acidity leve l of water in your neighbourhood.

3.0 Causes of Acid Rain

There is a residual debate over the effects of acid rain, its origins are now certain;

- Sulphur (IV) oxide and
- Nitrogen oxides are the chief conta minants.

Seventy percent of the sulphur (IV) oxide in the air is emitted by coal-fired power plants, which annually pump 200 million tonnes of the gas out of their tall stacks into the atmosphere. The tall stacks used by power plants just send the chemicals high into the sky, where stronger are big contributors as are garbage incinerators.

Nearly half of the nitrogen oxide pollution comes from the growing fleet of automobiles worldwide. (It is also a residue of the emissions of coal and other fossil-fuel-burning power plants).

The increase d focus on alternative fuels-like

- methanol and
- natural gas-

is aimed at reducing nitrogen oxides role in both smog and acid rain. But nitroge n oxides do not pollute just the air.

Deposits of nitrogen oxides are one of the key pollutants stimulating algal growth in some rivers and seas. This proliferation of algae has become so extensive in recent years that it is;

- killing fish
- killing shellfish, and
- rapidly accelerating the ageing of the water bodies.

Natural causes include

- forest fires
- volcanic eruptions
- bacterial decomposition and
- lighting.

These natural causes pump an additional 75 to 100 million tonnes of nitrogen oxides into the air each year.

But acid rain s major contributors are still human-made: a large coal-fired plant can emit in a single year as much sulphur (IV) oxide as is blown out in a volcanic eruption!

Part of the problem in studying air pollutants is that they are difficult to visualize.

If one were to stare at the stacks of a loca l electric company power plant all day, or watch the cars tailpipe for several hours, a single particle of sulphur (IV) or nitrogen oxide would not be see n.

Although they are invisible, these particles however are above the city or industrial plant that spawned them, and crease clouds that settle locally. Most, however, are sent spiralling high into the atmosphere; their fight many last days and take them thousands of kilometres away (Akpan, 2000).

Exercise 10.1

Which Nigerian cities would you expect to produce high quantities of sulphur (IV) oxide and nitrogen oxides? Give reasons for your answer.

En route, the pollutant molecules interact with sunlight, moisture, oxidants and catalysts, to change into new, acid-laden compounds of sulphur and nitrogen. After travelling considerable distances, the now highly acidic chemical return to earth in the for m of rain or snow, fog, frost, or dew-sometimes they can contain 30 times more acid than normal.

It can;

- damage vegetation
- damage wildlife
- ruin painted finishes on cars and homes, and
- tarnish buildings.

Tracing acid rain back to its source is difficult, which is one reason for government s reluctance to respond to the problem. No doubt all air pollutants have a negative impact on wildlife; it is contended that ozone created by car exhaust is more damaging to forests and trees than acid rain.

Sceptics (especially industries not eager to make large financial investments in cleaner technologies) prefer to blame drought, disease, and insects for the recent devastation of lakes and forests.

Unfortunately, the destruction is often evident only after the damage is extensive and before a specific chemical can be indicated. But After decades of study, scientists are convinced that acid rain is high on the list of man-made chemical combinations devastating the world s ecosystem.

3.1 Effects of Acid Rain

The effects of acid rain are diverse. Some of the effects are;

- Lakes and streams are no longer able to sustain many kinds of aquatic life
- Under continual acid precipitation, a lake gradually loses its buffering capacity against acidity, pH value of its waters begins to drop, and its ecosystems are threatened
- Spawning waters are threatened
- Acid-heavy water leaches important plant nutrients out of the ground
- Activities of heavy metals such as cadmium and mercury contaminate water supplies
- Status and tables made of bronze, limestone, marble, and sandstone are slowly wearing away
- The multi-trillion naira global timber industry has been hurt by weakened forests and both commercial and recreational fishing businesses have been affected
- Mountain forest- those closest to the acidic clouds best illustrate the long-term effects of acid rain; growth is stunted, leaves and needles drop inexplicably, frailer species die
- Sulphur (IV) oxide and nitrogen oxide emissions have been linked to increases in occurrence of asthma, heart disease, and lung disease, primarily among children and the elderly
- It is estimated that about N4, 000 billion is spent annually worldwide on illnesses directly related to air pollution.

The Ph scale measures how many hydrogen ions are in a substance. The more hydrogen ions, the lower the pH value corresponds to a tenfold increase in acidity. Acid rain has a pH of less 5

The first signs of acid rain s long-rang ecological damage appeared in Scandinavian lakes during the 1960s. Fish population were dwindling, and in some lakes disappearing entirely. Similar evidence of devastation continued to grow annually. But it was not until the early 1980s that scie ntists realise that the acid rains-as we ll as ozone and other human- made pollutants-were beginning to kill off the upper reaches of forests.

A word has been created to describe the devastation: Waldsterben, or forest death. The effect of pollution on trees has been compared to human physical exhaustion- they are weakened and more sussed. Thus scientists feel that air pollution does not kill trees directly, but rather weaken them to the point where they are no longe r able to withstand normal periods of moderate drought, insect infestation or disease.

Scientists working in western Africa have discovered alarmingly high rates of acidity in rains over some parts of the re gion, caused by human-made fires that rage for months across thousands of kilometres of savanna hs.

For years, farmers and herdsmen have set fires to clear shrubs and stimulate the growth of crops and grass.

Now, added to already slightly polluted skies, smoke from those fires has raise d the level of acidity in soil and rain water. While scientists and governments ponder this ne w source of pollution-and ways of dealing with it-the first, burn on!

Battery Acid
pH0

pH recorded
pH1-

Extremely Acidic

lemon juice
rain

* Lower

Neutral

mountain
pH2-

coca-cole
fogs

*Some

Extremely Alkaline

coffee
pH4-

*All fish
dead
bass begin to die pH6-

*Snails,
milk

tadpoles begin to die pH7-

distilled
Ph8-
water

baking soda pH9-

milk of
pH10-
magnesia pH11-

3.2 Prevention of Acid Rain

Everyone agrees that acid rain is a problem. Academy of Science reports, international panels, United Nation data, and more, insist that sulphur and nitrogen oxide emissions must be slowed. Yet just how is still hotly debated (See *Worldwatch Paper 58).*

3.2 Prevention of Acid Rain

It should be noted that chemical compounds naturally present in lakes, streams, and watersheds can neutralist acids, often for many years. Only when those neutralizers are depleted will a lake begin to gain acidity. Similarly, forest destruction can take years to surface.

Scientists have learned that visible symptoms of forest destruction become obvious only after damage is well underway and in some cases Lakes can rebuild themselves once input drops. But the recovery of a lake depends on the extent of damage. If sufficiently weakened, the lake s natural recover y mechanism is overwhelmed by increasing amounts of acid and other pollutants.

The latency period between acid rain pollution and the manifestation of its conseque nces has provided a fascinating case study of the relationship betwee n environmental science and environmental policy. As evidence mounts against acid rain pollution, the following ways are being suggested for its control:

pH12-

- Liming: This involves the addition of acid neutralizing lime to the lakes. It offers a very to stave off pe rmanent harm until there is a solution. It can also restore the health of lakes and streams where life has already been destroyed by acidification, though it works best and is least costly in small water systems. Yet while inexpensive, liming remains a stop-gap effort, not a solution.
- Washing: The most promising technology, one which coal and utility industry representative are watching anxiously, is the washing of sulphur from high sulphur coal. If it works as well as experiments suggest, it could allow coal-burning electric utilities to cut air pollution linked to acid rain without installing costly scrubbers. Instead of filtering sulphur (IV) oxide from smokestacks, the process removes the potential for pollution befor e the coal is burned. Tests suggest that 90 percent or more of all sulphur could be remove d by such washings.
- Use of low-sulphur fuels: This is one of the government initiatives which are pointed in new directions around the globe. Many countr ies have issued stringent sulphur fuels. The Nigerian crude oil has been of very great value because of its low sulphur content.

Exercise 10.2
Make a list of other countries producing low-sulphur petroleum.

But the fact that acid rain recognizes no boundaries remains a stumbling block to solutions. For every acid raindrops saved in one country through tough government laws, two more may be created in another country where laws are lax. Thus solutions must be hammere d out simultaneously in every nation if the problem is to be resolved. Acid rain does not carry a passport its ignorance of borderlines has governme nts have roles to play in the control of acid rain.

3.2.1 Individuals Efforts Towards Control of Acid Rain

Individuals can help by;

- using fossil fuels more wisely
- Car pools and mass transit help; so do fuel-efficient cars a nd trucks
- Using smart, efficient appliances at home and work helps, as well as turning off lights and appliances when not in use.
- Acid rain is a pollution that industry nee ds to address, but that individuals need to help keep in the public eye.
- One simple way to draw attention to the problem is by monitoring the acid levels in the rainfall in your own backyard. The tools required for at-home testing are

simple, and thought the results may not stand up in a scie ntific laboratory; they should give an indication of whether or not there are high levels of acid in your community s rainfall.

Exercise 10.3

A simple pH test on pond or stream water can be conducte d by using pH (litmus) paper, which is available at some stores. Take the following steps;

- Use a clean glass jar or container to collect the water sample; collect the water from the middle of the pond or mid-depth in a stream to get a representative sample
- Dip a piece of pH paper into the sample
- Immediately compare the colour of the wet pH paper to the colour chart that is provided with pH paper to determine the approximate pH value.

3.2.2 Government Actions towards c ontrol of Acid Rain

Companies that re duce the amount of emissions contributing to acid rain should be given ince ntives. Laws to reduce nitrogen oxide emissions from cars should be toughened. Scrubbers should be mandatory on all coal- and oil-burning power plants and ore smelters.

Exercise 10.4

Base on your experience and skills in the previous exercise; carry out similar tests with samples of water from several localities in the country. Are there any discernible tre nds? Comment critically on your results.

4.0 Conclusion

In this last Unit, you have learnt the causes, effects and ways of controlling acid rain. Though the phenomenon is not grave in Nigeria, aside from some spots in the Niger-Delta. However it is still a matter for concern for environmentalists and indeed, the people of Nigeria.

The world s 500 million cars (as at year 2000) are among the main culprits contributing to the growing problem of acid rain. Each year , automobiles and the thousands of electr icity-producing utilities around the globe pump over a hundred million tonnes of acidic particles into the atmosphere.

Nearly invisible, the dust-like particles of sulphur (IV) oxide from power plants and nitrogen oxides from car exhaust combine with the water vapour in the sky to form acid-laden clouds. These new compounds can travel hundre ds of kilometres

thought the air-across national boundaries before returning to Earth in the for m of dangerously acidic fog, dew snow, and rain.
While acid rain may look harmless, it is not. It can destroy lakes, forests, and ruin the health of humans. Absorbed by the soil, acid rain dissolves nutrients necessary for plants and trees to grow. Acid rain dissolved harmful metals from the soil at lake and river bottoms and excess acidity will encourage algae growth, both of which will harm aquatic life and their syste ms. Acid rain can also affect our drinking wate r.
When acid rain finds its way into reservoirs or seeping into groundwater, it can eventually pollute the water that comes from the kitchen tap. This polluted water can also corrode plumbing. Toxic metals are then dissolve d into the water we drink and bathe in. Acid rain contributes to lung cancer and there in mounting evidence of links to respiratory illnesses such as asthma, especially in children. The only real solution is reducing our reliance on the sources of acid rain. Non-pollution, alternative forms of energy may be best hope.

5.0 Summary

Sulphur (IV) oxide and nitrogen oxides are the chief contaminants. Seve nty percent of the sulphur (IV) oxide in the air is emitted by coal-fired power plants, which annually pump 200 million tonnes of the gas out of their tall stacks into the atmosphere. But acid rain s major contr ibutors are still human-made: a large coal-fired plant can emit in a single year as much sulphur (IV) oxide as is blown out in a volcanic eruption!
Part of the problem in studying air pollutants is that they are difficult to visualize. If one were to stare at the stacks of a loca l electric company power plant all day, or watch the cars tailpipe for several hours, a single particle of sulphur (IV) or nitrogen oxide would not be seen. Although they are invisible, these particles hover above the city or industrial plant that spawned them, and crease clouds that settle locally. Most, however, are sent spiralling high into the atmosphere; their fight many last days and take them thousands of kilometres away.

The effects of acid rain are diverse. Some of the effects are

- Lakes and streams are no longer able to sustain many kinds of aquatic life
- Under continual acid precipitation, a lake gradually loses its buffering capacity against acidity, pH value of its waters begins to drop, and its ecosystems are threatened
- Spawning waters are threatened

- Acid-heavy water leaches important plant nutrients out of the ground
- Activities of heavy me tals such as cadmium and mercury contaminate water supplies
- Status and tables made of bronze, limestone, mar ble, and sandstone are slowly wearing away
- The multi-trillion naira global timber industry has been hurt by weakened forests and both commercial and recreational fishing businesses have bee n affected
- Mountain forest- those closest to the acidic clouds best illustrate the long-term effects of acid rain; growth is stunted, leaves and needles drop inexplicably, frailer species die
- Sulphur (IV) oxide and nitrogen oxide emissions have been linked to increases in occurrence of asthma, heart disease, and lung disease, primarily among childre n and the elderly
- It is estimated that about N4, 000 billion is spent annually worldwide on illnesses directly related to air pollution.

Strategies for controlling acid rain include;

- Liming
- Washing
- Use of low-sulphur fuels

But importantly individuals can help by

- using fossil fuels more wisely
- Car pools and mass transit help; so do fuel-efficient cars a nd trucks
- Using smart, efficient appliances at home and work helps, as well as turning off lights and appliances when not in use.
- Acid rain is a pollution that industry nee ds to address, but that individuals need to help keep in the public eye.
- One simple way to draw attention to the problem is by monitoring the acid levels in the rainfall in your own backyard. The tools required for at-home testing are simple, and thought the results may not stand up in a scie ntific laboratory; they should give an indication of whether or not there are high levels of acid in your community s rainfall.

6.0Tutor Marked Assignment

1. List four common gases that have the potential of causing to acid rain.
2. With the aid of your Atlas identify five locations in the Niger-Delta that is currently experiencing acid rain.

7.0 References and Other Resources

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