COURSE GUIDE

CRP 308 AGRICULTURE AND BIORESOURCE MANGEMENT

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INTRODUCTION

Bio-resource or biodiversity is the name given to all life on earth. It means different forms of living organisms in any given space and time. Biodiversity is an expression of species richness, species diversity, and species uniqueness within specific locations. The concept is broad and complex but that complexity is what makes the earth a perfect place for humans to live.

Everything humans need the air, water, food, all depend on biodiversity. A natural woodland that is complex, resilient, thriving, and full of variety is what humans need. Humans rely on biodiversity to survive. The world food system is supported by biodiversity through the supply of genetic resources for crop and animal breeding, nutrient cycle, biological control of pests and diseases, erosion control, sediment retention, water regulation among others.

Biodiversity loss and nitrogen pollution are identified as the two main thresholds that have been crossed. The major driver of biodiversity loss in agriculture.

Using pesticides can have unexpected and unwanted effects. The same chemicals that farmers apply to get rid of crop pests harm other species living around the farm. Some of these species may be beneficial in the control of the real pest.

The use of inorganic fertilizers can grow more food nut using too much of it can pollute the water. Polluted water affects the organisms that drink the water or that live in it.

Some industrial farms have produced a few selected breeds of animals in their quest to produce more meat, milk, and eggs. This practice however leads to a decline in livestock diversity. The same principle applies to crops. If crops are all identical, it is much easier for a few diseases or pests to wipe them out of an entire harvest.

In parts where large tracks of forest are been cut down and replaced by monoculture or livestock grazing, these changes reduce the number of varieties of habitats available for various species.
In a nutshell, the ways that farmers grow crops and raise animals can either be good or bad for biodiversity.

Understanding biodiversity as the very essence of life and how human activities particularly agriculture can improve or destroy biodiversity will make stakeholders in agriculture be careful about their decisions, policies, programs, and practices in their quest to grow more food for the present population.

WHAT YOU WILL LEARN IN THIS COURSE

This course guide tells you briefly what the course is about, what course materials you will be using, and how you are to use them.

COURSE AIMS

This course aims to provide a good understanding of biodiversity, genetic diversity, and the levels biodiversity and their losses; the biotechnological process of preserving the genetic materials, their management and appropriation.

COURSE OBJECTIVES

In addition to the aims above, this course sets to achieve some objectives. After going through this course, you should be able to:

i. Explain genetic diversity, its sources, and importance
ii. Explain the status of species and name local species in the Nigerian ecosystem
iii. Define genetic erosion and identify the cause
iv. State the effects of genetic erosion
v. State the effects and methods of managing genetic erosion
vi. Define genetic recombination
vii. Explain the mechanism of genetic recombination
viii. State the applications of genetic recombination
ix. Define germplasm appropriation
x. Explain the status of germplasm conservation and appropriation
xi. Define plant biotechnology and explain traits of interest in plants
xii. Discuss the benefits of plant biotechnology to farmers, producers, and consumers
xiii. Explain the potential risks of plant biotechnology in forestry
xiv. State the need as well as strategies for conserving forest trees
xv. Define biological diversity, types, and uses of biological diversity
xvi. Explain the status of biodiversity on the farm
xvii. Identify the constraints to bio-resource management in Nigeria
xviii. Explain bio-resource legislations in Nigeria
xix. Discuss approaches to biodiversity management.

WORKING THROUGH THIS COURSE

The ideas have been carefully put together to ensure that adequate explanations are made to enhance better understanding of the course. You are, therefore, encouraged to spend quality time studying this course and ensure that you attend tutorial sessions where you can ask questions, assess your understanding of concepts and compare your knowledge with that of your classmates.

COURSE MATERIALS

You will be provided with the following:

i. Course guide
ii. Eight (8) modules of the content of twenty-five (25) units
iii. Recommended textbooks and lists of reference materials.

STUDY UNITS

There are twenty-five (25) study units in this course. This is arranged as follows:

Module 1 Genetic Diversity

Unit 1 Definition and Importance of Genetic Diversity
Unit 2 Sources of Genetic Diversity

Module 2 Species Diversity

Unit 1 Species diversity and importance
Unit 2 The Nigerian Ecosystem
Unit 3 Local species in Nigeria
Unit 4 Socio-Economic and Biophysical Endowment

Module 3 Genetic Erosion

Unit 1 Explanation of Genetic Erosion
Unit 2 Effects and Management of Genetic Erosion
Unit 3 Habitat Fragmentation and Genetic Erosion

Module 4 Genetic Recombination

Unit 1 Mechanism of Genetic recombination (crossing over)
Unit 2 Application of genetic recombination

Module 5 Germplasm Appropriation

Unit 1 Definition of Germplasm
Unit 2 Germplasm Conservations
Unit 3 Germplasm Appropriation

Module 6 Plant Biotechnology

Module 7 Biology Diversity

Module 8 Bio-resource Management

Each unit includes a table of contents, introduction, specific objectives, recommended textbooks, and summaries of key issues and ideas. At intervals in each unit, you will be provided with several exercises or self-assessment exercises. These are to help you test yourself on the material you have just covered or to apply it in some way. The value of these self-tests is to help you gauge your progress and to reinforce your understanding of the material. At least one tutor-marked assignment will be provided at the end of each unit. The exercises and the tutor-marked assignments will help you in achieving the stated learning objectives of the individual units and of the course.

RECOMMENDED TEXTS:

More recent publications are recommended for further reading.

- Buza, L; Young, A and Thrall, P. (2000): Genetic erosion, inbreeding, and reduced fitness in fragmented populations of the endangered tetraploid pea Swainsona recta. BiologicalConservation 93:177–186.
- Ledig, F. T. (1991). Secret extinctions: the loss of genetic diversity in forest ecosystems. In: Fenger MA, Miller EH, Johnson JF, Williams EJR, editors. Our living legacy: proceedings of a symposium on biological diversity. Victoria (BC): Royal British Columbia Museum. Pp127–140.
- Ledig, F. T. (1992). Human impacts on genetic diversity in forest ecosystems. Oikos 63:87–108.

- McGuire PE, Qualset CO, editors. 1990. Genetic resources at risk: scientific issues, technologies, and funding policies. Davis (CA): University of California, Genetic ResourcesConservation Program. Report No. 5.
- Adeoti, O. (2007). Challenges to managing water resources along the hydrological boundaries in Nigeria. Water Policy, 9, 105–118
- Grimble, R. and Laidlaw, M. (2002). Biological Resource Management: Integrating Biodiversity Concerns in Rural Development Projects and Programs. Environment Department working papers, No.85. World Bank, Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/18305 License: CC BY 3.0 IGO."

ASSESSMENT

There are two components of assessment for this course. These are:

i. Tutor-Marked Assignments (TMA's)
ii. End of course examination.

TUTOR-MARKED ASSIGNMENT (TMA)

The tutor-marked assignment (TMA) is the continuous assessment component of your course. It accounts for 30% of the total score. The TMAs must be answered before you are allowed to sit for the end-of-course examination. Thus, it is expected of you to apply information, knowledge, and techniques obtained from the course. The TMAs would be returned after you have done the assignment.

FINAL EXAMINATION AND GRADING

The examination concludes the assessment for the course. To prepare for this examination, revise all the areas covered in the course. Revision of all the exercises and the tutor-marked assignments before the examination will also be of help to you. The revision should start after you have finished studying the last unit. This examination constitutes 70% of the whole course. You will be informed of the time for the examination. It may or not coincide with the university semester examination.

SUMMARY

CRP 308 intends to introduce you to Agriculture and Bio-Resources Management. By the time you complete studying this course, you will be able to answer the following questions:

a) Explain genetic diversity, its sources, and importance

b) Explain the status of species and name local species in the Nigerian ecosystem
c) Define genetic erosion and identify the cause
d) State the effects of genetic erosion
e) State the effects and methods of managing genetic erosion
f) Define genetic recombination
g) Explain the mechanism of genetic recombination
h) State the applications of genetic recombination
i) Define germplasm appropriation
j) Explain the status of germplasm conservation and appropriation
k) Define plant biotechnology and explain traits of interest in plants
l) Discuss the benefits of plant biotechnology to farmers, producers and consumers
m) Explain the potential risks of plant biotechnology in forestry
n) State the need as well as strategies for conserving forest trees
o) Define biological diversity, types, and uses of biological diversity
p) Explain the status of biodiversity on the farm
q) Identify the constraints to bio-resource management in Nigeria
r) Explain bio-resource legislations in Nigeria
s) Discuss approaches to biodiversity management.

The questions are inexhaustible. There are many more you can answer. We wish you luck and success with the course and hope you will find it both helpful and interesting.

Best wishes!

MAIN COURSE

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MODULE 1 GENETIC DIVERSITY

Unit 1 Definition and Importance of Genetic Diversity
Unit 2 Sources of Genetic Diversity

UNIT 1 DEFINITION AND IMPORTANCE OF GENETIC DIVERSITY CONTENTS

CONTENTS

1.0 INTRODUCTION

In this unit, we will discuss genetic diversity, the analysis of genetic diversity, and the structure of the existing population is required for conservation and reintroduction of rare and endangered species. Genetic variability is critical for a species to adapt to environmental changes and survive in the long term. Knowledge of genetic diversity within a population and among populations is important, especially for identifying genetically unique structural units within a species and determining populations that need protection.

Genetic diversity of germplasm can be investigated using various techniques, including analysis of morphological and agricultural traits, isozymes, biochemical characteristics, and molecular markers. Genetic diversity quantifies the magnitude of genetic variability within a population, is a fundamental source of biodiversity. For more than 80 years, the study of genetic diversity has principally been the centre of evolutionary biologists. The pioneering work of the modern evolutionary synthesis provided the theoretical and empirical foundation for the study of genetic diversity, including the derivation of new standard quantitative metrics of genetic diversity such as heritability and genetic variance.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- define genetic diversity
- state the importance of genetic diversity.

3.0 MAIN CONTENT

3.1 Definition of Genetic Diversity

Genetic diversity is the variation in the genetic composition among individuals of a population, a species, an assemblage, or a community. Diversity on a genetic level is a reflection of the similarities and differences in the genes (segments of DNA on chromosomes) of individuals. These variations can evolve as a result of many different processes, such as mutation, and physical or behavioral isolation of populations.

3.1.1 Importance of Genetic Diversity

Genetic diversity provides the raw material for evolution by natural selection. The widespread evidence for evolution by natural selection in nature confirms the presence of genetic variation for traits that influence fitness. Genetic diversity will not always be an important driver of ecological processes. We argue that genetic diversity will have its largest ecological effects when four non-exclusive conditions are met.
Firstly, when a community or ecosystem is dominated by one or a few primary habitat-providing species, genetic diversity can play a role similar to species diversity in other systems. Interestingly, relatively few of the studies we examined focused on the genetic diversity of foundation species. However, the most wide-ranging effects (i.e. at the ecosystem level) all result from changes in diversity within habitat-forming plant species, suggesting that greater focus should be placed on the genetic diversity of these dominant species.

Second, when genetic diversity in one species affects the abundance or distribution of a keystone species (i.e. a species with an effect disproportionate to its biomass in the community), it can have large indirect ecological impacts.

Thirdly, an obvious yet nonetheless important prediction is that genetic diversity will only have prominent ecological effects for species that exhibit measurable genetic diversity within populations for relevant traits, and thus these effects cannot be assumed in the absence of genetic diversity data. For example, populations that are highly selfing, inbred, or have experienced a recent selective sweep for genes controlling ecologically important traits will likely exhibit low genetic diversity. Finally, given the documented importance of genetic diversity (Reusch *et al.* 2005) and species diversity for disturbance response and stability, we predict that genetic diversity will be most relevant in highly variable environments or those subject to rapid anthropogenic change.

Genetic diversity arises primarily as variants in the linear sequence of nucleotides in DNA. Mutations can happen in the coding region of genes, or the spacer regions within and between genes, in the number of copies of genes, the linkage relation between several genes, or indeed in whole chromosomes.

4.0 CONCLUSION

Although genetic diversity is not always obvious, it is extremely important as it is a requisite for evolutionary adaptation to a changing environment. Greater genetic variation occurs within populations and the importance is well established in this unit

SELF-ASSESSMENT EXERCISE

What is the importance of genetic diversity?

5.0 SUMMARY

In this unit, you have been exposed to the fact that:

- Diversity on a genetic level is a reflection of the similarities and differences in the genes (segments of DNA on chromosomes) of individuals.
- The importance of genetic variation gives room for the distribution of species within a community.

6.0 TUTOR-MARKED ASSIGNMENT

1) Define genetic diversity.
2) Explain the importance of genetic diversity.

7.0 REFERENCE/ FURTHER READING

Brown, A.H.D. and Hodgkin, T. (2007). Measuring, managing, and maintaining crop genetic diversity on the farm. In D.I. Jarvis, C. Padoch and H.D. Cooper, eds. Managing Biodiversity in Agricultural Ecosystems, pp. 13–33. Columbia University Press, New York, USA.

Kron, P. and Husband, B.C. (2006). The effects of pollen diversity on plant reproduction: Insights from apple. Sexual plant reproduction, 19, 125–131.

Reusch, T.B.H., Ehlers, A., Haemmerli, A. and Worm, B. (2005). Ecosystem recovery after climatic extremes enhanced by genotypic diversity. Proc. Natl Acad. Sci. U.S.A., 102, 2826–2831.

UNIT 2 SOURCES OF GENETIC DIVERSITY

CONTENTS

1.0 INTRODUCTION

The variational theory of evolution has a peculiar self-defeating property. If evolution occurs by the differential reproduction of different variants, we expect the variant with the highest rate of reproduction eventually to take over the population and all other genotypes to disappear. But then there is no longer any variation for further evolution. The possibility of continued evolution, therefore, is critically dependent on renewed variation.

For a given population, there are three sources of variation: mutation, recombination, and immigration of genes. However, recombination by itself does not produce variation unless alleles are segregating already at different loci; otherwise, there is nothing to recombine. Similarly, immigration cannot provide variation if the entire species is homo-zygous for the same allele. Ultimately, the source of all variation must be a mutation.

2.0 OBJECTIVE

By the end of this unit, you will be able to:

- state the sources of genetic diversity

3.0 MAIN CONTENT

3.1 Sources of Genetic Diversity

3.1.1 Variations from Mutations

Mutations are the source of variation, but the process of mutation does not itself drive evolution. The rate of change in gene frequency from the mutation process is very low because spontaneous mutation rates are low.

The mutation rate is defined as the probability that a copy of an allele changes to some other allelic form in one generation. If we look at the mutation process

from the standpoint of the increase of a particular new allele rather than the decrease of the old form, the process is even slower. Most mutation rates that have been determined are the sum of all mutations of *A* to any mutant form with a detectable effect. Any *specific* base substitution is likely to be at least two orders of magnitude lower in frequency than the sum of all changes. So, precise reverse mutations ("back mutations") to the original allele *A* are unlikely, although many mutations may produce alleles that are phenotypically similar to the original.

3.1.2 Variation from Recombination

The creation of genetic variation by recombination can be a much faster process than its creation by mutation. When just two chromosomes with "normal" survival, taken from a natural population of *Drosophila,* are allowed to recombine for a single generation, they produce an array of chromosomes with 25 to 75 percent as much genetic variation in survival as was present in the entire natural population from which the parent chromosomes were sampled. This outcome is simply a consequence of the very large number of different recombinant chromosomes that can be produced even if we take into account only single crossovers. If a pair of homologous chromosomes is heterozygous at n loci, then a crossover can take place in any one of the $n - 1$ intervals between them, and, because each recombination produces two recombinant products, there are $2(n - 1)$ new unique gametic types from a single generation of crossing-over, even considering only single crossovers. If the heterozygous loci are well spread out on the chromosomes, these new gametic types will be frequent and considerable variation will be generated.

3.1.3 Variation from Migration

A further source of variation is migration into a population from other populations with different gene frequencies. The resulting mixed population will have an allele frequency that is somewhere intermediate between its original value and the frequency in the donor population. Suppose a population receives a group of migrants whose number is equal to, say, 10 percent of its native population size. Then the newly formed mixed population will have an allele frequency that is a 0.90:0.10 mixture between its original allele frequency and the allele frequency of the donor population. The change in gene frequency is proportional to the difference in frequency between the recipient population and the average of the donor populations. Unlike the mutation rate, the migration rate (*m*) can be large, so the change in frequency may be substantial.

3.2 Assessment of Genetic Diversity in Crop Plants

The assessment of genetic diversity within and between plant populations is routinely performed using various techniques such as

i. morphological,
ii. biochemical characterisation/ evaluation (allozyme), in the pregenomic era, and
iii. DNA (or molecular) marker analysis especially single nucleotide polymorphism (SNPs) in the postgenomic era. Markers can exhibit similar modes of inheritance, as we observe for any other traits, that is, dominant/recessive or codominant. If the genetic pattern of homozygotes can be distinguished from that of heterozygotes, then a marker is said to be codominant. Generally, codominant markers are more informative than the dominant markers.

Morphological markers are based on visually accessible traits such as flower color, seed shape, growth habits, and pigmentation, and it does not require expensive technology but large tracts of land area are often required for these field experiments, making it possibly more expensive than molecular assessment in western (developed) countries and equally expensive in Asian and Middle East (developing) countries considering the labour cost and availability. These marker traits are often susceptible to phenotypic plasticity; conversely, this allows assessment of diversity in the presence of environmental variation which cannot be neglected from the genotypic variation. These types of markers are still having the advantage and they are mandatory for distinguishing the adult plants from their genetic contamination in the field, for example, spiny seeds, bristled panicles, and flower/leaf color variants.

The second type of genetic marker is called biochemical markers, allelic variants of enzymes called isozymes that are detected by electrophoresis and specific staining. Isozyme markers are codominant. They detect diversity at the functional gene level and have a simple inheritance. It requires only small amounts of plant material for its detection. However, only a limited number of enzymes markers are available and these enzymes are not alone but it has complex structural and special problems; thus, the resolution of genetic diversity is limited to explore.

The third and most widely used genetic marker type is molecular markers, comprising a large variety of DNA molecular markers, which can be employed for the analysis of genetic and molecular variation. These markers can detect the variation that arises from deletion, duplication, inversion, and/or insertion in the chromosomes. Such markers themselves do not affect the phenotype of the traits of interest because they are located only near or linked to genes controlling the traits.

These markers are inherited both in dominant and codominant patterns. Different markers have different genetic qualities (they can be dominant or codominant, can amplify anonymous or characterised loci, can contain expressed or non-expressed sequences, etc.). A molecular marker can be defined as a genomic locus, detected through a probe or specific starter (primer) which, in virtue of its presence, distinguishes unequivocally the chromosomic trait which it represents as well as the flanking regions. Molecular markers may or may not correlate with the phenotypic expression of a genomic trait. They offer numerous advantages over conventional, phenotype-based alternatives as they are stable and detectable in all tissues regardless of growth, differentiation, development, or defense status of the cell. Additionally, they are not confounded by environmental, pleiotropic, and epistatic effects. We are not describing much about the pregenomic era tools, since our paper deals with genomic advances and their assistance in crop genetic diversity assessment.

3.2.1 Analyses of Genetic Diversity in Genomic Era

A comprehensive study of the molecular genetic variation present in germplasm would be useful for determining whether morphologically based taxonomic classifications reveal patterns of genomic differentiation. This can also provide information on the population structure, allelic richness, and diversity parameters of germplasm to help breeders to use genetic resources with less pre breeding activities for cultivar development more effectively. Now germplasm characterisation based on molecular markers has gained importance due to the speedy and quality of data generated. For the readers' benefit, the availability of different DNA markers acronyms is given in the Abbreviations section.

- *MolecularMarkers.* DNA (or molecular) markers are the most widely used type of marker predominantly due to their abundance. They arise from different classes of DNA mutations such as substitution mutations (point mutations), rearrangements (insertions or deletions), or errors in replication of tandemly repeated DNA. These markers are selectively neutral because they are usually located in noncoding regions of DNA in a chromosome. Unlike other markers, DNA markers are unlimited in number and are not affected by environmental factors and/or the developmental stage of the plant. DNA markers have numerous applications in plant breeding such as

i. marker-assisted evaluation of breeding materials like assessing the level of genetic diversity, parental selection, cultivar identity and assessment of cultivar purity study of heterosis, and identification of genomic regions under selection,
ii. marker-assisted backcrossing, and
iii. marker-assisted pyramiding.

Molecular markers may be broadly divided into three classes based on the method of their detection: hybridisation based, polymerase chain reaction- (PCR-) based, and DNA sequence-based. Restriction fragment length polymorphisms (RFLPs) are hybridisation-based markers developed first in human-based genetic study during 1980s and later they were used in plant research. RFLP is based on the variation(s) in the length of DNA fragments produced by digestion of genomic DNAs and hybridisation to specific markers of two or more individuals of a species is compared. RFLPs have been used extensively to compare genomes in the major cereal families such as rye, wheat, maize, sorghum, barley, and rice. The advantages of RFLPs include detecting an unlimited number of loci and being codominant, robust, and reliable and results are transferable across populations. However, RFLPs are highly expensive, time-consuming, labour intensive, larger amounts of DNA required, limited polymorphism especially in closely related lines. At present polymerase chain reaction- (PCR-) based marker systems are more rapid and require less plant material for DNA extraction. Rapid amplified polymorphic DNAs (RAPDs) were the first PCR-based markers and are produced by PCR machines using genomic DNA and arbitrary (random) primers which act as both forward and backward primers in the creation of multiple copies of DNA strands. The advantages of RAPDs include being quick and simple and inexpensive and the fact that multiple loci from a single primer are possible and a small amount of DNA is required.

However, the results from RAPDs may not be reproduced in different laboratories and only can detect the dominant traits of interest. Amplified fragment length polymorphisms (AFLPs) combine both PCR and RFLP. AFLP is generated by the digestion of PCR amplified fragments using specific restriction enzymes that cut DNA at or near specific recognition sites in nucleotide sequences. AFLPs are highly reproducible and this enables the rapid generation and high frequency of identifiable AFLPs, making it an attractive technique for identifying polymorphisms and for determining linkages by analyzing individuals from a segregating population.

Another class of molecular markers depends on the availability of short oligonucleotide repeats sequences in the genome of plants such as SSR, STS, SCAR, EST-SSR, and SNP.

Many authors reviewed in detail different markers techniques.

- *Simple Sequence Repeat or Microsatellite.* Microsatellites [40] are also known as simple sequence repeats (SSRs), short tandem repeats (STRs), or simple sequence length polymorphisms (SSLPs) which are short tandem repeats, their length being 1 to 10 bp. Some of the literature define microsatellites as 2–8 bp, 1–6 bp, or even 1–5 pb repeats.

SSRs are highly variable and evenly distributed throughout the genome and common in eukaryotes, their number of repeated units varying widely among crop species. The repeated sequence is often simple, consisting of two, three, or four nucleotides (di-, tri-, and tetranucleotide repeats, resp.). One common example of a microsatellite is a dinucleotide repeat (CA), where n refers to the total number of repeats that ranges between 10 and 100. These markers often present high levels of inter - and intraspecific polymorphism, particularly when tandem repeats number is 10 or greater. These polymorphisms are identified by constructing PCR primers for the DNA flanking the microsatellite region. The flanking regions tend to be conserved within the species, although sometimes they may also be conserved in higher taxonomic levels. PCR fragments are usually separated on polyacrylamide gels in combination with AgNO3 staining, autoradiography, or fluorescent detection systems. Agarose gels (usually 3%) with ethidium bromide (EBr) can also be used when differences in allele size among samples are larger than10bp. However, the establishment of microsatellite primers from scratch for a new species presents a considerable technical challenge. Several protocols have been developed and details of the methodologies are reviewed by many authors [48–50].

The loci identified are usually multiallelic and codominant. Bands can be scored either in a codominant or as present or absent. The microsatellite-derived primers can often be used with many varieties and even other species because the flanking DNA is more likely to be conserved. These required markers are evenly distributed throughout the genome, easily automated, and highly polymorphic, and have good analytic resolution and high reproducibility making them a preferred choice of markers, most widely used for individual genotyping, germplasm evaluation, genetic diversity studies, genome mapping, and phylogenetic and evolutionary studies. However, the development of microsatellites requires extensive knowledge of DNA sequences, and sometimes they underestimate genetic structure measurements; hence they have been developed primarily for agricultural species, rather than wild species.

- *EST-SSRs.* An alternative source of SSRs development is the development of expressed sequence tag- (EST-) based SSRs using EST databases has been utilised. With the availability of large numbers of ESTs and other DNA sequence data, the development of EST-based SSR markers through data mining has become fast, efficient, and relatively inexpensive compared with the development of genomic SSRs.

This is because the time-consuming and expensive processes of generating genomic libraries and sequencing large numbers of clones for finding the SSR containing DNA regions are not needed in this approach. However, the development of EST-SSRs is limited to species for which this type of database exists as well as being reported to have a lower rate of polymorphism compared to the SSR markers derived from genomic libraries.

- *Single Nucleotide Polymorphisms (SNPs).* Single nucleotide polymorphisms (SNPs) are DNA sequence variations that occur when a single nucleotide (A, T, C, or G) in the genome sequence is changed, that is, single nucleotide variations in the genome sequence of individuals of a population.

These polymorphisms are single-base substitutions between sequences. SNPs occur more frequently than any other type of markers and are very near to or even within the gene of interest.

SNPs are the most abundant in the genomes of the majority of organisms, including plants, and are widely dispersed throughout genomes with a variable distribution among species. SNPs can be identified by using either microarrays or DHPLC (denaturing high-performance liquid chromatography) machines. They are used for a wide range of purposes, including rapid identification of crop cultivars and construction of ultrahigh-density genetic maps. They provide valuable markers for the study of agronomic or adaptive traits in plant species, using strategies based on genetic mapping or association genetics studies.

- *Diversity Arrays Technology (DArT).* A DArT marker is a segment of genomic DNA, the presence of which is polymorphic in a defined genomic representation. A DArT was developed to provide a practical and cost-effective whole-genome fingerprinting tool.

This method provides high throughput and low-cost data production. It is independent of DNA sequence; that is, the discovery of polymorphic DArT markers and their scoring in the subsequent analysis does not require any DNA sequence data.

To identify the polymorphic markers, a complexity reduction method is applied on the metagenome, a pool of genomes representing the germplasm of interest. The genomic representation obtained from this pool is then cloned and individual inserts are arrayed on a microarray resulting in a "discovery array." Labelled genomic representations prepared from the individual genomes included in the pool are hybridised to the discovery array. Polymorphic clones (DArT markers) show variable hybridisation signal intensities for different individuals. These clones are subsequently assembled into a "genotyping array" for routine genotyping. DArT is one of the recently developed molecular techniques and it has been used in rice, wheat, barley, eucalyptus, *Arabidopsis*, cassava, pigeon-pea, and so forth.

DArT markers can be used as any other genetic marker. With DArT, comprehensive genome profiles are becoming affordable regardless of the molecular information available for the crop. DArT genome profiles are very useful for the characterisation of germplasm collections, QTL mapping, reliable and precise phenotyping, and so forth. However, DArT technique involves several steps, including preparation of genomic representation for the target species, cloning, data management, and analysis, requiring dedicated software such as DArTsoft and DArTdb. DArT markers are primarily dominant (present or absent) or differences in intensity, which limits its value in some applications.

4.0 CONCLUSION

With all of the natural variations in the world, it is weird to think that all of the genetic variations comes from only a few simple sources. Genetic variation is so important for species that many species reproduce sexually to aid the process of producing new varieties.

SELF-ASSESSMENT EXERCISE

What is the significance of Genetic Conservation of Crop Plants?

5.0 SUMMARY

In this unit, you have been exposed to the fact that;

- The sources of genetic diversity are vital in the production of new varieties
- The sources of genetic variation include mutation, recombination and migration.

6.0 TUTOR-MARKED ASSIGNMENT

1) Explain in detail the sources of genetic diversity.

7.0 REFERENCES/FURTHER READING

Brown, A.H.D. and Hodgkin, T. (2007). Measuring, managing, and maintaining crop genetic diversity on the farm. In D.I. Jarvis, C. Padoch and H.D. Cooper, eds. Managing Biodiversity in Agricultural Ecosystems, pp. 13–33. Columbia University Press, New York, USA.

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MODULE 2 SPECIES DIVERSITY

UNIT 1 SPECIES DIVERSITY AND IMPORTANCE

CONTENTS

1.0 INTRODUCTION

Traditionally, ecologists have been concerned with the concept of ecological diversity. Species diversity is the most commonly used representation of ecological diversity, but it is not the only measure. Niche width and habitat diversity are also key components of ecological diversity. Niche width describes the availability of resources to an organism (or taxon) over spatial and temporal scales. It is the breadth of diversity of resources used by an individual/taxon. Habitat diversity measures the structural complexity of the environment. I will primarily focus on species diversity, but it should be noted that many of the methods used to define species diversity are also applicable to a degree, to niche width and habitat diversity. The concepts of niche width and habitat diversity are of utmost importance for understanding ecosystem function. Ecologists have found species diversity difficult to define and measure, and this may reflect the possibility that it is a 'non-concept. In general, there have been two approaches to measuring species diversity, both of which incorporate information on the number of species (species richness) and the relative abundances of individuals within each species (species abundance). One method has been to construct mathematical indices broadly known as diversity indices; the other involves comparing observed patterns of species abundance to theoretical species abundance models.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- explain Specie biodiversity.

3.0 MAIN CONTENT

3.1 Species Diversity

Species diversity, the taxonomic variety of living organisms, is one of the three principal levels of biological diversity which include genetic diversity within species, species diversity, and ecosystem or community diversity. In much environmental assessment, however, biodiversity is identified as synonymous with species diversity and measured by the number of species in an area – the species richness. While the species is often seen as the fundamental unit in ecology, using the number of species to measure diversity requires the resolution of several issues. First, there is the choice of taxonomic group, since differences in the species concept and the levels of discrimination applied in different taxa mean that species counts cannot automatically be combined across groups. Measuring species richness at the global or large regional scale often runs into problems of synonymy, the same species is given different names in different regions.

Species diversity and stand structure are essential for forest biodiversity because trees provide the basic needs and habitat for other species. It has been broadly accepted that species distribution and structure and their response to environmental factors are core concepts for ecological study.

3.1.1 Concepts of Species Diversity

1. Species Richness

Species richness describes the number of different species present in an area. More species = greater richness. This is the oldest and the simplest concept of species diversity - the number of species in the community or the region. The basic measurement problem is that it is often not possible to enumerate all of the species in a natural community or region, particularly if one is dealing with insect communities or tropical plant assemblages. More species = more richness.

2. Heterogeneity

Simpson (1949) proposed a second concept of diversity which combines two separate ideas, species richness, and evenness. The Simpson's reciprocal index is represented with the formula;

$$DI = \frac{N\,(N-1)}{\Sigma n(n-1)}$$

N = total number of individuals collected
n_1 = number of individuals of a species
DI = Simpson's diversity index

- A high index value suggests a stable site with many different riches and low competition (high richness and evenness)
- A low index value suggests a site with few potential riches where only a few species dominate.

Simpson's reciprocal index can be used to compare the biodiversity at two (2) locations.

3. Evenness

Species evenness describes the relative abundance of the different species in an area (similar abundance = more evenness). For many decades field ecologists had known that most communities of plants and animals contain a few dominant species and many relatively uncommon species. Evenness measures attempt to quantify this unequal representation against a hypothetical community in which all species are equally common.

3.1.2 Importance of Species Diversity

There are numerous reasons why species diversity is essential. Each species has a role in the ecosystem. For example, bees are primary pollinators. Imagine what would happen if bees went extinct. Fruits and vegetables could be next, and subsequently, the animals that feed off them - this chain links to humans. Various species provide us not only with food but also contribute to clean water, breathable air, fertile soils, climate stability, pollution absorption, building materials for our homes, prevention of disease outbreaks, medicinal resources, and more. Let's look at some examples.

Species diversity contributes to ecosystem health. Each species is like a thread holding together an ecosystem. If a species disappears, an entire ecosystem can start to unravel. Species diversity is crucial for ecosystem health. For example, in the Pacific Northwest, salmon holds together the entire ecosystem. Salmon carry rich nutrients from the ocean back to the stream environment. When salmon die, those nutrients are gobbled up by insects, plants, mammals, and birds. If salmon were to disappear, the impacts would be felt through the entire food chain.

4.0 CONCLUSION

In this unit, species richness cannot serve as a criterion for the creation of protected areas and species diversity is poorly suited for this as well. The other component of biodiversity, species evenness, is more informative: the lower its value is, the more scarce species are prone to extinction due to anthropogenic impact. It is necessary to support the existence of substantial parts of habitats of endemic, rare, and endangered species in areas with low species evenness, where dominant species are actively harvested. The restriction of economic activities in those areas is more effective for the conservation of the global species richness than simply protecting the diversity hotspots.

SELF-ASSESSMENT EXERCISE

Why is species diversity important?

5.0 SUMMARY

In this unit you have learnt that:

- Species diversity is defined as the number of species and abundance of each species that live in a particular location. The number of species that live in a certain location is called species richness. Abundance is the number of individuals of each species.
- The concept of species diversity includes species richness, heterogeneity and evenness.
- The importance of species diversity is discussed in detail.

6.0 TUTOR-MARKED ASSIGNMENT

1) Define species diversity.
2) Explain the concept of species diversity.
3) Discuss the importance of species diversity.

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UNIT 2 THE ECOSYSTEM

CONTENTS

1.0 INTRODUCTION

This unit will focus on the Ecosystem. You will appreciate its features and elements which are unique. The ecosystem is the contracted form of the ecological system. The relationships or interactions existing amongst the different biotic components as well as with abiotic components form an ecological system. Within the system, the biotic community cannot function independently as much as abiotic components, directly or indirectly, are influenced by the activities of the biotic components

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- define the ecosystem
- state the characteristics of the ecosystem
- explain the elements of the ecosystem.

3.0 MAIN BODY

3.1 The Ecosystems

The ecosystem may be defined as either an artificially created or natural unit, consisting of biotic and abiotic factors. In real situations, natural units are normally considered for various observations and studies.
These natural units can be large or small, depending on prevailing conditions, natural occurrences and availability of factors (living and non-living). These bear significant influence on natural units and constitute marked differences observed therein.

As such, ecosystems differ in structure and status. These differences bear direct influence on the variety of biotic components it can support without collapsing. As the biotic community depends, on the abiotic resources found therein, the sustainability of the ecosystem depends on their population and level of interactions existing within.

3.2 Characteristics of Ecosystem

There is much more to biodiversity than the number of species and kinds of ecosystems. The ecosystem exhibits three primary attributes: composition, structure, and function. Within each location, these attributes interact one with another.

Ecosystem components: These refer to the inhabiting species in all their variety and richness.
The various flora and fauna occupy habitats with distinctive features, and to which they are best –fit. They provide genes for various and diverse interactions.

Ecosystem structure: It refers to the physical patterns of life forms which are different, relative to the ecological conditions of an area. This could be described in terms of coastal, forest, or arid areas as shown by the type of vegetation and corresponding animal lives, beginning from the most delicate to the most complex in that habitat.

Ecosystem functions: Ecosystem functions are hard to see in action but the results can be felt. These among others include:

- The biogeochemical cycles: These are essential for the recycling useful environmental materials.
- The natural disturbances: These entail wildfires that release nutrients to the soil, weed- out of weak trees, and reset the succession clock. Other natural disturbances are the energy of falling water, which creates spawning beds for salmon even while it carves a mountain's bones; and the release of oxygen into the atmosphere.

These ecological processes create landscapes and diverse environmental conditions out of life itself. These features are all interdependent and thus support biological diversity.

3.3 Elements of the Ecosystem

The functioning ecosystem has different elements which constitute its uniqueness. The uniqueness of a functioning ecosystem lies in the degree of diversity found in it. Biodiversity is so complex but has, as the most basic element, its genetic variation.

Genetic variation: Genetic variation occurs within individual populations and between populations of species. The variations observed reflects differences in their:

- Physical characteristics
- Viability
- Productivity
- Resilience to stress, and
- Adaptability to change.

Distinct species: This term can be described in terms of their abundance or decline which most often attracts concern. Species, such as American elk, rainbow trout, and ponderosa pine are in abundance. Others like a woodpecker, Siler's pincushion cactus, the Nigerian hippotamus, manatee, crocodile, and others, have populations that are much reduced or which may even face extinction. The reduction in specific species necessitates their conservation. This perpetuates native species in numbers and distributions that provide a high likelihood of continued existence.

Associations of species: Associations of species are often called biological communities. They are usually recognised as distinct stands, patches, or sites such as old-growth forests, riparian areas, or wetlands. These communities form the biotic parts of ecosystems.
The variety of species in an ecosystem is a function of its structural and functional characteristics, the diversity of its ecological processes, and the physical environment. These varieties are actively expressed as the elements or make-up of an ecosystem.

4.0 CONCLUSION

The ecosystem bears a direct influence on biodiversity. Its functions, size, and structure determine the richness and variety of inhabiting species. An alteration in the structure, size, and function, affects, most times grievously, the biotic diversity within a locate

SELF-ASSESSMENT EXERCISE

What are the unexpected ecosystem effects that complicate agricultural impacts on biological resources?

5.0 SUMMARY

In this unit you have learnt that:

- Characteristics of biodiversity are ecosystem components, ecosystem structure and ecosystem functions.
- Elements of the ecosystem are genetic variation, distinct species, and association of species.

6.0 TUTOR-MARKED ASSIGNMENT

1. Define the ecosystem.
2. State the characteristics of the ecosystem.
3. Explain the elements of the ecosystem.

7.0 REFERENCES/FURTHER READING

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UNIT 3 LOCAL SPECIES IN NIGERIA

CONTENTS

1.0 INTRODUCTION

The Nigerian ecosystem is rich in indigenous biotic components. An index of 7,895 plant species identified in 338 families, 2,215 genera, and 22,000 animal species, confirms that the country is endowed with a variety of plant and animal species. These animal and plant species occur in different numbers within the country's vegetation, sustaining the rural economy. There are also exotic species, which have adjusted to the climatic conditions; they make up part of the biotic community. It has been reported that the wildlife diversity of Nigeria, about 0.14% and 0.22% are threatened and endangered, respectively. In attempts to protect biodiversity, Nigeria established several protected areas including 8 national Parks, 445 forest reserves, 12 strict nature reserves, and 28 game reserves.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- name local species of plants within the Nigerian ecosystem.

3.0 MAIN CONTENT

3.2.1 Local Species of Cereals

Cereal crops are interchangeably called grain crops. In many publications and correspondence, they are simply called grains or cereals. As of 2012, the top 5 bowls of cereal in the world ranked based on production tonnage are maize (corn), rice (paddy), wheat, barley, and sorghum. These crops are also among the top 50 agricultural commodities in the world with maize ranking second next to sugarcane. Rice (paddy) ranks third, wheat

- 4th, barley - 12th, and sorghum - 30th. Another cereal, millet, ranks no. 42 (FAOSTAT, 2014).

Table 1: Examples of Cereal Crops

S/No	Local Cereals	English Name	Local Name	Part Used
1	*Oryza sativa*	Rice	Edesi	Seeds
2.	*Sorghum vulgare*	Guinea Corn	-	Seeds
3	*Zea mays*	Maize	Oka	Seeds
4	*Pennisetum glauucum*	Millet	-	Seeds
5	*Triticum*	Wheat	-	Seeds
6.	*Digitariaibura*	Acha	-	Seeds

3.2.2 Local Species of Legumes

Africa has a vast array of indigenous legumes, ranging from large rainforest trees to small annual herbs.

Table 2: Examples of Legumes Crops

S/No	Local Legumes	English Name	Local Name	Part Used
1	*Glycine max*	Soybean	-	Seeds
2	*Vigna uniguiculata*	Cowpea	Nsama	Seeds
3	*Phaseolus vulgarus*	Common bean	Okofi	Seeds
4	*Mucuna pruriens*	Velvet beans	Ibaba	Seeds
5	*Sphenostylisstenocarpa*	African Yam beans	Ahuma	Seeds

3.2.3 Local Species of Fruit Trees

Fruit trees constitute important biological resources in many agroecological systems and forest ecosystems all over the world. Fruits are full of nature’s rich essential nutrients, antioxidants, and health benefits for ready use by humans (and other animals) without alternation in most cases, unlike vegetables and other edible agricultural/horticultural produce that may require necessary pre-treatments, like heating, sometimes before consumption.

Table 3: Examples of Local Fruit Trees

S/No	Local Fruit Trees	English Name	Local Name	Part Used
1	*Chrysophyllumalbidun*	Star Apple	Udara	Fruits
2	*Dacryodes edulis*	African pear	Eben	Fruits

3	*Persea Americana*	Avocado	Eben mbakara	Fruits
4	*Treculiaafricana*	African Breadfruit	Adian	Seeds
5	*Mangifera indica*	Mango	Mango	Fruits
6	*Irvingiagabonensis*	Bush mango	Uyo	Fruit/Seeds
7	*Carica papaya*	Pawpaw	Udia Edi	Fruits
8	*Eugineaoweriensis*	Apple	Apple	Seeds
9	*Citrus sinensis*	Oranges	Alum	Fruits/seeds
10	*Gareinia kola*	Bitter cola	Efiat	Seed

These native species may not necessarily represent the flora community in the country, there are many others that may not gain as much popularity depending on their location and usage, but constitute remarkable components of the floral community.

4.0 CONCLUSION

Though Nigeria has a vast Biodiversity, it is not evenly distributed. Flora and fauna diversity depends on climate, altitude, soils, and the presence of other species. This measure is higher in the tropics than in other localised regions. When a wide diversity of species are maintained, the web of life that sustains all biota is preserved.

SELF ASSESSMENT EXERCISE

What is the status of biodiversity in the Nigerian ecosystem?

5.0 SUMMARY

In this unit, you have learnt that:

- Bio-products common in the Nigerian ecosystem are local cereals, local legumes, and local fruit trees
- There are many others that may not gain as much popularity depending on their location and usage.

6.0 TUTOR-MARKED ASSIGNMENT

1. List four of each of the local legumes and fruit trees found in the Nigerian ecosystem.

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UNIT 4 SOCIO-ECONOMIC AND BIOPHYSICAL ENDOWMENT

CONTENTS

1.0 INTRODUCTION

Nigeria was among the 153 countries that signed the Convention on Biological Diversity (CBD) at the United Nations Earth Summit in June 1992. The Convention is probably the most alien compassing international agreement on biodiversity ever adopted. The five main aims are:

- Conserving biodiversity at all levels: genetic, population, species, habitat, and ecosystem;
- Sustainable development of biodiversity: to ensure that this diversity continues to maintain the life support systems of the biosphere;
- Fair and equitable sharing of benefits from biodiversity: to recognise that social and economic goals for the use of biological resources and benefits derived from genetic resources are central to the process of sustainable development and that this, in turn, will support conservation;
- Sharing of relevant technology for sustainable development; and
- Establishment of a global financial mechanism for the conservation of biodiversity

The Convention calls for partnership between nations and among government organisations, NGOs and the Private Sector. It calls for articulate planning strategies and programmes, with considerations for legislation, regulation, law enforcement, use of appropriate administrative mechanisms, research (data generation) and budgeting.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- explain the socio-economic and biophysical endowment of Nigeria.

3.0 MAIN CONTENT

3.1 Locations and Size

Situated in West Africa, Nigeria covers an area of 923,768 km2. It lies between latitudes 4o and 14oN and longitudes 3o and 15oE. It shares its 4,047-km international border in the east with Cameroon Republic, in the north with Niger Republic and Chad, and part of the western boundary with Benin Republic. In the south, the country is bounded by the Atlantic Ocean's Gulf of Guinea.

3.2 Political and Administrative Structure

Nigeria operates a federal system of government. There is a central government with its headquarters in Abuja. There are 36 states and the Federal Capital Territory (FCT) with 774 Local Government Areas that constitute the third tier of government. It is now common for reasons of coordination and for representation in national affairs to group the 36 states into six geopolitical zones.

The current constitution was adopted in 1999 and the present government represents the first democratically elected government in about twenty years. The executive arm is headed by a President, Commander-in-Chief of the Armed Forces, elected by popular vote for no more than two four-year terms. The Federal Executive Council, an appointed body, functions as a cabinet within the executive arm. The legislature is bicameral consisting of the Senate elected by popular vote to serve four-year terms, and a House of Representatives, also elected by popular vote to serve four-year terms.

The judiciary constitutes the third arm of government and is made up of the Supreme Court and the Federal Courts of Appeal with judges appointed by the federal government on the advice of an Advisory Judicial Committee.

A Governor who appoints Commissioners to oversee various state ministries heads the state. It is noteworthy that state ministry structure varies between states and does not necessarily follow the federal model. Local government administrations (LGA's) function as the main supporting bodies for activities within each state and are administered by elected Chairpersons.

2.3 Population and Settlements

The country is the most populous nation in Africa. Based on the 1991 census figure of 88.9 million, and an assumed growth rate of 2.8 percent per annum, Nigeria's current population has been estimated at 120 million. About 30% of the population lives in urban areas, such as Lagos, Ibadan, Warri, Enugu, Onitsha, Owerri, Benin City, and Port Harcourt, Kano, Kaduna, and Jos. The population exhibits a strong rural to urban migration which has increased since the creation of more states.

Nigeria's population exhibits a high ethnic and cultural diversity, composed of more than 250 ethnic groups, with Hausa, Fulani, Yoruba, Igbo, Ijaw, Kanuri, Ibibio, Edo, and Tiv as the major ethnic groups.
The population density in the country was put at 96 persons per km2 in 1991, although regional differences occur, with the southeastern region having the highest density of 247 persons per km2, while the lowest density occurs in the west-central with 43 persons per km2. In the northwest, the density was estimated at 76 persons per km2 while that of the southwest was estimated at 194 persons per km2. The 1991 census revealed that 64 percent of the population lives in rural areas but the urban population has been growing rapidly at an annual rate of 4.5 percent. Today, about 70 percent of the Nigerian population consists of rural dwellers, an indication of the importance of agriculture in the economy. Furthermore, as much as 1,000 persons per km2 density has been attained in many LGA's of Abia, Imo, and Akwa Ibom states in the south-eastern part of the country; Lagos and Ibadan in the southwest, and Kano in the north.

The escalating growth in population implies an increasing demand for biological resources. This, in turn, translates into increasing demand for arable land resulting in deforestation, shortened fallow period, soil deterioration, and increasing application of inorganic fertilisers, pesticides, and herbicides for agriculture. Thus, the increasing population growth has become very crucial among the set of factors that degrade the environment and threaten biodiversity.

3.4 Climate

In Nigeria, as in other parts of the tropics, moisture plays a critical role in the determination of the abundance of natural life. Two distinct seasons occur in Nigeria; the wet and dry seasons, with the highest rainfall occurring in the coastal regions of the southeast, where the mean annual rainfall is more than 2,000mm distributed throughout the year. As one moves from the coast towards the interior, the total amount of rainfall and length of the wet season decreases. The monthly temperature for most locations in the south ranges between 22o C and 32oC and 80C to over 40oC in the north. The highland areas of Obudu, Mambilla, and Jos Plateaus have cooler climates than the rest of the country. During the dry season, usually from October - April, the relative humidity at 6.00 a.m. averages about 30 percent while relative humidity at noon is less than 10 percent

3.5 Drainage system

Nigeria is drained by two major river systems that play a major role in the climate and vegetation of the country. The Komadougou-Yobe in the North with headwaters formed by the Hadejia, Jama'are, and Misau Rivers flows northeast from the north-central portion of the country, eventually forming the border with the Niger Republic before emptying into Lake Chad in the extreme northeast corner.

The Hadejia-Nguru Wetland, an important freshwater habitat for wildlife, is part of this system. The Niger-Benue system consists of the Niger flowing into the country across its western border with Benin and Niger Republics and southeasterly to the central part of the country. There it is joined by its major tributary, the River Benue, which flows southwesterly from its headwaters in the mountainous border with Cameroon. From the confluence at Lokoja, it flows southwards emptying into the Atlantic through the Niger Delta. The River Niger is the third-largest in Africa and the sixth largest in the world. Other important river systems include Ogun-Oshun, Benin-Owena, Anambra– Imo, and Cross-River.

3.6 Soils

The soil pattern in the country is determined mainly by its geology and the climate. Four main soil groups occur in a zonal pattern from the coast to the northern boundary.

- **Hydromorphic and Organic Soils**

These are derived from alluvial, marine and fluvio -marine deposits of variable texture. They occur extensively in the Niger Delta and in the coastal zone west and east of the Delta. They also occur intrazonally along the major rivers throughout the country.

- **Ferallitic Soils**

These are found in the rainforest mainly on sedimentary rocks. The soils are very old, deeply weathered and red to yellow in colour. They are predominantly clayed in texture and exhibit largely undifferentiated horizons.

- **Ferruginous Tropical Soils**

These are found at the drier margins of the forest zone but more extensively in areas of savannah vegetation. They occur mainly as derivatives of crystalline rocks although they are also found on other rocks rich in ferromagnesium minerals, sandy deposits and old holomorphic soils. The soils are invariably red or reddish in colour, rich in iron, often low in organic matter to the ferrallitic soils except that they are more often less permeable, more susceptible to erosion, and more fertile.

- **Arid and Semi-Arid Soils**

These soil types are typical of the northernmost regions with low rainfall. In Nigeria, they are recognised as regosols or brown soils. They have been developed on drift and continental sedimentary deposits and are mainly found in the Lake Chad Basin area.

3.7 Ecology and Ecosystem Diversity

Nigeria has a variety of ecosystems ranging from forests in the south through moist savannas in the central part of the country to dry arid savannas in the extreme north. Freshwater, brackish and marine ecosystems also occur, and elements of montane vegetation occur at high altitudes in the eastern borderlands.

The coastal fringe of the country is characterised by a mix of mangrove Rhizophora swamps and freshwater swamp forests on barrier islands, as well as stretches of sandy beaches. The Nigerian mangrove ecosystem is the largest in Africa. The water in this ecosystem is typically brackish, especially at estuaries. The mangrove forests are increasingly coming under the threat of Nipa (Nypa fructicans), an alien invasive, which establishes at disturbed sites and spreads into the mangrove vegetation. The spread of Nipa palm is affecting the fishery of the area.

Following the swamp forests is a belt of lowland rainforest. About 20% of the country, was formerly covered in this Guineo-Congolian lowland rainforests, but over 90% of these forests are, mainly as a result of anthropogenic activities, that became degraded or lost. Nigeria’s lowland rainforests are characterised by a great variety of plant species arranged in a complex vertical structure of forest canopies. Some economically important rainforest trees include Mahogany (Khaya species), Iroko (Milicia excelsa), African walnut (Lovoa trichilioides) and Mansonia

(Mansonia altissima). A number of tree species in this ecosystem are increasingly becoming threatened by illegal and legal logging activities. It is also the area sometimes referred to as the Palm belt because of the ubiquity of the oil palm (Elaeis guineensis) a principal economic tree crop of that ecosystem. Many Non-Timber Forest Products are extracted from these forests. They have important values as spices, food items, and medicines.

Above the lowland rainforest belt is a band of derived savanna, which is a previously forested area that has been transformed to become a distinct vegetation type. The derived savanna is a mosaic of disturbed forest and savanna, maintained in a predominantly savanna-like form by human activities.

North of the derived savanna biome is a band of Guinea savanna vegetation. Typical tree species of this zone include Doka (Isoberlinia spp) and Cassia (Cassia spp). Stream and riverbanks in this ecological zone often support riparian forests that show some floristic relationships with more southerly forests. A characteristic feature of the Guinea savanna is the presence of numerous inselbergs – a huge granitic outcrop that punctuates the landscape ecological zone. Inselbergs have their peculiar flora and fauna that make them distinctive from the surrounding habitats.

The northern fringe of the Guinea savanna slowly changes into the drier Sudan savanna. Typical trees include the Baobab (Adansonia digitata) and Dum Palm (Hyphaene thebaica). Elements of Acacia are also present. Along the drier northern fringes of the Sudan savanna, the effects of deforestation and periodic drought have changed the structure and composition of the vegetation such that Sahelian elements have penetrated further south.

A narrow band of true Sahelian vegetation, covering less than 10% of the country runs across the northeastern corner. The vegetation is typically thorn scrub and common trees include many Acacia species. In parts of this Sahel where the vegetation cover has been seriously disturbed (e.g., the Manga grasslands area north of Nguru in Yobe State), conditions that approximate true deserts may be found.

The highland areas of the Obudu and Mambilla Plateaus hold patches of montane forests and grasslands at altitudes above 1,200 m. The presence of tree ferns (Cyathea manniana), and the profusion of epiphytes are characteristic of montane forests in this ecosystem. The Jos Plateau also has its distinctive vegetation type. The extent of tree crop plantations and farmlands signifies the magnitude of the ecosystem modifications that have taken place in the country.

4.0 CONCLUSION

Biodiversity is the wealth of life on earth: the millions of plants, animals, and microorganisms; the genes they contain; and the intricate ecosystems they help build into the living environment. Conservation biology, a multidisciplinary science, has developed in recent decades in response to the biodiversity crisis. The socio-economic and biophysical endowment of Nigeria is well established in this unit

SELF-ASSESSMENT EXERCISE

What is the Nigerian biodiversity Conservation system?

5.0 SUMMARY

In this unit, you have been exposed to the fact that;

- The socio-economic and biophysical endowment of the Nigerian in areas like the climate, soils drainage systems, etc.
- The ecological diversity of the Nigerian system was greatly covered

6.0 TUTOR-MARKED ASSIGNMENT

1 Explain the Nigerian biophysical endowment.
2. How do socio-economic factors affect biodiversity conservation?

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MODULE 3 GENETIC EROSION

UNIT 1 DEFINITION OF GENETIC EROSION

CONTENTS

1.0 INTRODUCTION

In this unit, efforts will be made for you to learn that genetic erosion, causes of genetic erosion, and reasons for occurrence in both plants and animal species. In the previous module, we have defined and explained specific diversity or biodiversity to refer to the variability among living organisms from all sources including terrestrial, marine, and other aquatic ecosystems, and the ecological complexes of which they are part. Biodiversity also encompasses the variety of all forms of life on earth that provides the building blocks for our existence and ability to adapt to environmental changes in the future. Genetic erosion is a process that refers to a change in genetic diversity over time, and as such is difficult to specify in an index or indicator.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- define genetic erosion
- identify the causes of genetic erosion
- state reasons for its occurrence in plant and animals populations.

3.0 MAIN CONTENT

3.1 Genetic Erosion

From the beginning of agriculture, farmers have domesticated hundreds of plant species and within them, genetic variability has increased owing to migration, natural mutations and crosses, and unconscious or conscious selection. This gradual and continuous expansion of genetic diversity within crops went on for several millennia until scientific principles and techniques influenced the development of agriculture. The impact of humans upon biodiversity has gradually increased with growing technology, population, production, and consumption rates. Maxted and Guarino (2006) define genetic erosion as follows: "Genetic erosion is the permanent reduction in richness (or evenness) of common local alleles, or the loss of combinations of alleles over time in a defined area." This is helpful, in that it draws attention to the aspect of local adaptation. However, it is not clear why a definition should specify reductions in either richness or evenness. The problem with taking too broad a definition to construct an indicator comes in the summing up, the aggregation. Neutral or trivial changes could mask critical changes when summed over loci, genotypes, populations, or species. Most species that were originally diverse in Nigeria are becoming rare. It is obvious that Nigeria's plant diversity is being seriously eroded as a result of the multiplicity of environmental, political, and socioeconomic factors. These conditions are also reported in other African Countries, even those that are signatories to the Convention on Biological Diversity (CBD) of the United Nations Environment Programme (UNEP) (1994) and the Global Plan of Action (GPA) on plant genetic resources of the Food and Agricultural Organisation (FAO) (FAO, 1998). They seem to identify a singular cause of genetic erosion in crops as the replacement of local varieties by improved or exotic varieties and species. This is a result of the ever-increasing human population, greater competition for natural resources, and some interplay of natural factors.

Estimating Genetic Erosion

Brown *et al.* (1997) provided a useful list of features or indicators that could be measured singly or in combinations on individuals and populations of a given species in a defined area as part of a systematic effort to monitor changes in genetic diversity in the species.

- **The number of sub-specific entities.** Formal taxonomic categories, such as sub-species, and also entities such as ecotypes, chromosome races, and landraces groups, 'are a useful first approximation of genetic diversity within a species.

- **Population size, numbers, and isolation**. Small populations are at relatively greater risk of loss of alleles, increased inbreeding, and extinction due to stochastic events. The number and isolation of populations in an area will reflect both the overall genetic diversity in the area and how this is structured.
- **Environmental amplitude.** The number of distinct habitats or environments in which the species is found in a study area (for example, based on existing ecological and climatic classifications) reflects highly adaptive variation.
- **Genetic diversity at marker loci**. In the past few years, advances in molecular biology have resulted in the development of several powerful new techniques that have found important applications as diagnostic tools for investigating genetic variation in plants and animals. The most commonly used of which are Restriction Fragment Length Polymorphism (RFLP), Amplified Fragment Length Polymorphism (AFLP) analysis, and various microsatellite approaches. They provide a wide range of molecular approaches for the study of important biological topics in the field of conservation and sustainable use of plant and animal genetic resources, including the amount and structure of genetic diversity within species, and how this changes with time.
- **Quantitative genetic variation.** Additive genetic variance of metric characters within populations reflects variation at multiple loci and is a measure of the 'ability of a lineage to … adapt to changing … conditions'.
- **Inter-population genetic structure.** Markers and quantitative measures could be used to gauge not only the diversity within populations but also the level of genetic differentiation among populations, which is an important component of overall genetic diversity in an area.

3.2 Causes of Genetic Erosion

Genetic diversity is a dynamic entity that changes over time. Generally, many issues contribute to genetic erosion. Genetic erosion is caused by natural selection, dependence on improved varieties of crops, bad management practices, habitat loss, and other causes.

3.2.1 Natural Selection

Natural selection removes some genetic diversity (at least at the population, if not at the species, level). Too rapid a loss, or losses that aren't associated with natural processes, such as natural selection, can cause problems in a conservation or restoration context. In addition to habitat loss and fragmentation, other less obvious influences can also cause genetic erosion. For example, where there are no out-breeder, mating among relatives (inbreeding) is more likely in smaller populations where the process is cumulative, so that over time matings between unrelated individuals become impossible.

The problem of genetic erosion through inappropriate maintenance of *ex situ* collections is widely recognised. Genetic erosion can occur at many stages in the preparation, sub-sampling, exchange, storage, and regeneration of seed (Sackville Hamilton and Chorlton, 1997).

3.2.2 Dependence on Improved Varieties of Crops

The manifest cause of genetic erosion is the diffusion of modern varieties from crop improvement programs. Much of the evidence for genetic erosion presented in the 1970/71 FAO survey is data on the diffusion of modern cultivars. Landraces adapted to optimal local agronomic conditions are probably the crop plant genetic resources that are most at risk of future loss through habitat destruction or by replacement by introduced elite germplasm. With the development of scientific plant breeding, high-quality and homogenous new varieties were quickly and widely distributed suppressing landraces. Yield (or yield potential), which is the characteristic of most modern varieties, is the most important criterion for the choice of a variety by a farmer. The “Green Revolution” contributed and still undoubtedly contributes to the loss of genetic diversity. Population growth, urbanisation, developmental pressures on the land resources, deforestation, changes in land-use patterns, and natural disasters are contributing to abundant habitat fragmentation and destruction of the crops and their wild relatives. A major example of this is the use of improved okra (*Abelmoscus esculentus*) in place of the native materials of the tall okra (*A. caillei*) that is popularly known to be sensitive to day-length. Local varieties of crops including sword bean (Canavalia ensiformis), African yam bean (*Sphenostylisstenocarpa*) and Lima beans (*Phasceolus lunatus*) are now becoming extremely rare.

3.2.3 Bad Management Practices

Grazing pressure, fire, and excessive use of systemic herbicides are other factors that affect biodiversity loss. Fire destroys large areas of forest ecosystems annually with the elimination of sensitive species such as Afromosialaxiflora, Ceiba pentandra, Entada abyssinica, Hildegardiabarteri and Holarrherawulfbergia. Although fire is a natural phenomenon in the savanna, it is steadily entering the rainforest. Indiscriminate hunting of wildlife for food to complement subsistence farming and bush burning leads to loss of biodiversity and also depletes the ecosystem by causing the death of wildlife; destruction of eggs and plant species, while illegal grazing of livestock in game reserves constitutes a threat to the wildlife itself.

The major external forces advocate the introduction of high-yield varieties, accompanied by mechanisation and major chemical inputs, as the means to increase total production and economic return. These forces change the nature of the decision-making process dramatically; the farmer is encouraged to grow high-yield varieties in monoculture using inputs of fertiliser and pesticides.

Often there are relationships of substitution between ecological functions of agrobiodiversity and external input (for example fertiliser or pesticides). That means that external inputs can take over functions of agrobiodiversity and vice versa. In homogenous, high-input agricultural systems, ecosystem functions that are missing because of low agrobiodiversity are replaced with intensive management and external inputs. Because of this, those components of agrobiodiversity whose functions can be substituted at a lower cost are particularly endangered.

3.2.4 Habitat Loss

Habitat loss resulting from urbanisation accelerated by an increase in population destroys homes of plants and animals. If the habitat, and not just the plants are removed (such as in land conversion), and there is no subsequent regeneration from seedbanks or previously collected seeds, then loss of genetic diversity can occur immediately, assuming that there is some diversity in the removed plants that is not contained elsewhere. But even if genetic diversity is not lost immediately, it is often reduced gradually in the resulting smaller population.

The famine of the mid-1980s seriously threatened Ethiopia's biological resources. The study of Stephen *et al.* (2002) showed a marked reduction in rice diversity in the northeastern Philippines from 1996 to 1998 as a result of drought due to the El Ni˜no phenomenon in 1997 and flooding due to two successive typhoons in 1998. According to Erskine and Muehlbauer (1990), droughts of just a single season could result in people consuming seed stocks, while successive years of drought can prompt changes in cropping patterns and the geographic distribution of crops. Social disruptions or wars also pose a constant threat of genetic wipeout of such promising diversity.

3.2.5 Other Causes

Genetic erosion can also be caused by limited support for gene banks and inappropriate focus or change in institutional policies. The work of gene banks in Eastern Europe towards the end of the last century was reduced due to a lack of money and employees. Only international help was able to prevent catastrophic breakdowns. Other prominent causes of genetic erosion include the market preferences of consumers for uniform grains, vegetables, or foods, pest and disease outbreaks, urbanisation, population pressure, lack of recognition of current or future value of genetic resources; poor monitoring and management, and lack of sustainable breeding program.

3.3 Genetic erosion occurs in animal species for the following reasons

- Members of the endangered species cannot meet and breed as a result of habitat loss, habitat fragmentation, or geographical distance.
- The individual dies without breeding.
- The individuals do breed, but because they are restricted to a certain area and cannot travel to meet different members of the species, there is low genetic diversity and inbreeding occurs. Inbreeding leads to physical defects that weaken the entire species.

3.4 Genetic erosion occurs in plant species for the following reasons:

- Loss of habitat is a cause of genetic erosion here as well.
- Overgrazing an area can lead to loss of plant species; so also the spoiling of an environment by land clearing or chemical dumping or over-zealous construction.
- Replacing local varieties of plants with those that wouldn't occur there naturally, like plants from another area or genetically modified (GM) plants, can also lead to genetic erosion.
- Modern agriculture is also responsible to a large extent for the loss of genetic diversity. Farmers tend to grow a limited number of commercial crop varieties or GM crops, enforcing uniformity in farming, and so there has been a noticeable reduction in the many crop varieties that were seen with traditional farming.

4.0 CONCLUSION

Biodiversity loss is one of the world's most pressing crises. It threatens the very basis of more sustainable development and the quality of life. The resources in Nigeria (flora and fauna), which are very vital, are presently threatened by increased population pressure and intensified human development activities, as such, genetic diversity in animals and plants, in domestic populations, and the wild, is being lost at an increasing rate.

The loss of biodiversity occurring as a result of loss of natural habitat and movement restrictions imposed by human developments and activities is more alarming. The advent of scientific plant breeding this century and the rapid spread of high-yielding varieties characterised by narrow genetic bases had caused the displacement of traditional unimproved species that had a large genetic bases. In Nigeria, there is awareness about the loss of indigenous leaf vegetables as a result of neglect by research and development, fast rate of forest destruction for industrial development, and environmental degradation due to pollution as in the Niger Delta region

SELF-ASSESSMENT EXERCISE
What are the consequences of genetic erosion in plant science?

5.0 SUMMARY

In this unit, you have learned that:

- Genetic erosion is the process in which plant species or breeds face gradual or drastic diminishing or complete loss of their genetic pool.
- Causes of genetic erosion are by natural selection, bad management practices, habitat loss, dependence on improved varieties of crops, and other causes like lack of support in the gene banks.
- Genetic erosion occurs in plants and animals for different reasons.

6.0 TUTOR-MARKED ASSIGNMENT

1. Define genetic erosion.
2. Identify causes of genetic erosion.
3. State the reasons for genetic erosion in plants and animals.

7.0 REFERENCES/FURTHER READING

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UNIT 2 EFFECT AND MANAGEMENT OF GENETIC EROSION

CONTENTS

1.0 INTRODUCTION

Human impacts on ecosystem have been going on since its evolution. As human needs increases by the day, Agricultural and lndustrial activities are seen as tools which have altered the magnitude of change lately. The loss of biodiversity offers grave consequences which may require prolonged seasons to correct. Genetic diversity changes over time and space; and spatially reflects patterns in the environment, suggesting adaptation to prevailing conditions. Considering its usefulness, genetic erosion must be viewed seriously. Therefore in this unit, your attention will be drawn to the effects of genetic erosion as well as how it can be managed. As proper management requires up-to-date and relevant procedures to sustain genetic variability, these methods are outlined within the context

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- state and discuss the effects of genetic erosion
- discuss the methods of managing genetic erosion.

3.0 MAIN CONTENT

3.1 Effect of Genetic Erosion

3.1.1 Inbreeding and stress perception

Inbreeding affects most fitness-related traits negatively. However, the magnitude of inbreeding depression generally is found to vary

considerably according to species, population, trait, and environmental and ecological conditions additional deleterious loci.
All in all, genetic erosion caused by fragmentation decreases individual and population fitness and at the same time increases the sensitivity to stress conditions. The environmental dependency of inbreeding depression emphasizes that human-induced environmental changes, such as climate change, will impact strongly and negatively on fitness. Consequently, species that in recent times have suffered from habitat fragmentation and did become inbred could be much more vulnerable to human-induced environmental changes than species that still exist in large populations.

3.1.2 Inbreeding and plasticity

Generally, genetically eroded populations will have decreased levels of genetic variability and lower evolutionary potential (see next section). Consequently, their persistence might to a larger extent be dependent on the capability of the organism to respond to environmental challenges by phenotypic plasticity that can augment the evolutionary potential of a population. Thus, the presence of plastic responses may significantly affect the persistence of populations in a changing world.

As phenotypic plasticity has a genetic basis and genetic variation for plasticity is generally observed, genetic erosion might also hamper plastic responses. Moreover, plastic responses can be costly. Inbreeding has been observed to increase the amount of energy needed for maintenance significantly, leaving less energy to be available for allocation to other processes, such as plasticity.

3.1.3 Population size and levels of genetic variation

Genetic diversity is a prerequisite for adaptive evolution. Only when the rate of evolution at least matches the rate of continuous environmental change, populations may be able to persist. For an abrupt environmental change, the situation might be more complex as, in addition to the evolutionary processes, demographic processes increase in importance. Genetic drift is expected to decrease genetic diversity in small populations at a rate proportional to the population size. This is well supported by the rate of loss observed for neutral variation both in experimental and natural populations

3.1.4 Population size and adaptability

If levels of adaptive variation decrease with decreasing population size and the potential to respond to selection depend on the standing level of genetic variation, small populations that have been subject to genetic erosion are expected to show reduced adaptive potential. Several authors have addressed the consequences of bottlenecks and inbreeding for the selection response of quantitative traits. For many traits, a decrease in genetic variance was observed, consistent with the expectations for additive variation investigated the selection response of sternopleural bristles in D. melanogaster at regular intervals during consecutive generations of inbreeding. They showed that the response continuously declined over the generations, concluding that the longer populations have been subject to genetic erosion, the lower their adaptive potential.

3.1.5 Other Effects

The genes from some potential parent plants may not be represented in the seeds because of random factors such as phonological difference, distance from other plants, weather patterns that influence pollen dispersal, random mortality of plants, random abortion of embryos, and increased risk of extinction.

3.2 Management of Genetic Erosion

In formulating strategies for the conservation of any crop, it is essential to know its areas of distribution and identify regions where both collecting for conservation activities could usefully be initiated. This will be due to a combination of high levels of genetic diversity at the site(s), interest in the user community in the specific genetic diversity found at or believed to be found at the site, lack of previous conservation activities, and imminent threat of genetic erosion.

3.2.1 *Ex situ* conservation

Ex-situ conservation is defined as the conservation of components of biological diversity outside their natural habitat. In a broad sense, *ex situ* conservation of germplasm is a practice that humans have used since the beginning of agriculture, to expand cultivation and/or to colonise new lands and to ensure the spread of agriculture around the world plants have traveled, during human migrations and along the ancient caravan routes, from continent to continent.

The great genetic diversity to be found in the traditional stocks of peasant agriculture in the centres of genetic diversity, where the wild or weedy relatives of crop species can be found, were called gene centres or centres of diversity. Wild and primary gene pools constitute the genetic resources available for the adaptation of present-day cultivars, or for initiating new and potentially valuable pathways of crop evolution. As agriculture progressed with the beginning of scientific plant breeding and the human population increased, modern varieties were widely distributed displacing landraces from cultivation. This increased the need to formally store plants and seeds *ex situ*.

3.2.1.1 Ex situ Conservation Techniques

Among the various *ex situ* conservation methods, seed storage is the most convenient for the long-term conservation of plant genetic resources. Traditionally, many crops are conserved as seeds in gene banks. This involves desiccation of seeds to low moisture contents and storage at low temperatures. However, there is a large number of important tropical and sub-tropical tree species, which produce recalcitrant seeds that quickly lose viability and do not survive desiccation, hence conventional seed storage strategies are not possible. For vegetatively propagated and recalcitrant seed species, living plants can be stored in field gene banks and/or botanical gardens. Major disadvantages of field gene banks, such as high maintenance costs, the limited amount of genetic variation that can be stored, and vulnerability to natural and human disasters have led to efforts to develop *in vitro* conservation methods.

In vitro conservation is also used by botanical gardens for the reproduction of rare species. It guarantees freedom from pest infestation and diseases. However, it is extremely labor and cost-intensive and can therefore only be used for special material as a long-term storage possibility. The rapid developments in the field of biotechnology have opened up new avenues for the conservation of germplasm in the form of tissue culture, cryopreservation, pollen storage, and DNA banks.

The *ex situ* conservation of large numbers of cultivated plants depends on the longevity of the seeds. Most species belong to the orthodox seed type with a logarithmical progression of shelf life as humidity and storage temperature are reduced.

3.2.2 *In situ* conservation

Storing genetic resources in collections as backup seed stocks in *ex situ* collections does not substitute for the evolution of crop plants in the fields of farmers. Plant populations on farms can support a greater number of rare alleles and different genotypes than accessions in gene banks. As a result, *in situ* approach was proposed in the early 1970’s for strictly agricultural purposes, but it has been scarcely utilised in the international crop germplasm system. *In situ* conservation is defined as the conservation of ecosystems and natural habitats, and the maintenance and recovery of viable populations of species in their natural surroundings and, in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties. On-farm conservation is dynamic and is aimed at maintaining the evolutionary processes that continue to shape genetic diversity. It is based on the recognition that farmers have improved and grown genetic diversity and that this process continues among many farmers despite socio-economic and technical changes. Farmers play a big role through their selection of plant material which influences the evolutionary process and through their decisions to continue with a certain landrace or not. Each season the farmers keep a proportion of harvested seed for resowing in the following year.

3.3 Nursery Management

Good nursery management, based on awareness of possible genetic variation in seed characteristics, germination requirements, and growth patterns, can take measures to avoid inadvertent selection and minimise the impact on the genetic diversity of the original collection.

3.4 Genetic Vulnerability

Whereas genetic erosion is a key aspect of the dynamics of diversity in time, the phenomenon of genetic vulnerability arises from patterns of deployment or impoverishment of genetic diversity in space. Populations of a crop species are said to be genetically vulnerable if they lack the diversity necessary to adapt to abiotic challenge or to abiotic stress that is likely to intensify. The concept of vulnerability implies a lack or low level of genetic diversity, most graphically realised when vast areas of a region are a monoculture of a single variety. If one plant succumbs to a newly arriving disease, to a new biotype, or a new extreme of climatic stress, all the fields of the region respond similarly because of their shared genetic heritage particularly for the genes involved in the host plant's susceptible (or 'compatible') response.

The concept of 'vulnerability' could apply to a whole range of adverse situations arising from the precariousness of living systems. It is arguable that for vulnerability to be 'genetic' requires that other varieties or populations exist elsewhere that contain resistance or tolerance genes that would have moderated the loss in yield if they had been present. Thus the concept of genetic vulnerability should go beyond mere genetic uniformity *per se*. Ideally, genetic vulnerability should add the notion of genotype × environment interaction, i.e. not all genotypes (and in particular not all populations or varieties from other regions) succumb as readily as the home population to the new threat to yield. Indicators of genetic vulnerability should therefore include:

- A measure of the lack of genetic diversity, particularly for resistance genes affecting host-plant response to major likely diseases; and
- A measure of lowered diversity of host-pathogen interactions and differential responses to different biotypes, with some spatial structure.

Here, we first consider indicators for genetic vulnerability to biotic challenges and then assess the extension of this framework to indicators for vulnerability to abiotic stresses such as climate change.

Kinds of vulnerability

The first of these is genetic homogeneity. Increasing diversity in the current cropping region lowers vulnerability. Strictly, the diversity should refer to the genes determining plant response to disease. It is insufficient to have a large number of named varieties as a hedge against crop failure if they share the same genes for resistance. This was the case in the USA, where male-sterile yet disease-susceptible cytoplasmic DNA was shared among many maize hybrid varieties, resulting in them all being vulnerable to the southern corn leaf blight. However, knowledge of the comparative resistance structure of the varieties available to farmers is generally lacking, so that a census of variety names may be the only readily obtainable information.

Richness and evenness of varieties as indicators of genetic vulnerability

The indicator for the initial concept of genetic vulnerability is varietal diversity measured as both richness (the number varieties per crop, reduced if any are known to be closely related) and evenness (as measured by the evenness index).

Computing the latter requires estimates of the area planted to each variety. High scores of richness imply there are many future varietal options near at hand and that seed is available for an increase if needed. High richness implies insurance against pathogen evolution. In some cases, richness is high but much of the region is planted to a single dominant variety. When the dominant variety succumbs to a new disease biotype, losses will be incurred for a few seasons until more resistant varieties are multiplied and deployed. On the other hand, high evenness (lack of dominance) implies resistance diversity is already deployed to meet new stress and could save the farmer from severe immediate loss.

It is therefore arguable that a high value for evenness diversity (i.e. low dominance) is a better indicator of low genetic vulnerability than is a high richness score.

Mutational vulnerability

The second type of vulnerability listed in Table 5, mutational vulnerability, specifically aims to conceptualise vulnerability to a new virulence mutation in a pest organism. Strictly speaking, the pathogenic properties of a future new virulent mutant are unknowable. One approach to a quantitative measure is to test the response of the present cultivar(s) to a random sample of distinct isolates or defined pathotypes. From these data, it is possible to compute the probability of infection or the average level of damage caused by non-local isolates. The scores for each pathotype are not weighted by the pathotype frequency of occurrence. The indicator is thus the probability of disease (or the measured adverse effect caused by the disease) in non-local environments. Clearly, this indicator requires experimental measurement, essentially the assessment of the performance of a representative sample of local material in alien stress-prone environments.

Many breeders routinely conduct trials for many crop-disease or pest situations, but the data are dispersed and rarely synthesised. The summing of averages of individual variety scores, weighted by the current frequency of the varieties on the farm in a given region, would provide a synthetic overview of mutational vulnerability. Technical consistency of approach is necessary for the comparison of estimates over time and different locations.

Migrational vulnerability

The idea behind recognising migrational vulnerability as distinct from mutational vulnerability is to divide future risks into two categories. Defining the specific actual agent of risk in the mutational case is virtually impossible. The nature of a new mutant pathotype of a disease (its virulence spectrum or aggressiveness) in the future cannot be known for certain.

Therefore we cannot test specifically for genetic diversity to meet such a possible future challenge. The only strategy for unknowable risks is to retain as much diversity as possible. On the other hand, migrational vulnerability refers to pressures that are currently absent from a certain home environment but are foreseeable as inevitably arising from an alien source in the future if unchecked, e.g. the Ug99 pathotype of wheat stem rust.

Environmental vulnerability

Abiotic environmental stresses that arise from prolonged unidirectional changes in the physical environment, such as global warming, increasing regional aridity, or increasing climatic variability, resemble the threat to crop production from the invasion of pest organisms of known virulent strains (e.g. Ug99). Once again the degree of vulnerability to such a future threat can be measured experimentally by the performance or response of a local sample of varieties to a specific pressure. The values of the likely impact of several separate risks on productivity can then be integrated, weighting by an estimate of the likely probability of each threat.

Although this fourth type of vulnerability resembles migrational vulnerability in Table 5 it is worthwhile to recognise that it merits developing separate indicators because of the topicality of climate change, the marked difference in spatial scales, in how the stresses increase, and in how agencies will respond to such data. Plant ecologists (e.g. Gomez-Mendoza. and Arriaga, 2007) are developing approaches to model changes in the natural geographic distribution of species under various scenarios of future climate. These authors used current distributions to predict decreases of between approximately 1% and 50% for different species of *Pinus* and *Quercus* in Mexico as a result of climate change. They use these estimates as a measure of differential species vulnerability and recommend conservation priorities.

Off-site testing – pursuing measurement of G × E

It may seem to be overly problematic, unduly complex, and impractical to attempt a systematic, detailed risk and genetic remediation analysis to derive measures of vulnerability. The need to attempt such computation arises from the limitation of relying solely on estimates of varietal richness diversity alone. Such counts lack a test of the relevance of that diversity, i.e. whether it will help cope with future threats to productivity. As mentioned at the outset of this section, the unifying concept underlying reduced genetic vulnerability is the provision of a diversity of interactions. Whether this can be measured satisfactorily by the tools of genotype × environment (G × E) analysis in plant breeding remains to be investigated. In this case, ‘genotype’ represents the suite of available varieties and ‘environment’ the different pathogen populations or abiotic stress levels. Situations of low genetic vulnerability obtain when the G × E component of variance accounts for a large fraction of the overall performance variance, particularly when different cultivars are resistant or perform better in different stress states. Another indicator is the character of the variance-covariance matrix of performance across environments. Situations of low risk are associated with negative covariance values. This result is analogous with the modern investment portfolio theory of market economics, in which risk (i.e. vulnerability) is minimised when the total investment is made over a diversity of the stocks whose performance patterns in the past feature negative covariances. A portfolio of stocks that have responded differentially provides the best hedge against risk.

4.0 CONCLUSION

The loss of genetic diversity can weaken the entire species and can lead to eventual extinction. The disappearance of certain species can have an unfavorable effect on other species that might have depended on them in some manner for their survival and ultimately on the environment as a whole. Biodiversity loss must be managed by précised methods to avoid their extinction.

SELF-ASSESSMENT EXERCISE
How can genetic erosion be managed at the farmers level?

5.0 SUMMARY

In this unit, you have learned that:

- Genetic erosion ultimately leads to a reduction in species vigour and extinction of all life forms.
- Effects of genetic erosion include inbreeding and lowering of reproductive fitness.
- Genetic erosion can be managed by ex-situ and in-situ conservation and good nursery management.

6.0 TUTOR-MARKED ASSIGNMENT

1. State the effects of genetic erosion.
2. Discuss the effect of inbreeding and population size on genetic erosion.
3. Discuss the methods of managing genetic erosion.
4. What do you understand by genetic vulnerability?

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UNIT 3 HABITAT FRAGMENTATION AND GENETIC EROSION

CONTENTS

1.0 INTRODUCTION

Apart from the mentioned anthropogenic stresses, human interference with nature has other major implications. Large-scale destruction of natural habitats has caused large populations of many species to become fragmented, resulting in small 'remnant' populations that become increasingly isolated. Subdivision of large populations in combination with limited gene flow between the fragments has significant ecological and genetic consequences. Ecologically, habitat fragmentation will have demographic effects as small populations are progressively more affected by demographic and environmental stochasticity greatly increasing their extinction probability.

2.0 OBJECTIVE

By the end of this unit, you will be able to:

- explain habitat fragmentation and genetic erosion.

3.0 MAIN BODY

3.1 Habitat Fragmentation and Genetic Erosion

From a population genetics perspective, small relatively isolated populations become increasingly subject to genetic drift and inbreeding, resulting in loss of genetic variation and a decrease in fitness, a process here referred to as genetic erosion.

Genetic drift will cause allele frequencies to fluctuate, which over time leads to random loss and fixation of alleles and an increase in homozygosity. When selection coefficients are smaller than 1/2Ne, genetic drift becomes stronger than natural selection, and the variation is driven by the same dynamics as neutral genetic variation independent of whether the alleles have deleterious or beneficial effects on fitness (Kimura 1983:45). On the other hand, deleterious alleles with large fitness effects, such as recessive lethals and detrimentals, will be effectively selected against and removed from the population when becoming homozygous (purging). The probability of an allele becoming fixed through genetic drift equals its initial frequency. This means that rare alleles have the lowest probability to get fixed and thus the highest probability to get lost. As most stress resistance alleles have generally low frequencies in populations under benign conditions, these would be easily lost from small populations, making them less able to adapt genetically when subjected to stresses. Even though low-frequency deleterious alleles also would have a high probability to get lost by chance, still a significant proportion of these will get fixed as many loci carry mildly deleterious alleles: estimates for Drosophila are on the order of 5000 loci.

Because the force of genetic drift increases with decreasing population size, the potential to respond to natural selection will, in general, decrease with decreasing population size, even though this relation in practice will be confounded by selection and dispersal.

At the same time, in small isolated populations the inbreeding coefficient, f, increases over time as most parents will share ancestors (biparental inbreeding). The detrimental effects of inbreeding, particularly in normally outbreeding species, are well documented and do increase the extinction probability of populations. Inbreeding depression has not only been observed in captive, laboratory, and domestic species but also evidence for the occurrence of inbreeding depression in wild populations is accumulating. Moreover, inbreeding depression is often more severe in the wild compared to benign captive conditions.

Although the genetic basis of inbreeding depression is still under discussion, it is currently accepted to be mainly due to increased homozygosity for (partly) recessive, mildly deleterious alleles. This would also explain why inbreeding depression is significantly greater for traits directly related to fitness (life-history traits) than for morphological traits, as the former exhibit more directional dominance (a prerequisite for the occurrence of inbreeding depression) while the latter show mostly additive gene action.

4.0 CONCLUSION

In short, whereas sufficient tolerance and levels of genetic variation are required for populations to cope with the ongoing deterioration of natural environments, fragmentation of habitats and the concomitant genetic erosion are expected to significantly impede adaptive responses. In the following, we focus on the consequences of genetic drift, inbreeding, and inbreeding depression for adaptive responses and the persistence of biodiversity under stressful conditions.

SELF-ASSESSMENT EXERCISE

What is the research needed on genetic diversity extent and distribution?

5.0 SUMMARY

In this unit you have learned:

- Habitat fragmentation and its relation to genetic erosion
- The drift involves in the genetic erosion in a habitat.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the concept of habitat fragmentation and its effects on genetic erosion.

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MODULE 4 GENETIC RECOMBINATION

UNIT 1 MECHANISM OF GENETIC RECOMBINATION

CONTENTS

1.0 INTRODUCTION

Genetic recombination refers to the rearrangement of DNA sequences by the breakage and rejoining of chromosomes or chromosome segments. It also describes the consequences of such rearrangements, that is, the inheritance of novel combinations of alleles in the offspring that carry recombinant chromosomes. Recombination also serves as a mechanism to repair some types of potentially lethal damage to chromosomes.

Genetic recombination is often used as a general term that includes many types of DNA rearrangements and underlying molecular processes. We can observe it in both *eukaryotes* (like animals and plants) and *prokaryotes* (like archaea and bacteria). Keep in mind that in most cases, for an exchange to occur, the sequences containing the swapped regions have to be *homologous*, or similar, to some degree. The process occurs naturally and can also be carried out in the lab. Recombination increases the genetic diversity in sexually reproducing organisms and can allow an organism to function in new ways.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- define genetic recombination
- explain the mechanism of genetic recombination
- explain the types of genetic recombination.

3.0 MAIN CONTENT

3.1 Genetic Recombination

Genetic recombination is of fundamental importance for a wide variety of biological processes in eukaryotic cells. One of the major questions in recombination relates to the mechanism by which the exchange of genetic information is initiated. In recent years, DNA double-strand breaks (DSBs) have emerged as an important lesson that can initiate and stimulate meiotic and mitotic homologous recombination. In this regard, it can be viewed as the models by which DBSs induce recombination, describe the types of recombination events that DBSs stimulate, and compare the genetic control of DBS-induced mitotic recombination in budding and fission yeasts. The result of recombination is a novel genetic entity that carries genetic information in non-parental combinations. Biochemically, recombination is a process of combining or substituting portions of nucleic acid molecules. Recombination has been recognised as an important process leading to the genetic diversity of viral genomes upon which natural selection can function.

3.1.1 Examples of Genetic Recombination

3.1.1.1Meiosis

Genetic recombination occurs naturally in meiosis. Meiosis is the process of cell division that occurs in eukaryotes, such as humans and other mammals, to produce offspring. In this case, it involves *crossing-over*. What happens is that two chromosomes, one from each parent, pair up with each other. Next, a segment from one crosses over or overlaps, a segment of the other. This allows for the swapping of some of their material. What we end up with is a new combination of genes that didn’t exist before and is not identical to either parent’s genetic information. Note that recombination is also observed in *mitosis*, but it doesn’t occur as often in mitosis as it does in meiosis.

3.1.1.2Natural Self-Healing

The cell can also undergo recombinational repair, for example, if it notices that there is a harmful break in the DNA: the kind of break that occurs in both strands. What we observe is an exchange between the broken DNA and a homologous region of DNA that will fill the gaps. There are also other ways that recombination is used to repair DNA.

3.1.2 Functions of Genetic Recombination

Recombinant DNA Technology **-** This is a relatively new technology that is allowing scientists to change genes and organisms by manipulating DNA. What makes this so important is the fact that it has improved our understanding of diseases and, consequently, has expanded our ways of fighting them. As you might expect, DNA segments are joined together in this Technology. For example, a gene can be cut out from a human and introduced into the DNA of a bacterium. The bacterium will then be able to produce human protein that is otherwise only made by humans. The same thing is done in gene therapy. Let's assume a person is born without a particular essential gene and is suffering from an illness due to the absence of that gene. Scientists can now introduce the missing gene into that person's *genome* by using a virus that infects humans. First, they join the needed gene with the virus's DNA and then they expose the person to that virus. Since all viruses blend their DNA with their host's DNA, the gene that is added by the scientists ends up being part of the person's genome.

3.1.2 Genetic Recombination Types

At least four types of naturally occurring recombination have been identified in living organisms namely;

- **General or homologous recombination** occurs between DNA molecules of very similar sequences, such as homologous chromosomes in diploid organisms. General recombination can occur throughout the genome of diploid organisms, using one or a small number of common enzymatic pathways.
- **Illegitimate or nonhomologous** recombination occurs in regions where no large-scale sequence similarity is apparent, e.g. translocations between different chromosomes or deletions that remove several genes along a chromosome. However, when the DNA sequence at the breakpoints for these events is analyzed, short regions of sequence similarity are found in some cases. For instance, recombination between two similar genes that are several million bp apart can lead to deletion of the intervening genes in somatic cells.
- **Site-specific recombination** occurs between particular short sequences (about 12 to 24 bp) present on otherwise dissimilar parental molecules. Site-specific recombination requires special enzymatic machinery, basically one enzyme or enzyme system for each particular site. Good examples are the systems for integration of some bacteriophage, such as λ, into a bacterial chromosome and the rearrangement of immunoglobulin genes invertebrate animals.

- **Replicative recombination**, which generates a new copy of a segment of DNA. Many transposable elements use a process of replicative recombination to generate a new copy of the transposable element at a new location.

3.1.3 Recombinant DNA technology

Recombinant DNA technology uses two other types of recombination. The directed cutting and rejoining of different DNA molecules *in vitro* using restriction endonucleases and DNA ligases is well-known. Once made, these recombinant DNA molecules are then introduced into a host organism, often a bacterium. If the recombinant DNA is a plasmid, phage, or another molecule capable of replicating in the host, it will stay extrachromosomal. However, one can introduce the recombinant DNA molecule into a host in which it cannot replicate, such as a plant, an animal cell in culture, or a fertilised mouse egg. For the host to be stably transformed, the introduced DNA has to be taken up into a host chromosome. In bacteria and yeast, this can occur by homologous recombination at a reasonably high frequency.

3.1.4 Advantages of Genetic Recombination

Not only is recombination needed for homologous pairing during meiosis, but recombination has at least two additional benefits for sexual species. It makes new combinations of alleles along chromosomes, and it restricts the effects of mutations largely to the region around a gene, not the whole chromosome. Since each chromosome undergoes at least one recombination event during meiosis, new combinations of alleles are generated. The arrangement of alleles inherited from each parent is not preserved, but rather the new germ cells carry chromosomes with new combinations of alleles of the genes. This remixing of combinations of alleles is a rich source of diversity in a population.

Over time, recombination will separate alleles at one locus from alleles at a linked locus. A chromosome through generations is not fixed, but rather it is "fluid," having many different combinations of alleles. This allows nonfunctional (less functional) alleles to be cleared from a population. If recombination did not occur, then one deleterious mutant allele would cause an entire chromosome to be eliminated from the population.

3.2 Mechanisms of Genetic Recombination

Homologous recombination is a type of genetic recombination in which nucleotide sequences are exchanged between two similar or identical molecules of DNA. It is most widely used by cells to repair harmful breaks that occur on both strands of DNA, known as double-strand breaks (DSB). DNA integration by homologous recombination provides a way of introducing mutations to the mouse genome at preselected loci, which is referred to as gene targeting. There are two modes of DNA integration by homologous recombination. In the insertion mode, foreign DNA is added to the chromosome with no loss of the preexisting chromosomal DNA. In the replacement mode, foreign DNA replaces part of the chromosomal DNA. Gene knockout (KO) is the most commonly used strategy of homologous recombination by replacement. This method involves creating a DNA construct containing a drug resistance gene in place of the target gene. The construct also contains a minimum of 2 kb of homologous sequence flanking the target gene. Homologous recombination (HR) is a native spontaneous event occurring in plants. HR can happen between two short identical DNA repeats and the DNA sequence flanked by these two DNA repeats will be deleted. Compared with site-specific recombination, HR does not require recombinase to induce SMG removal so it is a simpler strategy and has been implemented to delete SMG in GMO. For example, a vector that carries the trait gene, *uidA*, and the two SMGs, *aadA* and *bar*, with the SMGs being flanked by three 418 bp direct repeats, was constructed. HR is an outcome, rather than a process; a detectable result, rather than an underlying mechanism. A particular recombinant chromosome may result in more than one way, with dramatically different mechanisms behind the same outcome.

4.0 CONCLUSION

Genetic recombination can be found in many groups of DNA and RNA viruses. Both the observed natural sequence rearrangements and the data obtained with the use of experimental systems demonstrate that recombination plays an important role in providing genetic diversity during virus infections. The molecular mechanisms involved in genetic recombination depend on the class of viruses. DNA viruses utilise mechanisms of homologous (general) recombination available in the host cells, although some DNA viruses encode their recombination proteins. Also, site-specific (nonhomologous) recombination events were found for certain classes of DNA viruses.

SELF-ASSESSMENT EXERCISE

What is Recombination in the Plant Genome and its Application in Biotechnology?

5.0 SUMMARY

In this unit, you have been intimated with the facts that;

- Genetic recombination refers to the rearrangement of DNA sequences by the breakage and rejoining of chromosomes or chromosome segments.
- Examples of genetic recombination include meiosis and natural half selfing.
- Types of genetic recombination include general or homologous, illegitimate or non-homologous, site-specific and replicative genetic recombination
- Understand the process of recombinant DNA technology
- Understand the mechanism of genetic recombination

6.0 TUTOR-MARKED ASSIGNMENT

1. Define genetic recombination.
2. State the examples of genetic recombination.
3. State the types of genetic recombination.
4. Explain the mechanism of genetic recombination.

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UNIT 2 APPLICATION OF GENETIC RECOMBINATION

CONTENTS

1.0 INTRODUCTION

Recombinant DNA changes the natural genetic makeup and the characteristics of an organism by inserting DNA from another organism. Also known as genetic engineering, recombinant DNA technology is widely used in agriculture to create genetically modified organisms that produce genetically modified crops. The first GM food was the Flavr Savr tomato, produced in 1994, which had a longer shelf life and an enhanced flavour. Since then, the number of GMOs has exploded as producers prefer them over traditional crops because they yield more and require less care.

2.0 OBJECTIVES

By the end of this unit, you should be able to

- Discuss the application of genetic recombination in plant science

3.0 MAIN CONTENT

3.1 Application of Genetic Recombination

r-DNA technology has been exploited to provide selective improvements in various specialties that include crop agriculture, pharmaceutics, gene therapy, vaccine design, and bioremediation. The latter is a waste management technique that deliberately introduces GMOs into a site to neutralise environmental contaminants (breaking down hazardous substances into less toxic or non-toxic compounds) with the aim of cleansing thoroughly, quickly, and cheaply polluted soil or water. The following is the beneficial effect of genetic recombination applications.

3.1.1 Agriculture

In agriculture development of genetically modified crops with a purpose to improve both yield and resistance to plant pests or herbicides seems to have gained a degree of public acceptance and is already practised in a commercial context in several countries. The genetically modified tomato CGN-89564-2 was the first commercially grown, genetically engineered crop product to be granted a licence for human consumption. This was developed in 1994 to express the trait of delayed softening of tomato flesh as a practical means to minimise post-harvest crop losses.Ironically given its brand name of 'Flavr Savr', this failed in the marketplace due not to public apprehension overeating a genetically altered food *per se* but to an apparent lack of taste. Nevertheless, the introduction of genetically modified fruit paved the way for use of GMOs in food, and today genetic modification is widespread. In the US, 88% of corn and 93% of soybeans are genetically altered and much of this finds its way unlabelled into processed foods.

The introduction of pest-resistant brinjal (also known as eggplant or aubergine) was met with criticism in some countries, in contrast to the concurrent popularity of pest-resistant cotton. Both attempts at implementation followed incorporation of the identical crystal protein gene (*Cry1Ac*) from the soil bacterium *Bacillus thuringiensis* (Bt) into the genome of the host plant expression of which synthesises so-called Bt toxins that confer resistance to predation by lepidopteran insects. However, of the two uses as food and as clothing the one which caused anxiety among the general public involved human consumption. The benefits to humans of using Bt toxin should be stressed in an attempt to overcome the initial unpopularity of consuming Bt-brinjals in developing countries such as India, Bangladesh and the Philippines. GM foods make up a vast majority of the foods available in the market today. Recombinant DNA has increased the overall production of crops, as well as decreased the amounts of herbicides and insecticides used by farmers. This means that the farmers produce larger amounts of food while spending less time caring for the crop and paying less for insecticides and herbicides. Higher yields also benefit the consumer, as more food is available at lower prices. GM foods are the new normal.

3.2.2 Bioremediation

Pseudomonas putida and *Nitrosomonas europaea* are the organisms that are typically utilised in bioremediation. The objective is to isolate the original genes located in these bacteria that promote bioremediation, then modify and incorporate them into a suitable host to be used as a bioremediation agent usually *E. coli*. This may, however, impact normal ecosystems as well; for example, bacteria that have an improved ability to digest petroleum could, if exposed, cause destruction of important petroleum products. Hence, stringent monitoring of in situ bioremediation is essential. In producing genetically modified bacteria the simplest way of screening is to incorporate a marker gene, which, typically confers antibiotic resistance. This achieves the purposeful generation of antibiotic-resistant organisms which, if mishandled, could become problematic under natural conditions.

3.2.3 Biotechnology

An appreciable biotechnological success and novel commercial application is the production of genetically modified fluorescent zebrafish, *Danio rerio,* and similar species using genes encoding glowing characteristics. This is marketed under the GloFish® patent in the US where fish coloured bright red, green, orange-yellow, blue, and purple are sold as pets to be kept in the controlled environment of an indoor aquarium. In the event of a release, inadvertent or deliberate, into the environment the survival capacity of these constantly fluorescent fish is markedly reduced due to increased vulnerability to predation compared to wild-type fish; thus, the risk of sustained ecological impact is considered to be marginal. However, in-depth research to confirm or refute this notion is currently not possible because of insufficient understanding and a lack of technology to study the nexus of evolutionary biology and ecology with specific reference to the introduction of a novel species into, and its subsequent migration from, an ecosystem.

3.2.4 Medicine

Drug delivery systems in medicine that are based on bacterial or viral hosts could prove hazardous if either the organism is genetically unstable and converts to a pathogenic type or if purification is incomplete. In an analogous proof of concept from the agricultural sphere, the use of the soil bacterium *Agrobacterium tumefaciens* as a vehicle for gene transfer is very effective and has become widely adopted despite its tumorigenicity, causing crown gall disease of dicotyledonous plants. Genetic reversion is also a major concern regarding the experimental technique of gene therapy to treat or prevent otherwise incurable genetic disorders and acquired diseases, research into which was slowed in the early 2000s due to cases of viral vector instability. Consequently, identification of a preferred system to safely and efficiently deliver an altered gene of choice has become a priority as the technology advances from development and laboratory research to clinical translational trials.

4.0 CONCLUSION

The utilisation of genetic engineering in the production of transgenic organisms is a recent major development in the agriculture, medicine, bioremediation, and biotechnology industries. Despite the now-widespread use of GMOs the potential for less obvious long-term ecological impacts is acknowledged. The acceptance by the lay public of genetically engineered products appears to be affected by perceived increased risk to personal health and the environment, especially when relating to food production and consumption. Ecological impacts observed to date have proved much less threatening and occurred with less frequency than public perception would suggest. However, in some notable cases, GMOs have hurt wildlife due to both determined and undetermined changes.

SELF-ASSESSMENT EXERCISE

What are the uses of recombinant DNA in Agriculture?

5.0 SUMMARY

In this unit, you have learnt that:

- The application of biotechnology in agriculture has resulted in benefits to farmers, producers and consumers.
- Benefits of genetic recombination include; introduction of insect and pest resistance varieties, herbicide-tolerant plants, bioremediation and other DNA recombinants roles.

6.0 TUTOR-MARKED ASSIGNMENT

Discuss the importance of plant biotechnology to farmers, producers, and consumers.

7.0 REFERENCES/FURTHER READING

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MODULE 5 GERMPLASM APPROPRIATION

UNIT 1 GERMPLASM APPROPRIATION

CONTENTS

1.0 INTRODUCTION

All biotic components are made up of genetic materials. There are naturally preserved for continuity. Recent development shows that their availability may not be consistently guaranteed. Germplasm is living tissue from which new plants can be grown. It can be a seed or another plant part – a leaf, a piece of stem, pollen, or even just a few cells that can be turned into a whole plant. Germplasm contains the information for a species' genetic makeup, a valuable natural resource of plant diversity. Biotechnology can never thrive except on its resources. This unit will seek to identify where they can safely be preserved.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- define germplasm
- mention potential germplasm storage centres.

3.0 MAIN CONTENT

3.1 Definition of Germplasm

Germplasm is living tissue from which new plants can be grown. It can be a seed or another plant part – a leaf, a piece of stem, pollen, or even just a few cells that can be turned into a whole plant. Germplasm contains the information for a species' genetic makeup, a valuable natural resource of plant diversity.

Agriculture benefits from uniformity among crop plants within a variety, which ensures consistent yields and makes management easier. However, genetic uniformity leaves crops especially vulnerable to new pests and stresses. Genetic diversity of germplasm gives plant breeders the sustained ability to develop new high-yielding, high-quality varieties that can resist constantly evolving pests, diseases, and environmental stresses. Sexually compatible wild species and landraces – ancestral varieties of crop species- are the key to genetic diversity, but the amount of land where plants grow wild continues to shrink and many plant species and varieties are disappearing. This is why the plant science community has developed conservation programs to gather, preserve, evaluate, catalogue and distribute germplasm for people all over the world to use.

3.1.1 Reasons for Collecting Germplasm

The main reasons that can be put forward for collecting germplasm of a given gene pool in a given area are that:

- It is in danger of genetic erosion or even extinction;
- A clear need for it has been expressed by the users, at national level or internationally;
- The diversity it represents is missing from, or insufficiently represented in, existing *ex situ* germplasm collections;
- More needs to be known about it.

These are not mutually exclusive. Germplasm maybe both threatened and useful, and there may be gaps both in collections of a gene pool and in what is known about it.

Important as germplasm collecting may be, it is essential to remember that it is not the end of the story. It needs to be seen as simply one facet of a conservation strategy that may also include an *in situ* component, for example. A successful collecting programme does not mean that one can stop worrying about conservation of the target gene pool.

3.1.2 Germplasm Characterisation

Germplasm characterisation refers to the recording of distinctly identifiable characteristics, which are heritable. This is distinct from preliminary evaluation, which is the recording of a limited number of agronomic traits important in crop improvement. Germplasm characterisation is carried out in precision fields under adequate agronomic conditions and plant protection. For each accession several morpho-agronomic traits are recorded using the descriptors developed in collaboration with Bioversity International (formerly IPGRI). Following these procedures, majority of the germplasm collection at ICRISAT gene bank has been characterised. Systematic description of each accession leads to classification in small and well-organised sectors that will facilitate enhanced utilisation of germplasm. The major objectives of germplasm characterisation are:

- To describe accessions, establish their diagnostic characteristics and identify duplicates
- To classify groups of accessions using sound criteria.
- To identify accessions with desired agronomic traits and select entries for more precise evaluation
- To develop interrelationships between, or among traits and between geographic groups of cultivars
- To estimate the extent of variation in the collection.

To accomplish these objectives, a multi-disciplinary approach is essential. At ICRISAT, the data generated by various disciplines are fed back to the germplasm database. As a result of intensive field and laboratory screening and purification, a wide range of sources for desirable traits were identified in the assembled germplasm.

3.2 Germplasm Storage Centres

Over the years, genebanks have been established in some countries and the number of accessions conserved now exceeds the six million in about 1400 genebanks (FAO 1998). The mission of the Consultative Group on International Agricultural Research (CGIAR) is to achieve sustainable food security and reduce poverty in developing countries through research and development in the fields of agriculture, forestry, fisheries, policy, and environment. Exploration, exchange, and conservation of plant genetic resources are some of the main objectives of the CGIAR. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT – one of the 15 CGIAR centers) has responded to this need by establishing a Genetic Resources Unit for assembly, characterisation, evaluation, maintenance, conservation, documentation, and distribution of germplasm of sorghum (*Sorghum bicolor* (L.) Moench.), pearlmillet (*Pennisetum glacum* (L.) R. Br.), chickpea (*Cicer arietinum* L.), pigeonpea (*Cajanus cajan* (L.) Millsp.), groundnut (*Arachis hypogaea* L.), finger millet (*Eleusine coracana* (L.) Gaertn.), foxtail millet (*Setaria italic* (L.) P. Beauv.), barnyard millet (*Echinocloa crus-galli* (L.) P. Beauv.), kodo millet (*Paspalum scrobiculatum*L.), little millet (*Panicum sumatrense* Roth. *ex* Roem. & Schult.), and proso millet (*Panicum miliaceum L.*).

In summary, Germplasm can be preserved in standardised places like

1) Seed banks
2) Crop type collection centers or field gene banks
3) Natural ecosystem
4) Collection mission
5) Cryopreservation centers.

4.0 CONCLUSION

Seeds are the most convenient part of plant for storage, except a few species that have recalcitrant behavior e.g. *Tel fairia occidental i*s. In storage, under good temperature and humidity regimes, seeds can be stored for several years. Therefore, following collection, reliable seed banks must be put in place for the conservation of the collected samples. It must be emphasised that regular checks are carried out to test the viability of the stored seeds periodically. The seed bank will serve as major insurance against permanent loss of any species that had been previously collected.

SELF-ASSESSMENT EXERCISE

What is the essence of Germplasm Assembly?

5.0 SUMMARY

In this unit, you have learnt that:

- Germplasm can be defined in different ways among which is the collection of genetic resources for organisms
- Reasons for collecting germplasm
- Germplasm characterisation
- Germplasm can be preserved in standard places under regulated conditions
- Seeds are the most convenient part of plant storage with exception of a few species with recalcitrant behaviour.

6.0 TUTOR-MARKED ASSIGNMENT

1) Define germplasm
2) Give reasons for collecting germplasm
3) What is germplasm characterisation
4) Name standard places where germplasm can be properly preserved.

7.0 REFERENCE/ FURTHER READING

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UNIT 2 GERMPLASM CONSERVATIONS

CONTENTS

1.0 INTRODUCTION

As you go through this unit, basic facts on germplasm conservation, the need to conserve, benefits of germplasm conservation, and obstacles to effective use of germplasm will be explored. It would be important to appreciate that conservation is a process that involves adequate planning, controlled exploitation, judicious use, and efficient management of resources to ensure their availability for present and future use. As the human population increases, there is increasing demand on available resources. Conservation of the germplasm thus ensures the continuity of wild species on which biotechnology thrives upon.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- define germplasm conservation
- state the need to conserve germplasm
- identify the benefits of germplasm conservation
- explain the obstacles to effective use of germplasm.

-3.0 MAIN CONTENT

3.1 What is Germplasm Conservation

This is an activity involving the conscious storage of genetic materials under standardised conditions by regulated agencies for safe-keeping and most importantly to avoid loss by extinction. This is carried out by technological innovations and approaches that ensure conformity with original conditions even in artificial environments. Biotechnological approaches have been employed extensively in the process, even as research seeks to accommodate new bio-materials. The conservation of germplasm in genebanks in the form of seeds requires that the integrity of the material conserved be maintained to the highest standard over prolonged periods. For this to happen, it is necessary to set standards based on current scientificknowledgeand availabletechnologies fortheproperhandling and storage seeds in gene banks that will ensure their conservation over the longest possible time, without the need for frequent costly regeneration. Standards for routine gene bank operations andquality assurance must be followed; Several pre-and post-harvest factors such as crop management, seed production environment, maturity, harvest and cleaning, and drying practices influence initial seed quality and its subsequent longevity. Maintaining seed quality in the accessions of a large collection requires careful planning and following standard protocols during the process of seed production and storage. *Ex situ* seed storage is the most convenient and widely used method of conservation.

3.1.1 Types of Conservation

1. **Active collection**

Active collections refer to collections kept for medium-term, which are immediately available for distribution for utilisation and multiplication. Active collections are kept in conditions, which ensure that the accession viability remains above 65% for 10~20 years. Different combinations of storage temperature and moisture content can provide this longevity (IPGRI 1996). Ideally, these are maintained in sufficient quantity to be available on request. The active collections of ICRISAT genebank are stored in standard aluminum cans for all crops and in plastic cans for groundnut at 4°C and 30% relative humidity (Figure 3) (p.65). Depending on the crop species, the equilibrium moisture content for these samples ranges between 7% and 10%.

2. **Base Collection**

Base collections refer to collections kept for long-term, solely for ‘posterity’, and are not drawn upon except for viability testing and subsequent regeneration. The accessions in base collection should be distinct, and in terms of genetic integrity, as close as possible to the sample provided originally. The base collections of ICRISAT germplasm are maintained at – 20°C in vacuum packed standard aluminum foil pouches at 3%~7% seed moisture content, depending on the crop species and with initial seed viability above 85%. Base collections ensure long-term viability of material (more than 50 years) as a security to the active collection. The storage conditions maintained for both the collections are the preferred standards for international genebanks. Hamilton *et al*. (2003) have described considerations for improved conservation and utilisation concepts and strategies.

3.2 Need for Germplasm Conservation

The rapid decline in the abundance of wild or local biodiversity demands the setting apart of genetic material mainly to avoid its disappearance from natural environments. In the excessive demand for desired varieties, certain wild forms tend to be ignored. Thus, it is observed that there is:

- The increasing availability of cultivars,
- Their supply is more controlled,
- The quality is high,
- Their botanical identification is not questionable,
- There are genetic improvements as well as agronomic manipulation,
- Their post-harvesting is usually good and they are relatively safe (little or no adulteration).

3.3 Benefits of Germplasm Conservation

The benefits include the following:

- Building blocks/ gene pool for genetic improvement/enhancement
- Genes for adaptations/endurance to varying, unfavourable biotic/abiotic stresses/environments
- Contribute to developing high yielding varieties
- Contribute to sound pest and disease management
- Reduce dependency on external inputs.

3.4 Obstacles to the effective use of Germplasm

Several obstacles limit the effective use of plant genetic resources. These include:

- The lack of characterisation and evaluation data,
- Poor coordination of national policies and poor linkages between the national genebanks and the users of the germplasm.
- The utilisation of plant genetic resources maintained by farmers is limited due to a lack of information on their characteristics and lack of availability.

Though International Research Centres (IRC) and African National Agricultural Research Systems (ANARS) have developed new improved varieties, these varieties often do not reach farmers because of lengthy testing requirements which have to be repeated even in countries with similar agro-ecological conditions. For existing and approved varieties, the lack of national capacity to maintain the variety and provide basic seed promptly hampers exploitation of the varieties. Other obstacles are:

- **Weak Disaster Management**

Disasters (droughts, floods and conflicts) are increasing in frequency around the world including Africa where acute disasters are developing into chronic disasters which lead to food and seed insecurity. However, although it is generally accepted that disasters occur regularly, there is little planning or consultation at national or regional levels and African countries currently do not have the necessary capacity to respond to disaster effectively and sustainably. Several efforts to deal with the impact of disasters such as food aid, food imports by the government, and supply of seeds as part of relief programmes have had only minimal impact on the overall food situation, and the frequent introduction during disasters of unsuitable varieties erodes biodiversity and leads to loss of valuable local genetic resources.

- **Inadequate Regional Seed Marketing**

There is a lack of collaboration, consultation, and harmonisation at the regional and continental levels concerning the development, movement, and use of high-yielding vegetatively propagated materials and seeds. This has led to unduly restrictive seed certification and variety release requirements, which differ from country to country, and which, together with excessive phytosanitary and foreign currency regulations, function as non-tariff barriers that hamper seed exchange. Better coordination and capacity building are needed at the national, regional, and continental levels to overcome the constraints related to seed trade through harmonisation of seed rules and improved policies.

3.5 Germplasm Documentation

Documentation is essential in good genebank management to allow efficient and effective use of germplasm. Characterisation and evaluation data are of little use if they are not adequately documented and incorporated into an information system that can facilitate access to data. Information plays a significant role in biodiversity conservation. Accurate information about conserved materials is essential to enhance better use of germplasm. Computerised documentation systems enable rapid dissemination of information to users as well as assist curators manage the collections more efficiently. Tools like GIS and satellite imagery help in searching for germplasm with specific characteristics, monitor changes in crops and varieties, or deciding where to locate an *in situ* reserves. The Genebank Information Management System (GIMS) of ICRISAT is a user-friendly module designed to integrate various documentation activities, provide information on accessions due for regeneration viability monitoring at any given point of time.

The vast germplasm data collected on chickpea and pigeon pea germplasm have been summarised and presented to users in the form of catalogs. Details on germplasm exploration and collection missions were summarised as progress reports. Core collection (10% of the entire collection) and mini core collection (10% of core collection or 1% of the entire collection) of ICRISAT mandate crops were established and the information was published through journal articles for the benefit of fellow research workers. A Manual of Genebank Operations and Procedures' has also been published documenting the history of the collections, procedures for germplasm acquisition, maintenance, documentation, conservation, and distribution

3.6 Germplasm distribution

Distribution of germplasm and related information is fundamental to ICRISAT's mission of increasing crop productivity and food security. As per the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) germplasm is supplied under the Standard Material Transfer Agreement (SMTA). Germplasm conserved at ICRISAT genebank has become an important source of diversity available to researchers in both public and private sectors throughout the world. For example, between the years 1975 and 2008, ICRISAT genebank has distributed over 692,000 samples of its mandate crops and small millets to users in 144 countries. The global collections held at ICRISAT serve the purpose of restoration germplasm to the source countries when national collections are lost due to natural calamities, civil strife, etc. We supplied 362 sorghum accessions to Botswana; 1827 sorghum and 922 pearl millet to Cameroon; 1723 sorghum and 931 chick pea to Ethiopia; 838 sorghum and 332 pigeon pea to Kenya; 1436 and 445 sorghum accessions respectively to Nigeria and Somalia; 71 pigeon pea accessions to Sri Lanka and 44,701 accessions of ICRISAT mandate crops to the National Bureau of Plant Genetic Resources (NBPGR), India. Thus the national programs of several countries have regained their precious plant germplasm heritage which could have been lost if this was not conserved in the ICRISAT gene bank.

Impact of germplasm supply

Besides distribution and restoration of native germplasm to several countries, ICRISAT genebank has promoted testing and release of several of its germplasm accessions directly as cultivars in different countries. In total 66 germplasm accessions of different crops conserved in the genebank have been released directly as cultivars in 44 countries contributing to food security. As detailed above, and a vast number of germplasm accessions distributed have been used as building blocks for hybrids that are cultivated in many parts of the world. As of December 2007, seventy-seven national programs have released 548 cultivars using breeding materials supplied by ICRISAT. Few examples of ICRISAT germplasm that have contributed significantly towards food security are described here.

Pigeonpea germplasm accession ICP 8863 collected from farmer’s fields in India was found very promising against fusarium wilt and was purified for the trait. The purified line was found high yielding and it was released for cultivation in 1986 as Maruthi in Karnataka state, India. This variety is also grown on large hectares in adjacent states, namely, Maharashtra and Andhra Pradesh. A sorghum variety, Parbhani Moti was released in Maharashtra, India, in 2002. This variety is an excellent Maldandi-type [predominant postrainy (Rabi) sorghum landrace in Maharashtra and Karnataka states of India] with large, lustrous grains and high yield. This was selected from a germplasm collection from Ghane Gaon, Sholapur district of Maharashtra, India made by ICRISAT genebank staff during 1989. Iniari is a large-seeded, early maturing and high tillering pearl millet landrace found in Benin, Burkina Faso, Ghana, and Togo. This landrace was selected and a variety ICTP 8203 was released as MP 124 in Maharashtra and Andhra Pradesh and PCB 138 in Punjab, India in 1988. The same was released as Okashana 1 in Namibia and as Nyakhombe in Malawi. Direct selection from the same landrace leads to the development of large-seeded, downy mildew resistant male sterile line ICMA 88004. Another example is the release of barnyard variety (PRJ 1) in Uttaranchal state, India during 2003. This variety yielded 45.4% higher grain yield compared to the check variety VL 29. It provides substantial fodder yield as well. This variety is a selection from ICRISAT germplasm collection IEC 542 that originated in Japan.

3.7 Utilisation of germplasm in crop improvement

The increase in accession numbers in genebanks and lack of corresponding increase in their use by the crop improvement scientists was a clear indication that the collections were not being used to their full potential (Marshall, 1989). A very large gap exists between availability and actual utilisation of the materials. This was true both in the International Programs (CGIAR institutes) as well as in the national programs. For example, very few of the >14, 000 groundnut and >19, 000 chickpea accessions conserved in the genebank have been utilised in cultivar development of these two crops at ICRISAT (Upadhyaya *et al*., 2003, 2006a). Similarly, in the national programs, the germplasm lines used in breeding programs are very limited. In China, the introduced germplasm and wild relatives have seldom been used in groundnut improvement. In the USA, the cultivar ‘Dixie Giant’ was a germplasm source in all pedigrees of runner-type groundnut and ‘Small White Spanish-1’ cultivar in >90% pedigrees. These two lines contributed nearly 50% of the germplasm of runner cultivars of groundnut in the USA. In India, 86 chickpea, 14 lentil, and 47 pigeon pea varieties have been developed through hybridisation between 1967 and 2003. Only 10 germplasm lines contributed 35% of genetic base in chickpea, 30% in lentil, 48% in pigeonpea, 69% in urdbean, and 71% in mungbean. Most plant breeders prefer to work with their breeding lines, rather than exotic materials. Not only the limited use of germplasm is a worrisome issue, the large-scale deployment of a single cultivar complicates the whole situation even more. For example in the Netherlands, the three top varieties of nine major crops covered from 81% to 99% of the respective planted area. One cultivar accounted for 94% of spring barley. Sometimes, even if the number of cultivars is more, the degree of genetic diversity between them is very low. In European barley, the protection against powdery mildew is increasingly dependent on one gene and one fungicide. Extensive use of fewer and closely related parents in crop improvement is contrary to the purpose of collecting a large number of germplasm accessions and could result in the vulnerability of cultivars to pests and diseases. The fears of epidemics similar to the southern corn leaf blight in the USA (resulting in a huge economic loss) and late blight of potato (that wiped out the potato crop resulting in the famine in Europe) due to the narrow genetic base of crop cultivars looms large even today.

3.7.1 Developing core and mini core collections

The main reason for the low use of germplasm in crop improvement programs is the lack of information on a large number of accessions, particularly, for traits of economic importance which display a great deal of genotype x environment (G x E) interaction and require multilocation evaluation. To overcome the size-related problem of collection, developing a “core collection”, consisting of about 10% of the entire collection, representing the genetic variability of the entire collection, has been proposed. In developing a core collection, available passport and characterisation/evaluation data were used. Grouping of accessions from geographically similar countries, or regions of a big country, helps in making homogeneous groups. The data on accessions in the regional groups are then subjected to multivariate analysis to classify the accessions into different clusters using a suitable clustering method. From each cluster, 10% accessions are randomly selected to identify a core collection. Core and entire collections are compared for various parameters to determine whether the core collection is representative of the entire collection. Scientists at ICRISAT have developed core collections of all mandate crops and finger millet and foxtail millet.

4.0 CONCLUSION

Though, International research centres and African national agricultural research systems have developed new improved varieties. However, these varieties often do not reach farmers because of lengthy testing requirements which have to be repeated even in countries with similar agro-ecological conditions. For existing and approved varieties, the lack of national capacity to maintain the variety and provide Basic Seed promptly hampers exploitation of the varieties. Germplasm is basic to crop improvement programs for sustainable agriculture. Trait-specific genetically diverse parents for genetic enhancement are the primary need of the plant breeder. Agronomically superior lines are preferred by breeders to maintain the agronomic performance of breeding lines while improving the trait. Our strategic research on core and mini core collections, and identification of new diverse sources will enhance the use of germplasm in breeding programs, aimed at producing agronomically superior cultivars with a broad genetic base.

SELF-ASSESSMENT EXERCISE

What is germplasm repatriation?

5.0 SUMMARY

In this unit you have learnt that:

- Germplasm can be preserved to avoid its disappearance from the natural environment.
- The rapid decline in the abundance of wild biodiversity necessitates its conservation
- Germplasm conservation has many benefits
- Germplasm are conserved through several types such as active or base conservation.
- Several obstacles limit the effective use of plant genetic resources

6.0 TUTOR-MARKED ASSIGNMENT

1) Explain germplasm conservation
2) State the need to conserve germplasm
3) Identify the benefits of germplasm conservation
4) State the types of germplasm conservation and germplasm characterisation
5) Explain three the obstacles to the use of plant genetic resources.

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UNIT 3 GERMPLASM APPROPRIATION

CONTENTS

1.0 INTRODUCTION

In this unit, the focus would be laid on germplasm appropriation. An appropriation may be defined as an act of taking something which belongs to someone else, especially without permission. We will be looking at how farmers' rights to genetic resources are usurped.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- discuss germplasm appropriation
- explain the appropriation status in Nigeria
- explain the appropriation status in Nigeria.

3.0 MAIN CONTENT

3.1 Germplasm Appropriation

The concept of Farmers' Rights was formulated as retrospective equity to acknowledge the different contributions which farmers have made towards "conserving, improving and making available plant genetic resources particularly those in the centers of origin/diversity". The rights were vested in the international community, as trustees for present and future generations of farmers. It was proposed that they would be implemented through an international fund for plant genetic resources. In many regions, there seems to be a lack of collaboration, consultation, and harmonisation at the regional and continental levels concerning the development, movement, and use of high-yielding vegetatively propagated materials and seed. This has led to unduly restrictive seed certification and variety release requirements, which differ from country to country, and which, together with excessive phytosanitary and foreign currency regulations, function as non-tariff barriers that hamper seed exchange.

Most times farmers do not know their rights and maybe cheated out of accruing benefits. Better coordination and capacity building are needed at the national, regional, and continental levels to overcome the constraints related to seed trade through harmonisation of seed rules and improved policies.

3.2 Germplasm Appropriation in Nigeria

Germplasm Appropriation in Nigeria seems to be passive if non-existing. Even though Nigeria has joined the league of International Treaty Community, the majority of known species are disappearing from their natural habitats without control, documentations or assessments. Individuals may gather biodiversity for preservation, without legal authority, and to no registered controlled environments. Farmers and Users mostly recognised over time that certain herps are no longer found. There is no enforced legislation to promote germplasm appropriation.

3.3 Germplasm Regeneration

Regeneration is the renewal of germplasm accessions by sowing and harvesting seeds, which will possess the same characteristics as the original population. Germplasm regeneration is the most critical operation in genebank management, because it involves risks to the genetic integrity of germplasm accessions due to selection pressures, outcrossing and mechanical mixtures, among other factors. Seed regeneration should be undertaken only in the postrainy season. Due to the low ambient relative humidity and absence of rains in the postrainy season, incidences of diseases and pests are low, and consequently, the quality of the seed produced is high. The short days during the postrainy season also induce flowering in photosensitive germplasm accessions, enabling their seed production. ICRISAT genetic resources scientists have developed regeneration guidelines for sorghum, pearl millet, pigeon pea, and finger millet in collaboration with Bioversity International (BI) (formerly IPGRI).

Reasons for regeneration
Germplasm is regenerated for the following purposes:

Initial seed increase

In case of new collections or materials received as donations, the quantity of seeds received by the genebank is often insufficient for direct conservation. It is also possible that the seeds are of poor quality due to low viability or infections. All such materials need multiplication for the first time.

Long-term conservation

Seed accessions that are not in base collection as well as in backup collection.

Replenish seed stocks in active and base collections

Seed increase of accessions that have

- Low viability (percent germination <75%), identified during periodical monitoring, and
- Insufficient stocks (<50 g for cereals and <100 g in legumes) for either distribution or conservation.
- Active collections should preferably be regenerated from original seeds in the base collection. This is particularly important for outbreeding species such as pearl millet, pigeon pea and sorghum. However, using seeds from the active collection ***for up to three regeneration cycles*** before returning to original seeds (base collection) is also acceptable (Genebank Standards, FAO/IPGRI 1994).
- Base collections should normally be regenerated using the residual seed in that same sample.

Meet special requirement

Special requirements for seed multiplication may arise for accessions that are often requested or with special traits that breeders and researchers frequently use (high yielding, pest, and disease resistant accessions, genetic stocks, etc.) or accessions required for safety duplication and repatriation.

Consider the following factors when regenerating germplasm accessions:

- Suitability of environment to minimise natural selection.
- Special requirements if any to break dormancy and stimulate germination (eg, scarification).
- Correct spacing for optimum seed set.
- Breeding system of the species and need for controlled pollination.

Procedures for regeneration

- If possible, regenerate germplasm in the ecological region of its origin. Alternatively, seek a location that does not selectively eliminate some genotypes in preference to others in a population.
- If no suitable site is found, seek collaboration with an institute that can provide a suitable site or regenerate in a controlled environment.
- Examine the biotic environment in the context of prior information about the plants and experience. An inappropriate biotic environment due to its differential effect can be detrimental to plants, seed quality, and genetic integrity of an accession.

Selection of accessions

- Regenerating accessions that have inadequate quality (low viability) should take priority over accessions with an inadequate number of seeds.
- Regenerating accessions in base collections should take priority over accessions in active collections.

Preparation of field

- The regeneration plot should be as uniform as possible.
- The field should have good drainage.
- Consider the need for soil analysis and apply treatments appropriate for the crop and site (eg, fertilisers, soil amendments, irrigation, etc).
- If possible, solarise the field to eliminate soil-borne pathogens.
- Prepare the regeneration field considering:
    - number of accessions to be regenerated,
    - number of plants per accession,
    - spacing between rows and between plants, and
    - mechanical accesses for weeding.
- Method of preparation depends on:
    - soil structure,
    - species to be sown or transplanted and its cultural requirement, and
    - where there is a need for plant supports, eg, for climbers such as *Cajanus. Albicans* or *Cajanus. volubilis.*

Solarisation

Solarisation refers to heating the soil by covering it with polyethylene sheets during hot summer to control soilborne diseases. It is particularly useful to control fusarium wilt in chickpea and pigeon pea, which is a major limitation during regeneration, as accessions/plants that do not have resistance get killed and eliminated. Solarisation is conducted for at least 6 weeks during the hottest part of the year.

- Thoroughly cultivate the land and level it to minimise protrusions.
- Give 50 mm irrigation before laying the polythene sheets.
- Use a clear transparent polythene sheet, 25–100 μm thick.
- Insert two edges of the polythene sheet in the furrows, and bury the edges in the soil tightly.
- Place weights on the sheet to prevent flapping and tearing of polythene sheets in the wind.
- When planting, leave a buffer zone of at least 0.5 m around the edges of solarised area due to dilution of heat near the edges.
- Do not allow irrigation water to flow in from other non-solarised areas and during crop growth.

Cleanliness

- Identify the problem weeds, pests, and pathogens, by inspection and prior experience.
- Consider reducing such problems during land preparation by application of appropriate treatment (such as weedicides).
- Keep the plots clean from alien seed and plants by
    - herbicide spray,
    - sterilising soil,
    - ploughing to encourage weed germination followed by herbicide spraying, and
    - deep ploughing to kill emerging seedlings.
- Consider the risk of contamination with alien pollen and take appropriate measures to reduce it. Ensure that field preparation is appropriate for the chosen method of establishing plants, eg, ridges and flatbeds.

Fertilisers

- Fertiliser requirement varies by crop and location of regeneration.
- If possible, arrange for soil testing and apply fertilisers as per the recommendation.

Weeds

- Arrange for 2-3 manual weedings depending on the weed populations.

Preparation of seed

- Dry, thresh and clean the seed if the samples are newly acquired.
- Those in storage,

- identify the candidate accessions that require regeneration using the genebank documentation system,
- remove the containers from the genebank the previous day.
- draw seed samples keeping in mind the minimum sample size required for regeneration and current level of germination.

Ensure absolute accuracy in identification of accessions while drawing the seeds from the genebank, packaging and labeling the seed. Use the genebank documentation system to print labels.

Seed pretreatments

Specific pretreatment may be necessary to improve seed germination and establishment.

- Break dormancy for species or accessions (eg, stratification, scarification).
- Apply proprietary seed dressings to reduce soil-borne disease and insect damage.
- Inoculate with appropriate symbionts (*Rhizobium* treatment for legumes).
- For wild species and accessions with limited seeds, pre germinate in controlled conditions, eg, incubator, agar, etc, and transplant the seedlings.

Sowing and crop management

Crop management for regeneration differs from normal commercial practices where interplant variation is not of primary consideration.

To maximise seed yield and avoid losses of alleles:

- Use 100 or more plants in cross-pollinating species and 25-50 plants in self-pollinating species.
- Provide suitable conditions for growth to trigger abundant flowering.
- Eliminate competition by weeds.
- Ensure maximum survival.

Regular inspection of plants is mandatory to achieve these objectives.

Sowing

- Sow at an optimum time so that maturity and harvesting coincide with the most favorable weather conditions.
- If there is variation between accessions at flowering time, sort on maturity (eg, early and late) based on previous documentation and

adjust the planting dates so that all accessions mature under a uniform favorable environment.

- Sow in uniformly spaced rows and with uniform spacing between plants within rows.
- Avoid competition for light and nutrients by sowing at wide spacing.
- Ensure complete control of weeds, pathogens, and pests.
- Ensure the continued absence of alien plants in the vicinity throughout the regeneration cycle by hand weeding or inter cultivation.

Irrigation

- Irrigate the field when necessary.
- Never subject the crop to water stress.
- Ensure adequate drainage and no waterlogging.

The flowering stage is sensitive in plant development. Care must be taken to avoid any stresses such as high temperature (see sowing date) and drought.

Verifying accession identity

- Accession identity should be verified while the plants are growing by comparing:

➢ morphological data in documentation system, or
➢ reference material such as original herbarium specimens or seed.
➢ Roguing must be undertaken with caution and only when it is absolutely clear that the rogue plants are genuine mixtures.

Unless the species is an obligate inbreeder, appropriate pollination control should be implemented.

Elimination of alien pollen can be achieved through:

- Bagging selected inflorescence with pollen-proof or pollinator-proof cloth bags.
- Erecting temporary pollinator-proof cages over the plots (pigeon pea).

Pollination of male-sterile lines depends on the genetic control of male sterility. In the case of genetic male-sterility, pollen is collected manually from the maintainer line and applied to the stigmas of the male-sterile line.

Harvesting and post-harvest management

- Harvest at optimum maturity:
  - when maximum number of seeds are ripe, seeds become tolerant to desiccation,
  - before deterioration sets in, and
  - before natural dispersal occurs, eg, through shattering.
- Stagger the harvest if there are differences in maturity of the accessions.
- Harvest individual plants within an accession when there are differences in flowering and maturity between plants.
- Mix an equal proportion of seeds from different mother plants.
- Bags to hold harvested seeds or heads should be made of porous material enabling good air circulation for drying.
- Options for harvesting depend on the crop:
  - harvest plants individually, preferably by hand. If machine harvested, use custom-built machinery because commercial machinery cannot be cleaned adequately between regeneration plots.
  - harvest infructescences individually by hand. If bags are used for controlling pollination, they can be left in place until harvest. However, this procedure requires caution concerning infestations of pathogens and pests inside the bags.
- Initiate seed drying immediately after harvesting to prevent seed deterioration.
- If seeds cannot be processed quickly, they should be placed in a temporary holding area under a controlled environment (eg, short-term storage, at 20°C and 30–40% RH).

Seed drying and processing

- Drying should be in two stages:
  - initial drying to reduce the moisture content low enough for effective threshing without damaging the seed, and
  - final drying for conservation in genebank (refer to Section 4C for more details).

Initial drying

Generally refers to drying of plants, panicles, pods, etc.
Options for initial drying include:

- Outside in shade, if the climate is suitable,
- ➢ requires additional control measures against birds, insects, and dew,

- Passive drying in a room with good ventilation and air circulation,
- ➢ not feasible in hot and humid climates of moist tropics,
- Active drying under forced ventilation.

Threshing and cleaning

- Threshing should be done at optimum moisture (<15%) to avoid damage to seeds.
- Seeds may be threshed preferably by hand.
- Use purpose-built equipment that can be cleaned adequately between accessions.

Final drying

The moisture content to which seeds should be dried depends on species, seed characteristics, and intended storage duration (medium-term or long-term). Drying to low moisture content improves the longevity of some species, while it can damage other species. Seeds dried to low moisture content can be brittle, and therefore, should be handled carefully.

Options for final drying include:

- Drying in artificially dehumidified conditions,
    - ➢ with self-indicating silica gel, which is cheaper and least expensive, or
    - ➢ in the controlled environment of seed-drying cabinet or room.

Seed health

To ensure the production and conservation of high-quality seeds with maximum potential longevity, organise:

- Periodic field inspection by pathologists and virologists during the growing season, and
- Seed health tests of a representative sample of the harvested seeds.

Initial viability testing

Test the germination of the seeds after drying and before packing them for storage following methods.
For species with dormancy, apply appropriate dormancy breaking treatments when testing.

4.0 CONCLUSION

The conservation ethic advocates management of natural resources to sustain biodiversity in species, ecosystems, the evolutionary process, and human culture and society. This should be of benefit to foreign and local farmers.

SELF ASSESSMENT EXERCISE

What is the identification of gaps in the germplasm collections?

5.0 SUMMARY

In this unit you have learned that:

- The concept of Farmer's Rights was formulated to acknowledge the contributions of farmers towards conserving, improving, and making available plant genetic resources particularly, those in the centers of origin/diversity.
- There seems to be a lack of collaboration, consultation, and harmonisation at the regional and continental levels concerning the development, movement, and use of high-yielding vegetatively propagated materials and seeds.

6.0 TUTOR-MARKED ASSIGNMENT

1) Discuss germplasm appropriation.
2) Explain the appropriation status in Nigeria.

7.0 REFERENCE/FURTHER READING

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MODULE 6 PLANT BIOTECHNOLOGY

UNIT 1 PLANT BIOTECHNOLOGY

CONTENTS

1.0 INTRODUCTION

Technology has gained enormous access into different sectors including Agriculture. Biotic resources are flexible enough to allow genetic manipulation to meet human needs. Plants have been raised through technological innovations because all of the biological processes of trees contain targets for biotechnological alteration and improvement, and the utilisation processes offer potential targets for biotechnology as well.
Thus, biotechnology is often associated with genetically modified organisms (GMOs) or transformations that involve the introduction of selected foreign genes into the plant genome. DNA transfer could be from another crop species or even from bacteria or virus.This technology identifies these specific genes and modifies them to affect biochemical pathways which results in phenotypes with perceived superior traits.In this unit therefore, you will be exposed to the concept of biotechnology and attributes of focus in plants.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- define plant biotechnology
- state the types of plant biotechnology
- explain traits of Interest in Plants.

3.0 MAIN CONTENT

3.1 Plant Biotechnology

This is a scientific transformation that involves the introduction of selected foreign genes into the plant genome which affects biochemical pathways producing desired phenotypes with superior features. This technology has been used in transforming trees and crops. Various wild plant species with less or undesirable attributes have been altered to adapt to new or stressful conditions through this standardised process which have proved dependable.

Our natural ecosystems are subject to increasing pressures, and negative effects can already be seen in some regions of the world. In the years 1999 – 2000, 9.4 million hectares of forests were lost worldwide.

Tropical deforestation accounts for 20 percent of the world’s greenhouse gas emissions and the loss of essential terrestrial and freshwater resources for humanity and critical habitats for endangered species.
Biotechnological innovations have been employed to replenish the natural abundance and transform low quality species into highly desirable ones with recorded evidences.

Plant biotechnology in use today is a product of advanced technology, which allows plant breeders to make precise genetic changes to impart beneficial traits to plants. This practice of plant biotechnology has been around for centuries.

The use of less advanced methods by early farmers and plant breeders to improve plants reflected their traditional breeding methods which included selecting and sowing the seeds from the strongest, most desirable plants to produce the next generation. By selecting and breeding plants with characteristics such as higher yield and resistance to pests and hardiness, these early farmers dramatically changed the genetic makeup of plants long before the science of genetics was understood. As a result, most of today’s plants bear little resemblance to their wild ancestors.

The tools of modern biotechnology allow plant breeders to select genes that produce beneficial traits and move them from one organism to another. This process is far more precise and selective than crossbreeding, which involves the transfer of tens of thousands of genes and provides plant developers with more detailed knowledge of the changes being made. The ability to introduce genetic material from other plants and organisms opens up a world of possibilities to benefit food production.
Plant biotechnology is a precise process in which scientific techniques are used to develop molecular- and cellular-based technologies:

- To improve plant productivity, quality, and health;
- To improve the quality of plant products;
- To prevent, reduce or eliminate constraints to plant productivity caused by diseases, pest organisms, and environmental stresses.

This process and technology transform the genetic components of plant species to produce observable improvements.

3.2 Plant Biotechnology Types

The basic type of modern plant breeding includes:

- Mutation breeding
  In mutation breeding, seeds are treated with either radiation or mutagenic chemicals to induce larger or smaller lesions in the genes. The mutations are at random over the genome. Usually, mutation results in a loss of function of genes.
- Green revolution
  Green revolution' leads to greatly increased crop yields based on the incorporation of dwarfing genes discovered by Norman Borlaug and the widespread use of agrochemicals
- Plant tissue culture breeding

The process of selectively mating plants in aseptic culture results into;

- ➢ Embryo rescue
- ➢ Somaclonal variation selection
- ➢ Somatic hybrid (i.e. fusion protoplast).
- ➢ Generation of haploid (i.e. anther/microspore culture)

In summary, the above basic types of modern plant breeding can be grouped into two major areas of plant biotechnology namely:

- Plant Tissue Culture (plants cloning)
- Recombinant DNA technology (gene cloning).

3.3 Traits of Interest in Plants

Gene alteration can result in unique gene combinations unachievable by traditional plant breeding. This allows species to have attributes or traits that would not be possible through natural processes. These attributes can be characterised as:

Silvicultural Traits: these are features like

- Growth rate
- Nutrient uptake
- Crown/stem
- Flowering control

Adaptability Traits: these are features like

- Drought tolerance
- Cold tolerance
- Fungal resistance
- Insect resistance

Wood Quality Traits: these are features like

- Wood density
- Lignin reduction
- Lignin extraction
- Juvenile fiber
- Branching

3.3.1 Impact Plant Biotechnology

- Economic impact

With full adoption of biotechnology, aggregate income for all regions, measured by gross national product (GNP), is estimated to rise by US$210 billion a year, by the end of the period (2006-2015).

- Environmental impact
  - In vitro conservation
  - Pesticide reduction
- Health impact
  More food, better food and more healthy
- Society impact

Reducing famine, calorie under-nutrition, food crisis

4.0 CONCLUSION

Innovations leading to the generation of non-genetically engineered crops have been employed to support the increasing food, water and fiber shortages associated with population growth and climate change. Its application in agriculture captures desired features to enhance commercialisation of these products which ultimately support human population.

SELF-ASSESSMENT EXERCISE

What is the impact of plant biotechnology on agriculture in a changing world?

5.0 SUMMARY

In this unit, you have been intimated with the facts that;

- Plant biotechnology is a precise process in which scientific techniques are used to improve productivity
- Biotic resources are flexible enough to allow genetic manipulation to meet human needs
- Plant biotechnology focuses on improving traits of interests based on silvicultural traits, adaptability traits, and wood quality traits.
- The basic areas/types of plant biotechnology include Plant Tissue Culture (plants cloning) and recombinant DNA technology (gene cloning)
- The impact of plant biotechnology includes environmental, social, and health impacts.

6.0 TUTOR-MARKED ASSIGNMENT

1. Define plant biotechnology.
2. Explain the traits of interest in plants.
3. State the types of plant biotechnology.
4. Explain the impact of plant biotechnology.

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UNIT 2 IMPORTANCE OF PLANT BIOTECHNOLOGY

CONTENTS

1.0 INTRODUCTION

There have been indications of positive achievement using plant biotechnology as analysed in the previous unit. Are they available in our environment? This unit will seek to explain potential benefits accruing to various groups of people. Modern civilisation would be impossible without the domestication of a small number of plants, particularly wheat, rice and maize. Domestication generates plants with high yields, large seeds, soft seed coats, non-shattering seed heads that prevent seed dispersal and thus facilitate harvesting, and a flowering time that is determined by planting date rather than by natural day length. These improvements are driven by technological innovations.

2.0 OBJECTIVE

By the end of this unit, you will be able to:

- discuss the importance of plant biotechnology to farmers, producers and consumers.

3.0 MAIN CONTENT

3.1 Importance of Plant Biotechnology

Biotechnology has many other useful applications besides those that are medically related. Many of these are in agriculture and food science. These include the development of **transgenic crops -** the placement of genes into plants to give the crop a beneficial trait. Benefits include;

1. Pest and Weed Control

Plant biotechnology has helped make both insect pest control and weed management safer and easier while safeguarding plants against disease.

For example, genetically engineered insect-resistant cotton has allowed for a significant reduction in the use of persistent, synthetic pesticides that could contaminate groundwater and the environment.
In terms of improved weed control, herbicide-tolerant soybeans, cotton, and corn enable the use of reduced-risk herbicides that break down more quickly in soil and are non-toxic to wildlife and humans.

2. Herbicide Tolerant Plants

Herbicide-tolerant plants particularly are compatible with no-till or reduced tillage agriculture systems that help preserve topsoil from erosion. The Flavr Savr tomato was the first genetically modified commercial crop food Plant biotechnology has been used to protect plants from devastating diseases. The papaya ringspot virus threatened to ruin the Hawaiian papaya industry until papayas resistant to the disease were developed through genetic engineering — something that saved the U.S. papaya industry. Research on potatoes, squash, tomatoes, and other crops continues similarly to provide resistance to viral diseases that otherwise are very difficult to control

3. Increase in Yields

Biotech plants can make farming more profitable by increasing crop quality and in some cases may increase yields. The use of some of the crops can simplify work and improve safety for farmers, which allows farmers to spend less time managing their crops and more time on other, profitable activities. Biotechnology-derived varieties of pest-protected corn, cotton and potatoes and herbicide-tolerant soybeans significantly have reduced pesticide and herbicide use, boosted yields, and saved growers tens of millions of dollars. A study by the National Center for Food and Agriculture Policy found that six biotech crops — canola, corn, cotton, papaya, soybean and squash — increased grower incomes by an additional $1.9 billion, boosted crop yields by 5.3 billion pounds and reduced pesticide use by 46.4 million pounds in 2003. These savings came from reduced inputs including time, labour, and wear and tear on farm equipment.

4. Quality Traits

Biotech crops provide enhanced quality traits, such as increased levels of beta-carotene in rice and improved oil compositions in canola, soybean, and corn. For example, scientists have developed a new strain of rice, called golden rice, that naturally produces betacarotene, the precursor to vitamin A. Golden rice can provide enough beta-carotene to make up for vitamin A deficiencies in the diets of poor children, and it also can increase the amount of vitamin A in breast milk, an important source of nutrition for infants. Furthermore, scientists have enriched the same strain of rice with additional iron to combat anemia, which affects hundreds of millions of the world's poor.

5. Drought and Salty Soils Resistant Crops

Crops with the ability to grow in salty soils or better withstand drought conditions also are in the works. Thus, Plant biotechnology also can be a key element in the fight against hunger and malnutrition in the developing world.

Today, an estimated 800 million people do not have access to sufficient supplies of food. By 2030, the global population is expected to reach, if not exceed, eight billion people, putting a further strain on food supplies. But while the world population is expected to grow rapidly, particularly in developing countries, the amount of available agricultural land is limited. Only 10 percent of the world's land surface is arable, and over-farming and soil erosion are growing problems in some areas. To overcome those dynamics, farmers will need to find ways to grow more food while using less land.

4.0 CONCLUSION

Plant biotechnology is a precise process in which scientific techniques are used to develop molecular- and cellular-based technologies to improve plant productivity, quality, and health; to improve the quality of plant products; or to prevent, reduce or eliminate constraints to plant productivity caused by diseases, pest organisms and environmental stresses. This process and technology already is in widespread use in the United States today. Plant biotechnology practically increases the production of main food staples, improves the efficiency of production, reduces the environmental impact of agriculture, and provides access to food for small-scale farmers.

SELF-ASSESSMENT EXERCISE

Can biotechnology be used as a tool for sustainable development?

5.0 SUMMARY

In this unit, you have learnt that:

- The application of biotechnology in agriculture has resulted in benefits to farmers, producers and consumers.

- Benefits of biotechnology include; pest and weed control, herbicide-tolerant plants, increase in yields, quality traits, and production of drought and salty soil-resistant crops.

6.0 TUTOR-MARKED ASSIGNMENT

Discuss the importance of plant biotechnology to farmers, producers, and consumers.

7.0 REFERENCES/FURTHER READING

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UNIT 3 APPLICATIONS OF PLANT BIOTECHNOLOGY IN FORESTRY

CONTENTS

1.0 INTRODUCTION

In the last unit, we considered the benefits of biotechnology to different human groups who survive in various environments. These areas, are occupied by both plants and animals. Its sustainability depends on the vegetation cover. Biotechnology is an artificial process of recombining genes from different organisms and by-passing natural barriers to sexual reproduction. It promotes the engineering of new biochemical pathways to increase species that are stress tolerant. Its application has enabled crops, trees and their products possess traits that meet public demands, easing primitive stress conditions. We will thus consider the benefits and potential risks of plant biotechnology in forestry.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- identify the benefits of biotechnology in forestry
- explain the potential risks of plant biotechnology in forestry.

3.0 MAIN CONTENT

3.1 Applications of Plant Biotechnology

Biotechnology has many other useful applications besides those that are medically related. Many of these are in agriculture and food science. These include the development of transgenic crops - the placement of genes into plants to give the crop a beneficial trait. Benefits include:

3.1.1 Improved Yield from Crops

Using biotechnology techniques, one or two genes may be transferred into a crop to give a new trait to that crop. This is done in the hope of increasing its yield. However, these increases in yield have proved to be difficult to achieve. Current genetic engineering techniques work best for single gene effects - that is traits inherited in a simple Mendelian fashion. Many of the genetic characteristics associated with crop yield, such as enhanced growth, are controlled by a large number of genes, each of which just has a slight effect on the overall yield. There is, therefore, still much research, including plant genetic research, to be done in this area.

3.1.2 Reduced Vulnerability to Environmental Stresses

Crops are dependent on environmental conditions. Drought can destroy crop yields, as can too much rain or floods. But what if crops could be developed to withstand these harsh conditions? Biotechnology will allow the development of crops containing genes that will enable them to withstand biotic and abiotic stresses. For example, drought and excessively salty soil are two significant factors affecting crop productivity. But some crops can withstand these harsh conditions. Why? Probably because of that plant's genetics. So biotechnologists and plant geneticists are studying plants that can cope with these extreme conditions, trying to identify and isolate the genes that control these beneficial traits. The genes could then be transferred into more desirable crops, with the hope of producing the same phenotypes in those crops.

3.1.3 Increased Nutritional Qualities of Crops

Maybe you’ve heard over and over that eating beans is good for you. True? Well, maybe. But what if it were genetically possible to increase the nutritional qualities of food? One would think that would be beneficial to society. So, can biotechnology be used to do just that? Scientists are working on modifying proteins in foods to increase their nutritional qualities. Also, proteins in legumes and cereals may be transformed to provide all the amino acids needed by human beings for a balanced diet.

3.1.4 Improved Taste, Texture or Appearance of Food

Have you ever gone to the grocery store, bought some fruit, and never gotten around to eating it? Maybe you haven’t, but maybe your parents have. Modern biotechnology can be used to slow down the process of spoilage so that fruit can ripen longer on the plant and then be transported to the consumer with a still reasonable shelf life. This is extremely important in parts of the world where the time from harvest to the consumer may be longer than in other areas. In addition to improving the taste, texture, and appearance of the fruit, it will also extend the usable life of the fruit. As the world population grows and grows, this may become a fairly important issue. Extending the life of fruit can expand the market for farmers in developing countries due to the reduction in spoilage. This has successfully been demonstrated with the tomato. The first genetically modified food product was a tomato which was transformed to delay its ripening. Researchers in Indonesia, Malaysia, Thailand, the Philippines, and Vietnam are currently working on developing other delayed ripening fruits, such as papaya.

3.1.5 Reduced Dependence on Fertilisers, Pesticides, and Other Agrochemicals

There is growing concern regarding the use of pesticides in agriculture. Therefore, many of the current commercial applications of modern biotechnology in agriculture are focused on reducing the dependence of farmers on these chemicals. For example, *Bacillus thuringiensis* (Bt) is a soil bacterium that produces a protein that can act as an insecticide, known as the Bt toxin. But it is a naturally occurring protein, not a foreign chemical. Could this protein be used in crops instead of pesticides? Traditionally, an insecticidal spray has been produced from these bacteria. As a spray, the Bt toxin is in an inactive state and requires digestion by an insect to become active and have any effect. Crop plants have now been engineered to contain and express the genes for the Bt toxin, which they produce in its active form. When an insect ingests the transgenic crop, it stops feeding and soon thereafter dies as a result of the Bt toxin binding to its gut wall. Bt corn is now commercially available in several countries to control corn borer (an insect-like a moth or butterfly), which is otherwise controlled by insecticidal spraying.

In addition to insects, weeds have also been a menace to farmers - just ask anyone with a garden how much they hate weeds. They can quickly compete for water and nutrients needed by other plants. Sure, farmers can use herbicides to kill weeds, but do these chemicals also harm the crops? Can biotechnology help with this issue? Some crops have also been genetically engineered to acquire tolerance to the herbicides - allowing the crops to grow, but killing the weeds. But the lack of cost-effective herbicides with a broad range of activities - that do not harm crops - is a problem in weed management. Multiple applications of numerous herbicides are routinely needed to control the wide range of weeds that are harmful to crops. And at times these herbicides are being used as a preventive measure – that is, spraying to prevent weeds from developing rather than spraying after weeds form. So these chemicals are being added to crops. This practice is followed by mechanical and/or hand weeding to control weeds that are not controlled by the chemicals. Crops that are tolerant of herbicides would be a tremendous benefit to farmers. The introduction of herbicide-tolerant crops has the potential to reduce the number of chemicals needed during a growing season, thereby increasing crop yield due to improved weed management and decreased harm to the crops.

3.1.6 Production of Vaccines in Crop Plants

Most little children hate shots. And many children in parts of the world do not even have access to vaccines. But what if these vaccines were available in an edible form? Modern biotechnology is increasingly being applied for novel uses other than food. Banana trees and tomato plants have been genetically engineered to produce vaccines in their fruit. If future clinical trials prove successful, the advantages of edible vaccines would be enormous, especially for developing countries. The transgenic plants could be grown locally and cheaply. Edible vaccines would not require the use of syringes, which, in addition to being unpleasant, can be a source of infections if contaminated.

3.2 Benefits of Using Biotechnology in Forestry

- To produce Free for the viral, fungal, and bacterial pathogens of quality seedlings.
- Uniform growth and increases yield (20-30%).
- Shorter crop rotation with the minimum cost of cultivation maximum land use is possible in a low landholding country like India.
- Planting is possible as seedlings are made available throughout the year.
- High multiplication rate per unit area.
- A quick way for breeding and production of excess plants.
- Homogeneity in plant growth and timing of flowers and fruits.
- Easy transfer of seedlings and availability throughout the year.
- Revealing trees' unique biological properties which increases wood yield and quality
- Reducing pressure on natural forests by increasing productivity of managed forests
- Improving disease and insect resistance assisting in the restoration of endangered tree varieties
- Reducing the environmental impact of pulping assisting in cleaning up toxic waste serving as a new source for feed and pharmaceuticals.

3.2.1 Risks of using plant biotechnology in forest production

- Trees could become invasive, supplanting natural forests
- Environmental impacts could persist because of the long life spans of trees.
- It could be difficult to track "escapes" and to reverse potential damage.
- It could be difficult to predict the consequences for complex ecosystems.
- It could alter the aesthetic qualities of forests.
- It could clash with the cultural need for natural forests consumer concerns could emerge.
- It could foster inequities between large and small landowners.

4.0 CONCLUSION

Biotechnology uses the tools of genetic engineering, which is the process of manipulating genes and involves the isolation, manipulation, and reintroduction of DNA into cells. This process introduces new characteristics physiologically, producing desired attributes. These tools have been invaluable for researchers in helping understand the basic biology of living organisms. As products are meeting desired purposes, these indicate possibilities of greater achievements, especially in agriculture.

SELF-ASSESSMENT EXERCISE

What are the challenges of plant biotechnology adoption in developing countries?

5.0 SUMMARY

In this unit, you have been informed that:

- Applications of plant biotechnology are observed in crop production and forest conservation
- Biotechnology in forestry is largely associated with potential benefits and risks factors.

6.0 TUTOR-MARKED ASSIGNMENT

1) What are the benefits of using biotechnology in forestry?
2) Explain the potential risks of plant biotechnology in forestry.

7.0 REFERENCE/FURTHER READING

Cole, C. T. (2003). Genetic variation in rare and common plants. Annual Review of Ecology, Evolution, and Systematics 34:213–237.

FAO, (2004). A preliminary review of biotechnology in forestry, including genetic modification. Forest Genetic Resources Working Paper FGR/59E, Forest Resources Development Service, Forest Resources Division Rome, Italy.

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UNIT 4 FOREST BIOTECHNOLOGY AND CONSERVATION

CONTENTS

1.0 INTRODUCTION

There is significant social and ecological value in conserving larger areas of biodiversity-rich natural forests and in reducing economic demands on those forests by increasing yields from the planted forests. This suggests that total value in plantations is not simply a financial equation. While intensive forestry and biotechnology are no panaceas in the absence of concerted efforts by governments and the private sector to expand protected areas, they are important tools that support sustainable forestry programs. This unit will thus focus on the necessities and strategies for conserving forest trees.

2.0 OBJECTIVES

By the end of the unit, you will be able to:

- state the need for forest conservation
- state the strategies for conserving forest trees.

3.0 MAIN CONTENT

3.1 Forest Biotechnology and Conservation

The world's forests are under severe pressure from unsustainable logging and road building. The threats are especially acute in the tropics, where just 45% of the original extent of habitat remains and the remainder are being lost at a rate of 1% per year. Current rates of tropical deforestation are equivalent to an area half the size of Florida being removed from the lower 48 annually.

Of course, commercial timber production is not the only contributing factor, since many other forces are driving the global forest crisis. But the infrastructure associated with timber extraction is often at the vanguard of habitat conversion and threats to endangered species. A compelling example was published recently in nature: gorilla and chimp populations in Gabon and the Democratic Republic of the Congo which showed a drop by 80% from 1983-2000, leading scientists to recommend immediate designation of the species as “critically endangered.” The decline was attributable to illegal bushmeat hunting and Ebola virus epidemic, but a significant root cause was the expansion of new a logging road network into remaining intact tropical forests in western equatorial Africa. Trends in the tropics are highly relevant to the future of forests and the forest and paper industry in North America.

A new report commissioned by AFPA and conducted by Seneca Creek Associates found that illegal logging – mostly but not entirely in the tropics – significantly depresses the U.S. and Tropical deforestation accounts for 20% of the greenhouse gas emissions responsible for global warming and the threat of climate instability.

Global warming, in turn, presents enormous risks to the world’s biodiversity. Research findings estimate that one-third of all species could be committed to extinction under current global warming scenarios as a consequence of disruption of habitat ranges and other results of changing climate patterns.

Moreover, forest destruction is a major driver of the loss of terrestrial and freshwater resources that provide essential ecosystem services for humanity and critical habitat for endangered species around the world. For instance, the global amphibian assessment recently published by CI, IUCN, and Nature serve concluded that more than 40% of salamanders, frogs, toads, and other amphibians are in decline, with habitat loss as the major driver underlying this threat. Fortunately, ingredients exist for convergence of interests between the business world, the conservation community, and the world’s consumers.

3.2 Conservation of Forest Trees

Reports by WWF-International titled “The Forest Industry in the 21st Century” concluded that meeting projected increases in global wood demand over the next five decades will not require significant expansion of commercial logging beyond the estimated 600 million hectares of timber lands that currently account for 90% of the world’s industrial wood supply.

A broad consensus may be emerging around the elements of a strategy that produces benefits for industry, communities and biodiversity. Thus, Forest trees can be conserved by a strategy that produces benefits for industry, communities and biodiversity. One element of the strategy is a shift away from commercial logging and road construction in biodiversity hotspots and major tropical wilderness areas. Another critical need is to secure and expand protected areas around the world. An additional component is to achieve best environmental practices on existing plantations, without tapping substantial new areas of natural forest for fiber production. The strategy must also include efforts to build international pressure on “bad actors” conducting egregious logging, and strengthen enforcement systems to crack down on illegal timber.

Stepping up appropriate strategies for the future in research, development, and technology transfer in forest biotechnology as well as addressing associated societal and regulatory issues seem very demanding. A general response is that the research & development strategy should be focused on whether and how forest biotechnology might contribute to achieving the objectives of conserving threatened forests and biodiversity while meeting society’s needs for forest products. For example, does forest biotechnology have the potential to enhance fiber production while enabling reduced chemical applications and improved water efficiency, on intensive plantations established on degraded agricultural lands? It is important to recognise that intensified timber management on existing plantations, while a preferable alternative to liquidating remaining tropical forests, does not unto itself guarantee positive results for conservation. Intensive forestry or biotechnology should not be oversold as a panacea in the absence of concerted efforts by governments and the private sector to expand protected areas, stabilise and rebuild populations of endangered species, and create conservation corridors that combine the protection of key biodiversity areas with ecologically compatible economic uses across the larger landscape (Buis, 2000).

4.0 CONCLUSION

The forest has been the reservoir of biotic components. Its elimination exposes both biotic factors and edaphic factors to adverse conditions with grave consequences on the human population as well. Biodiversity should be taken care of in carefully structured, transparent, and independent regulatory frameworks. If shortcuts are taken on regulatory issues and public participation could result in lengthy delays or loss of valuable new technological innovations.

SELF-ASSESSMENT EXERCISE

How is biotechnology used in forest conversation?

5.0 SUMMARY

In this unit, you have learnt that:

- The threats to the world's forests are especially acute in the tropics
- Global warming presents enormous risks to the world's biodiversity
- Forest trees can be conserved by a strategy that produces benefits for industry, communities, and biodiversity.

6.0 TUTOR-MARKED ASSIGNMENT

1) Why is forest conservation necessary.
2) State the strategies for conserving forest trees.

7.0 REFERENCES/FURTHER READING

Buis, S. (2000). Writing woody plant specifications for restoration and mitigation practices. Native Plants Journal 1:116–119.

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MODULE 7 BIOLOGY DIVERSITY

UNIT 1 HISTORICAL PERSPECTIVES

CONTENTS

1.0 INTRODUCTION

In this unit, we will consider biodiversity; its origin, various definitions proffered as well as its levels. It is interesting to note that most times, biodiversity is relatively considered to be a new concept but its first prominence was in the 1980s. It is an abstract and extraordinarily complex concept that is often used in the current public policy to explain issues regarding the biotic components in our environment.

Several specialists in different fora have proffered various definitions, which present biodiversity not simply about animal populations or conservation, but as an umbrella-style political approach to the interactions between human populations and the environment. More often than not, it is simply used as a proxy description of habitat or wilderness; when the phrase ‘biodiversity loss’ is used, it is more often than not a description of habitat loss or deforestation.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- explain the origin of biodiversity
- define biodiversity.

3.0 MAIN BODY

3.1 Historical Perspectives

The term ‘biological diversity’ was used first by wildlife scientist and conservationist Raymond F. Dasmann in the 1968 lay book “A Different Kind of Country” advocating conservation. This term was widely adopted only after more than a decade when in the 1980s it came into common usage in science and environmental policy. Thomas Lovejoy, in the foreword to the book “Conservation Biology”, introduced the term to the scientific community. Until then the term “natural diversity” was quite common, introduced by The Science Division of The Nature Conservancy in an important 1975 study, The Preservation of Natural Diversity”.

By the early 1980s, Robert E. Jenkins, Lovejoy, and other leading conservation scientists at the time in America advocated the use of “biological diversity”. The term’s contracted form ‘biodiversity’ may have been coined by W. G. Rosen in 1985 while planning the 1986 National Forum on Biological Diversity organised by the National Research Council (NRC). Biological diversity first appeared in a publication in 1988 when entomologist E. O. Wilson used it as the title of the proceedings of that forum.
From the period earlier referred to, the term “biological diversity” has achieved widespread use among biologists, environmentalists, political leaders, and concerned citizens. A similar term in the United States is ‘natural heritage’. It predates the others and was more accepted by the wider audience interested in conservation. Natural heritage is broader than biodiversity because it includes geology and landforms (geodiversity).

3.2 Definitions of Biodiversity

‘Biological diversity’ or ‘biodiversity’ can have many interpretations. These interpretations vary from one biologist, conservationist or ecologist to another, and a definition of biodiversity that is altogether simple, comprehensive, and fully operational is unlikely to be found. Some scientific definitions used by resource managers and ecologists and which can help to develop an understanding of the broad concept of biodiversity, have been identified and were presented as:

- The variety and variability among living organisms and the ecological complexes in which they occur.
- The full range of variety and variability within and among living organisms and the ecological complexes in which they occur, and which encompasses ecosystem or community diversity, species diversity and genetic diversity.

- The variety of life and its processes including the variety of living organisms, the genetic differences among them, and the communities and ecosystems in which they occur.
- The totality of genes, species, and ecosystems in a region.

These various definitions, amongst others, seem to describe in different manners in most circumstances and present a unified view of the traditional levels at which biological variety has been identified.

4.0 CONCLUSION

Everything in an ecosystem is part of the web of life. When we try to pick anything out by itself, we find that it is hitched to others. The various species, carrying different genetic components interact and depend upon one another for what each offers. These differences are identified in their characteristics, needs, and locations.

SELF-ASSESSMENT EXERCISE

What are the Resources that affect agriculture?

5.0 SUMMARY

In this unit you have learnt that:

- The term biodiversity as a concept seems new but has its historical background.
- The definition of biodiversity has different perspectives depending on the school of thought from which this being viewed.
- Biodiversity is defined in a way as the variety and variability among living organisms and the ecological complexes in which they occur.
- Levels of biodiversity include genetic diversity, species diversity and ecosystem diversity.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the origin of biodiversity.
2. Define biodiversity

7.0 REFERENCES/FURTHER READING

Leveque, C. & J. Mounolou (2003) Biodiversity. New York: John Wiley. ISBN 0-470-84957-6.

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UNIT 2 MEANING OF BIOLOGICAL DIVERSITY

CONTENTS

1.0 INTRODUCTION

Biodiversity refers to the wide variety of ecosystems and living organisms: animals, plants, their habitats, and their genes. It is crucial for the functioning of ecosystems that provide us with products and services without which we couldn’t live. Biodiversity is everywhere. The breadth of the concept of biodiversity reflects on the interrelationship of genes, species, and ecosystems. Our planet supports between 3 and 30 million species of plant systems, animals, and fungi, single-celled prokaryotes such as bacteria, and single-celled eukaryotes such as protozoans. Of this total biological system, only about 1.4 million species have been identified and named so far. A little more than half the named species are insects which normally dominate terrestrial and freshwater communities worldwide.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- define biodiversity
- discuss in details biodiversity.

3.0 MAIN CONTENT

3.1 Meaning of Biological Diversity

- Biodiversity is the variability among living organisms from all sources, including terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems.
- Biodiversity forms the foundation of the vast array of ecosystem services that critically contribute to human well-being.

- Biodiversity is important in human-managed as well as natural ecosystems.
- Decisions humans make that influence biodiversity affect the well-being of themselves and others.

Biodiversity is defined as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems." The importance of this definition is that it draws attention to the many dimensions of biodiversity. It explicitly recognises that every biota can be characterised by its taxonomic, ecological, and genetic diversity and that the way these dimensions of diversity vary over space and time is a key feature of biodiversity. Thus only a multidimensional assessment of biodiversity can provide insights into the relationship between changes in biodiversity and changes in ecosystem functioning and ecosystem services. Given that cultivated systems alone now account for more than 24% of Earth's terrestrial surface, any decision concerning biodiversity or ecosystem services address the maintenance of biodiversity in these largely anthropogenic systems. Features allowing for a high diversity of ungulate species are as follows:

- The system is spatially very diverse, with animals using different parts at different times.
- It is an open system, into and out of which there is considerable movement of migratory species. On the 100 km2 of the central Savuti grassland, animal numbers vary annually from virtually zero (for all species) to 16,500 zebra, 2,500 buffalo, 1,500 Tsessebe, and 600 wildebeest. Zebra and buffalo are there during the rainy season and Tsessebe during the dry season, while wildebeest are more variable. Elephant numbers can be high, depending on the availability of surface water.
- The strength of biological interactions is variable and often weak. Feeding overlap and resource competition between species are impossible to estimate, due either to species moving out of the area or to sudden influxes of large numbers of other ungulates. Predation is opportunistic; environmental conditions are never constant for long enough to permit strong biological interactions to develop.
- The system is driven by external, episodic events, e.g. the supply of surface water in the Savuti Channel, drought, fire, and disease.

3.1.1 Assessment of Biodiversity

A key feature of biodiversity assessment is the very duality of its nature. If we consider the species and ecosystems in a given region, the first viewpoint is to examine the geographical distribution and the ecological niche of each species; a second is to study the various ecosystems and characterise their floristic composition and structure. To address this duality, the following approaches are carried out at the FIP and are being integrated under Geographic Information Systems (GIS).

1. The habitat/ecosystem oriented approach

This approach is derived from biogeography and phytoecology and was the cornerstone of the ecological mapping programme initiated in the late 50s by the FIP. It consists in studying and classifying vegetation about ecological conditions (climate and soil), characterising the species composition, structure, and physiognomy of the vegetation units, in analyzing their dynamics and succession under 'natural' and 'disturbed' regimes. The ultimate outputs of this approach are the following vegetation and land use maps, along with floristic lists attached to each vegetation type.

2. Regional level (Scale: 1/250,000)

Forest map of South India (published by the French Institute, and the Karnataka, Kerala and Tamil Nadu Forest Departments – 1982, 1984, 1997).
Area covered: From Kanyakumari to Goa
Main theme: Vegetation types (based on phenology, physiognomy, floristic associations and ecology). 154 unique habitats are identified and classified according to their ecology and degradation Stages. Other layers: plantations (forest and commercial) hydrography, transport, settlements, forest administrative units and PA network).

3. The species oriented approach

This approach is in the direct lineage of taxonomic and botanical studies. It is best illustrated by the *"Atlas of Endemic Plants of the Western Ghats"* published by the FIP (Ramesh & Pascal 1997).

The species-oriented approach consists in collecting information on the location of the species from various sources: herbaria, literature, and field surveys. This information may be extended to include the ecological conditions (bioclimate, soil, altitude, topography) and the type of ecosystems in which the plant is encountered, the role it plays in these ecosystems, as well as its biological traits (morphology, architecture, growth, and reproductive strategy). The ultimate goal is to have a sort of 'identity card' for each species. This information is most crucial for rare and endangered species in the perspective of their *in situ* conservation.

1. GIS to integrate both approaches

Both of the above approaches end with large sets of spatial information and especially with maps. A major issue is to ensure the consistency of this information and to recombine it according to various viewpoints. To perform this, different 'layers' of GIS data have been created using Arc/Info to generate the following information:

- Vegetation physiognomy and human pressures (deduced from the density of population or road network) to assess disturbance levels
- The spatial distribution of several species to determine biodiversity 'hotspots'
- Past and present maps for monitoring land cover and land use changes.

Conservation value maps using biodiversity indicators (richness, diversity, endemicity, uniqueness etc.) to prioritise the area for conservation and management.

3.2 Developing an information system to prioritise biodiversity conservation areas and management zones

Developing a good strategy requires a highly reliable and meaningful information system at different levels. In the wide field of biodiversity, the French Institute of Pondicherry (FIP) research programmes have been focusing for about four decades on species and ecosystem diversity at the local (i.e. stand and community), landscape and regional levels. The Institute has been concentrating on plant ecology with a strong emphasis on trees and forests, from open woodland to dense moist evergreen forests, considering their present status as well as their long-term history. Geographically speaking, most of the studies are being carried out in the western ghats and some projects in the eastern ghats and mangroves.
The biodiversity-related programmes of the FIP could be listed under two main headings: 'assessment of biodiversity' and 'monitoring the dynamics of biodiversity'. These programmes are being carried out in collaboration with Forest Departments in Karnataka, Kerala, Tamil Nadu and Andhra Pradesh, the School of Environmental Sciences (JNU), the Kerala Forest Research Institute, the Centre for Ecological Sciences (IISc), the Salim Ali School of Ecology (Pondicherry University) and the National Remote Sensing Agency (Department of Space).

Monitoring the dynamics of biodiversity

Biodiversity assessment has the following outputs: lists of species, sets of values for several diversity indices and land use and vegetation maps. More often these statistics bear no meaning by themselves. Their significance depends more on their absolute and relative variations over space and time. Thus, it is crucial not only to study the biological diversity but also

i. To monitor it about factors (ecological, human, and social), which influence its dynamics, and
ii. To study the processes (biological, ecological, human, and social) that govern its evolution.

Land use and land cover changes

The first step in monitoring changes in biodiversity consists in comparing successive observations. At the local level, this can be done by observing the appearance and disappearance of species: it requires that the same sites be sampled on several occasions. To observe this, two permanent plots have been set up in the Biligirirangan hills (3.5 ha) and the Kadamakal RF (28 ha), both in Karnataka. In addition to these, initial data have also been collected from one hundred 1-ha permanent plots, established by the Karnataka Forest Department in the Karnataka, part of the western ghats.

At the regional and landscape levels, this can be done using past and present land cover and land use maps. The joint development of satellite imagery, image analysis techniques, and GIS has opened avenues for such studies. At the regional level, such studies are being carried out for the entire western ghats of Karnataka and at the landscape level, it was done for the Agastyamalai area, which is one of the 'super hotspots' in the southern western ghats.

Ecosystem uses and forest products

Understanding changes in biodiversity requires the analysis of the processes that are at play. The first major set of processes is constituted by those related to human activities, especially the direct exploitation of the ecosystems and species. This is where the social sciences play a key role: the land tenure system, the representation of ecosystem and species and the sacred and economic values of the resources are important factors to explain the changes.

To understand the processes and to assess the impact of anthropogenic activities on biodiversity, the following work is being carried out in the Kodagu district of Karnataka:

- Impact of extension of coffee and cardamom plantations
- Assessment of biodiversity and disturbance gradient

- Modelling of the sacred grove system using the Multi-Agent System.

Forest dynamics

Biological processes and ecological factors temporally govern plant demography and constitute a major set of processes, which have a strong influence on changes in biodiversity. It is thus important to analyze, in 'natural' and 'disturbed' conditions, how the plants regenerate, grow and die when they interact with each other. Such studies are best carried out at the local level in large permanent plots where the environmental conditions can be described.

Since the mid-80s, the FIP has been monitoring such plots in the low-elevation wet evergreen forests of the Kadamakal Reserved Forests in Karnataka, comparing an unlogged compartment to a once-selectively-logged compartment, analyzing the spatial variation of diversity according to topographical heterogeneity, studying silvigenesis, tree regeneration and growth strategy concerning environmental factors and monitoring phenology

4.0 CONCLUSION

Everything in an ecosystem is part of the web of life. When we try to pick anything out by itself, we find that it is hitched to others. The various species, carrying different genetic components interact and depend upon one another for what each offers. These differences are identified in their characteristics, needs, and locations. Biodiversity assessment was also discussed in this unit.

SELF-ASSESSMENT EXERCISE
What is the threat to Biodiversity?

5.0 SUMMARY

In this unit you have learnt that:

- The term biodiversity as a concept seems new but has its historical background.
- The definition of biodiversity has different perspectives depending on the school of thought from which this is being viewed.
- Biodiversity is defined in a way as the variety and variability among living organisms and the ecological complexes in which they occur.
- Levels of biodiversity include genetic diversity, species diversity and ecosystem diversity.

- Assessment of biodiversity can be assessed through the habitat/ecosystem oriented approach, regional level, the species oriented approach, and the GIS to integrate both approaches.

6.0 TUTOR-MARKED ASSIGNMENT

1) Define biodiversity.
2) Discuss the biodiversity assessment approaches.

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UNIT 3 TYPES AND USES OF BIODIVERSITY

CONTENTS

1.0 INTRODUCTION

Efforts have been made in the previous units to define the concept of biodiversity and in this unit, you will learn about the types and uses of biodiversity. This knowledge is meant to prepare you to appreciate the nature of biodiversity and how you would be in the position to manage it in the Nigerian environment.

2.0 OBJECTIVES

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

- explain the types of biodiversity
- discuss the uses of biodiversity
- explain biodiversity loss.

3.0 MAIN CONTENT

3.1 Types of Biodiversity

There are three main types of biodiversity. These are genetic, species and ecological biodiversity.

3.1.1 Genetic diversity

It refers to the variation of genes within the species. This constitutes a distinct population of the same species or genetic variation within the population or varieties within a species.

3.1.2 Species diversity

It refers to the variety of species within a region. Such diversity could be measured based on the number of species in a region.

Measurement of Species Diversity

The assessment of biodiversity in a given ecosystem depends on making detailed inventories of species and varieties. This is a stupendous task. The National Academy of Sciences, USA has estimated that at least a fivefold increase in the number of systematists will be needed than at present to deal with a sizeable proportion of the diversity still existing, particularly in tropical forests. According to one estimate, out of the 10 million species existing, only 1.5 million have been described so far.

The measurement of species diversity is essentially a statistical problem on which several research papers have been published. For instance, Fager20 computed a *number of moves index* of diversity from a given sample on observed frequencies of a set of species in a given community which is scaled to give a value between 1 and 0. Patil and Taillie21 suggested an *average variety index*, based on ranks, as a population diversity measure that increases with the addition of a new species. Lyons and Hutcheson22 developed a large-sample distribution of the underlying statistics for the number of moves index of diversity and found it to be approximately normally distributed when species1 frequencies are asymptotically normal. However, for exact small-sample moments, Monte Carlo methods are used on high-speed computers.

With the advent of molecular genetics, data on diversity are being collected at an unprecedented rate by DNA sequencing. A global effort to survey genetic diversity among the world’s human population is underway, led by Luca Cavalli-Sforza of Stanford University.

The project, known as *Human Genome Diversity Project* (HGDP), envisages preparing cell lines and DNA from blood, hair, or saliva samples taken from anonymous individuals in different populations across the globe, particularly those populations which have been geographically isolated or have a distinct culture and language. DNA sequences at a few dozen carefully chosen sites along the genome in individuals from every population will be compared. The resulting information – which sequence variables occur at each site in each population, and how prevalent each one is – can be used to infer degrees of relatedness and construct genealogical trees.

3.1.3 Ecological diversity

Ecological bio-diversity is the intricate network of different species present in the local ecosystem and the dynamic interplay between them. An ecosystem consists of organisms from many different species living together in a region that are connected by the flow of energy, nutrients, and matter that occurs as the organisms of different species interact with one another.

The World Conservation Monitoring Centre recognised 17 megadiverse countries in July 2000 including Australia, Brazil, China, Colombia, Democratic Republic of the Congo (DRC) (formerly Zaire), Ecuador, India, Indonesia, Madagascar, Malaysia, Mexico, Papua New Guinea, Peru, the Philippines, South Africa, the United States of America (USA) and Venezuela. Together, these 17 countries harbour more than 70% of the earth's species. Some of the very valuable "gene pool" from these countries have been identified and they have been utilised for the built-up of modern agriculture and allied business.

3.2 Uses of Biodiversity

Biodiversity is important to humans for many reasons. Biodiversity is also considered by many to have intrinsic value—that is, each species has a value and a right to exist, whether or not it is known to have value to humans. The biodiversity book by the Commonwealth Scientific and Industrial Research Organisation (CSIRO; Morton & Hill 2014) describes 5 core (and interacting) values that humans place on biodiversity:

1) **Economic**—biodiversity provides humans with raw materials for consumption and production. Many livelihoods, such as those of farmers, fishers, and timber workers, are dependent on biodiversity.
2) **Ecological life support**—biodiversity provides functioning ecosystems that supply oxygen, clean air, and water, pollination of plants, pest control, wastewater treatment and many ecosystem services.
3) **Recreation**—many recreational pursuits rely on our unique biodiversity, such as birdwatching, hiking, camping, and fishing. Our tourism industry also depends on biodiversity.
4) **Cultural**—the Australian culture is closely connected to biodiversity through the expression of identity, spirituality and aesthetic appreciation. Indigenous Australians have strong

connections and obligations to biodiversity arising from spiritual beliefs about animals and plants.

5) **Scientific**—biodiversity represents a wealth of systematic ecological data that help us to understand the natural world and its origins.

Any loss or deterioration in the condition of biodiversity can compromise all the values outlined above and affect human wellbeing. The Millennium Ecosystem Assessment in 2005 was the first global effort to examine links between human wellbeing and biodiversity. The assessment found benefits to societies from biodiversity in material welfare, security of communities, the resilience of local economies, relations among groups in communities, and human health. It also emphasised the term 'ecosystem services' under 4 broad categories:

- Provisioning services—the production of food, fibre and water
- Regulating services—the control of climate and diseases
- Supporting services—nutrient cycling and crop pollination
- Cultural services—such as spiritual and recreational benefits.

In summary, the uses of biodiversity can also be expressed as;

3.2.1 Food and Shelter

Biodiversity is very important in the provision of food, fuel, and fibre for domestic consumption while it equally serves as materials for shelter and other buildings. Apart from those managed within the ecosystem, a lot more growth in the wild.

3.2.2 Environmental Maintenance

Biodiversity helps in the detoxication and decomposition of water, stabilisation, and moderation of earl climate. To an extent also, moderation of floods, control of drought, temperature, and extremes of force of wind is another role played by biodiversity.

3.2.3 Agriculture

Biodiversity plays an important role in the generation and renewal of soil fertility including, the nutrient cycle which results from its decomposition. Biodiversity is responsible for the pollination of plants including many crops and also, in the control of pests and diseases. The maintenance of genetic resources as a key input to crop varieties and livestock breeds, medicines, and other products is attributed to biodiversity.

3.2.4 Forest Products

An estimated harvest of 50,000 to 70,000 plant species is used for traditional and modern medicine worldwide. About a 100million metric tonnes of aquatic life, including fish, mollusks, and crustaceans are taken from the wild every year. So also, meat from wild animals forms a critical contribution to food sources.

3.2 Loss of Biodiversity

With the current rate of development, population growth and migration communities are increasingly unable to meet their sustained needs. However, the present-day drastic changes in the environment and habitat due to population explosion and unmanaged developmental activities are so unnatural that the species are not getting full liberty of time and space for their survival and adaptive radiation, therefore, resulting in loss of biodiversity, which is a global crisis. It is high time that our natural wealth is preserved from loss.

3.2.1 Threats to Biodiversity

The diversity in India i.e .forests, grasslands, wetlands, mountains, deserts and marine ecosystems face many pressures. One of the major causes for the loss of biological diversity in India has been the depletion of vegetative cover to expand agriculture. Since most of the biodiversity-rich forests also contain the maximum mineral wealth and also the best sites for water impoundment, mining and development projects in such areas have often led to the destruction of habitats. Poaching and illegal trade of wildlife products have adversely affected biological diversity.

3.2.2 Causal factors of threat

Causal factors of threat may be natural or man-made, they are;

1) Development pressure
    - Construction
    - Forest-based industries
    - Hydel/Irrigation projects
    - Mining
    - Oil drilling
    - Pollution
    - Resource extraction
    - Road &
    - Transport
2) Encroachment

- Agriculture
- Expansion of forest villages
- Fishery d. Grazing/increased domestic animals
- Habitat depletion/change
- New settlements
- Shifting cultivation

3) Exploitation
   - The collection made by scientific/educational institutions
   - Exploitation by local authorities as revenue resources
   - Firewood collection
   - Food gathering and hunting
   - Poaching
4) Human-induced disasters
   - Floods
   - Major oil spills/leakage
   - Epidemics
   - Forest fires
5) Management of Natural resources
   - Genetic uniformity
   - Inadequate water/food for wildlife
   - Increased competition
   - Introduction of exotic species
   - Predation
6) Management of Human Resource
   - Change in people's lifestyle
   - Increasing demands
   - Dilution of traditional values
   - Human harassment
   - Inadequate trained human resources
   - Lack of effective management
   - Inappropriate land use
7) Political and policy issues
   - Change in use / legal status
   - Civil unrest
   - Intercommunity conflict
   - Military activities

4.0 CONCLUSION

We have stressed that types of biodiversity include genetic diversity, species diversity, and ecological diversity. The uses of biodiversity have been categorised into the provision of food and shelter, maintenance of the environment, enrichment of soil fertility for agriculture and forest products, and the loss of biodiversity, threats to biodiversity, and causal factors are well explained.

SELF-ASSESSMENT EXERCISE

What are Community and Ecosystem Diversity?

5.0 SUMMARY

Having gone through this unit, it is expected that you should be able to explain;

- The types of biodiversity.
- Biodiversity is useful in the provision of food and shelter, agriculture, environment, and forest products.
- The loss of biodiversity, its threat, and causal factors

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain three types of biodiversity
2. Discuss the uses of biodiversity within the Nigerian ecosystem
3. Discuss in details loss in biodiversity, its threats, and causal factors.

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UNIT 4 BIODIVERSITY ON THE FARM

CONTENTS

1.0 INTRODUCTION

A major tenet of sustainable agriculture is to mimic diversity that is commonly found in natural ecosystems but may be lost in agricultural terrain. Biodiversity refers to the variety of plants, animals, and microorganisms above and below the soil that interacts within an ecosystem. Plants and animals are consistently integrated into diverse landscapes. As a result, these systems are typically more stable, withstanding disturbances, and recovering better than less diverse systems. Organic cropping systems promote a diverse, balanced ecosystem as a practice to enrich the soil and prevent weed, insect pests and disease problems. Crop diversity, crop rotations, intercropping, cover cropping, conservation tillage, and incorporation of organic matter are all important components of farm biodiversity.

2.0 OBJECTIVE

By the end of this unit, you will be able to:

- explain biodiversity on the farm.

3.0 MAIN CONTENT

3.1 Biodiversity on the farm

Biodiversity is the variability among living organisms from all sources, including terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems.
Benefits of encouraging diversity on the farm

- Improves soil quality
- Enhances insect, weed and disease control
- Encourages beneficial organisms
- Spreads economic risk.

3.1.1 Benefits of Diverse Cropping Systems

1.0 Improves Soil Diverse

Crop rotations improve soil, increase farm biodiversity and boost crop yields. High-quality soils encourage dense populations of microorganisms, enhance natural biological control of pathogens, the slow turnover of nutrients, encourage communities of beneficial insects and improve soil aeration and drainage. Crop rotations, management of crop residues, conservation tillage, incorporation of animal manures, and the use of nitrogen-fixing crops can increase soil health and productivity.

2.0 Breaks insect, disease, and weed cycles

Diverse plantings often decrease insect pest populations. Specialised herbivores are more likely to find and remain on pure crop stands where food sources are concentrated. Fields containing a variety of crops are often rich in above- and below-ground beneficial organisms that naturally control insects, inhibit growth of disease organisms, boost a crop's natural defenses and suppress some weeds. The use of crop diversity, crop rotations, scattered fields, adjacent uncultivated land and a perennial crop component are methods that can be used to reduce pest pressure.

3.0 Encourages beneficial organisms

Planting crops that support natural enemies or directly inhibit insect attack helps to stabilise insect communities. Spatially and temporally diverse plantings ensure that natural enemy populations are provided continuous availability of resources. Beneficial insects can also be provided food and habitat by including areas of adjoining, uncultivated land and wild vegetation. Further, using ground covers and surface residues can enhance the abundance and efficiency of predators and parasitoids.

4.0 Spreads economic risk

Increasing farm diversity offers the opportunity to increase profits while decreasing production costs. Adding new crops that fit the climate, geography, and management requirements can increase profits by providing the opportunity to exploit niche markets, expand marketing opportunities and offset commodity price swings.

3.1.2 Strategies for increasing biodiversity:

- Plant crop mixtures and multiple crop varieties.
- Include beneficial flowers, perennials, hedgerows or areas of uncultivated land.
- Provide nesting areas for pollinators.
- Incorporate cover crops.
- Reduce tillage.
- Increase organic matter.

3.1.3 How to Increase On-Farm Biodiversity

1.0 Diversify plant species

Increasing within-field biodiversity can be achieved through planting crop mixtures and multiple crop varieties. The establishment of diverse plantings at field margins should also be considered. Planting strips of beneficial flowers, incorporating perennials, establishing hedgerows (a row of trees or shrubs separating fields), and leaving areas of land uncultivated are methods of increasing diversity on non-cropped land. To increase the diversity of native pollinators, establish nest blocks and allow access to areas of soil, such as soil piles, for nesting. Branches of trees and shrubs, such as those in hedgerows, will also provide nesting sites for pollinators.

2.0 Crop rotation

Crop rotation refers to the sequence of crops and cover crops grown in a specific field. Rotation designs should include multiple crop families, manage short- and long-term crop fertility needs, reduce weed pressure, disrupting weed and disease cycles and optimise crop production.

3.0 Intercropping

Two or more crops grown close can produce beneficial interactions. Intercropping can be achieved by growing crops in alternating rows (row intercropping), growing crops in larger alternating strips (strip intercropping), growing crops together with no distinct row arrangement (mixed intercropping) or by planting a second crop into a standing crop at the reproductive stage (relay intercropping). Special attention should be given to the spatial arrangement, plant density, and expected maturity dates of selected crops.

4.0 Cover crops

Cover crops are used to protect the soil from erosion during times when a field is not under production. Crops that are easy to plant, establish and control or kill should be selected. Suitable varieties provide reliable ground cover and have no negative impact on the following crop. It is important to evaluate the rooting depth and crop characteristics, such as weed and disease suppression, nitrogen fixation, and the attraction of pollinators and natural enemies. Planting dates and climate requirements are also important for consideration, as suitable crops vary by geography and climatic conditions.

5.0 Conservation tillage

Conservation tillage requires minimal soil disturbance, keeping at least 30 percent of the soil covered by crop residue. After harvest, crop residues are left or cover crops are established until the next crop is planted. Several methods of conservation tillage have been established. No-till planting uses specialised equipment, disturbing only a small area where the seed or transplants are set. Strip- or zonetillage creates a tilled seedbed 5 to 7 inches wide along the plant-rooting zone, leaving the rest of the field undisturbed. Ridge-tillage creates permanent soil ridges on top of which crops are grown.

6.0 Incorporation of organic matter

Increasing organic matter provides harbors for soil microbes and intensifies soil biological activity, helping to lessen the risk of disease. The breakdown of organic matter by soil microbes returns nutrients to the soil removed during crop production. Animal manures, cover crops, crop residues and organic amendments can be incorporated into the soil to increase organic matter content over time.

3.2 Assessing Genetic Diversity in Natural Populations

The technique of *gel electrophoresis* enables us to measure genetic variation in a natural population by sampling about 50 or more individuals and identifying the genotypes of each individual in respect of about 20 or more genes coding for an equivalent number of proteins or enzymes. The frequency of heterozygotes for each gene is first determined and then the average heterozygosity for all the genes in the sample is calculated.

Several scientists working in different laboratories have measured genetic variation in several organisms using this technique. Reliable estimates of average heterozygosity are now available for more than 100 species of plants and animals. A great deal of genetic variation is found in most natural populations of sexually reproducing organisms. On average, invertebrate organisms are heterozygous at about 13 per cent of their loci. On the other hand, vertebrates are less polymorphic, being heterozygous for about 6 per cent of the loci. On average, human beings are heterozygous for about 6.7 per cent of the loci. Plants, on the contrary, show a rather high degree of heterozygosity.

In addition to the enzyme or protein polymorphism, recent advances in biotechnology have enabled use of new types of polymorphisms discovered at the DNA level. Bacterial restriction endonucleases, which cleave DNA at sequence-specific sites, break down a very long DNA molecule into small fragments. If the variation in the DNA sequence at a particular locus is such that one of the variants is cleaved by a restriction enzyme and the other is not, then the variant that is not cleaved at that locus will be associated with a longer fragment of DNA. This kind of sequence variation is known as *Restriction Fragment Length Polymorphism* (RFLP). Such markers are found in the coding as well as non-coding regions of the DNA. They are usually biallelic and codominant so that they allow all the three genotypes to be discriminated. Another powerful technique for generating polymorphism is that of the *Polymerase Chain Reaction* (PCR) which requires much less DNA to produce a detectable band on the film. It amplifies a segment of DNA flanked by two specific sequences. It has proved useful in generating markers known as *Random Amplified Polymorphic DNA* (RAPD). Such markers are essentially two-allele loci with presence of the two recognition sequences dominant to absence. At certain loci in the genome, the variation between individuals occurs in the form of a variable number of repeats of a particular sequence of base pairs. For minisatellites or *Variable Number of Tandon Repeats* (VNTR), the repeat unit is of the order of 10 lip and the number of units can be in thousands. Micro-satellites or *Short Tandon Repeats* (STR) or *Simple Sequence Repeats* (SSR) have repeat units of only 2 or 3 bp. Each of the possible numbers of repeats in VNTR or STR represents a different allele. At each locus, therefore, we can have a very large number of alleles. The main method of detecting STR is based on PCR.

The RFLP, RAPD, and hypervariable (VNTR and STR) markers are extremely useful in linkage analysis for mapping of the mutations responsible for hundreds of Mendelian diseases. The RFLP and RAPD markers have also been found useful in the identification of *Quantitative Trait Loci* (QTLs) through correlation between the trait and the marker. In plants and animals, the RFLP maps can be used to select the desired gene combinations indirectly from a breeding population, usually known as *Marker-Assisted Selection* (MAS). It has also been useful in the selection of genotypes in early generations from a segregating population and is being used in breeding improved varieties of several crop plants across the world. The first most notable achievement in this regard has been in tomatoes17 wherein QTLs governing fruit mass and fruit pH have been identified and selected for high solid content.

The high level of genetic variation discovered in natural populations indicates that these populations have plenty of scope for evolution to occur. Whenever a new environmental challenge appears – whether due to climate change or man-made pollution or due to any other cause – the populations are usually able to adapt to it. The evolution of resistance to insecticide in insect species (recently reported in more than 200 species) or heavy metal tolerance in plants or antibiotic resistance in bacteria is proof of this adaption. Further in outcrossing organisms, the high degree of genetic variability provides the genetic basis of individuality. In the case of human beings, for instance, if the genome is taken to consist of 10,000 allelic pairs coding for proteins, the average heterozygosity of 6.7 percent amounts to producing an immensely large number of 10,200 gametes.

Extinction of species

There are two types of extinction of species generally thought to be very rare. Firstly, a plant or animal species could be transformed over several generations into a physically distinct descendant by natural selection. The species gradually adapts to its changing environment. Secondly, there could be terminal extinction as the outright elimination of a species. There have been five such large-scale mass extinctions in the last 500 million years. There is no unanimity in the cause of such mass extinctions. Asteroid impacts are one possibility which coincided with the disappearance of dinosaurs 65 million years ago. In none of these large-scale extinctions, did humans play any role. The Neolithic hunters came on the scene only 10,000 years ago which is not a long time in the history of life. Against this background, the present-day endangered species and depletion of biological diversity is quite a serious matter. With the loss of genetic variability within a species, the pool of genetic resources for further evolution is gradually drained. The loss of every gene, species, or ecosystem limits our options for the future.

4.0 CONCLUSION

Farmers realise the importance of biodiversity more than most—the variety of plants, animals, and microorganisms within an ecosystem, both above and below the soil. That's because farms are ecosystems in and of themselves. The subterranean soil, the animals that live there, and the crops themselves each play an important role in the broader environment. A change within this delicate system can have wide-reaching effects, and farmers understand that the decisions they make on their land must be considered carefully.

SELF-ASSESSMENT EXERCISE

What are the benefits of biodiversity in ecosystems and Aesthetic and Cultural?

5.0 SUMMARY

Having gone through this unit, it is expected that you should be able to explain;

- The biodiversity on the farm.
- Benefits of biodiversity on the farm.
- How to increase on-farm biodiversity.

6.0 TUTOR MARKED ASSIGNMENT

1. Explain biodiversity on the farm.
2. Discuss the benefit of biodiversity.
3. Discuss in detail how to increase on-farm biodiversity.

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MODULE 8 BIO-RESOURCE MANAGEMENT

UNIT 1 BIO-RESOURCE MANAGEMENT

CONTENTS

1.0 INTRODUCTION

In this unit, your attention will be drawn to bio-resource management, how it is done in Nigeria. The country's projections and constraints to management will be considered. It is necessary to note that the continual depletion of plant and animal species and the degradation of ecosystems stemming primarily from economic motives have become an important issue of growing global concern. Despite the unbridled rate of increase in the exploitation of biodiversity globally, the rate of replacement has not been commensurate with use. Thus, the number of threatened and endangered species is increasing. There is a need to preserve their diversity. Focus on the activities of the Nigerian Conservation Foundation will be of great importance.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- define bio-resource management
- explain the status of bio-resource management in Nigeria
- state the purposes of the Nigerian Conservation Foundation (NCF)
- where are the locations of NCF projects?
- state Nigeria projections on bio-resource management
- identify the Nigerian constraints to bio-resource management.

3.0 MAIN CONTENT

3.1 Bio-resource Management

Biological resource means any resource of biological origin. The problem facing at present is the overexploitation of bioresources which would not only have a negative impact on the environment but may also destroy the environment. Therefore, properly handling bioresources in an appropriate way is important for optimum use without overexploitation of our bioresources wealth (Kannaiyan, 1999).

Bio-resource management involves responsible use of our living resources - the natural environment, animals and plants - for both traditional and new applications. Management is an aspect of conservation. It goes hand in hand with adequate planning to control the exploitation of resources and employ judicious use of the resources. The management of bio-resources is an integral aspect of natural resource management which carters for all abiotic wellbeing to sustain biotic components. The edaphic and other environmental conditions must be conducive for bio-resource management to be successful. These conditions include proper waste control and management, especially gaseous emissions which promote global warming – a condition that increasingly supports biodiversity loss.

3.1.1 Bio-resource Management in Nigeria

In Nigeria, the government had set up various agencies to manage natural resources within its territory. Thus, bio-resource management is taken alongside the management of natural resources by

- The Establishment of Conservation Agencies
- National Biosafety Management Agency (NBMA)
- The Forestry Department of the State and Federal Ministry of Agriculture
- The Federal Environmental Protection Agency (FEPA)
- The Rivers Basin Development Authorities
- The Department of Wildlife Conservation
- National Environmental Standards and Regulations Enforcement Agency (NESREA)
- Zoological and Botanical gardens in some Nigeria Universities
- Forestry Research Institute of Nigeria (FRIN)
- The Nigerian Conservation Foundation and Nigerian Game Reserves Authorities.

The Nigerian Conservation Foundation (NCF) is one of the foremost environmental nongovernmental organisation (NGO) in Nigeria today. It was established to achieve the following purposes:

- Saving the country's flora and fauna from extinction
- Protecting the environment from pollution and degradation
- Improving the quality of life of the custodians of our wildlife heritage.

Since its inception, NCF has been deeply involved in specific projects targeted at improving the quality of the Nigerian environment and its management. NCF projects are found in different locations across the nation. These conservation centres include

- ➢ Game Reserves, for the preservation of rare animals, like
- Yankari Game Reserve in Bauchi State
- Borgu Game Reserve in Niger State
- Kainji Game Reserve in Niger State
- Obudu Cattle Ranch in Cross River State
- Okomu Sanctuary in Edo State
- ➢ Forest Reserves, for the preservation of plants and trees, like
- Olomu Forest Reserve in Kwara State
- Milki Hill Forest Reserve in Enugu State
- Zamfara Forest Reserve in Zamfara State
- Shaha River Forest in Ogun State
- ➢ The centres which protect the environment alongside biotic components are;
- Hadejia-Nguru Wetland Conservation project
- Kano Desertification Control Project, etc.

These projects still need support –financially, technically, etc for sustenance.

3.2 Nigerian Projections on Bio-resource Management

In practice, biodiversity' suggests sustaining the diversity of species in each ecosystem as we plan human activities that affect the use of the land and natural resources. Thus, the Federal Government's policy goal on the conservation of biodiversity is to ensure sustainable use of forest resources and preservation of the many benefits accruing from soil, water, and wildlife conservation for economic development.

Among the current priority programmes in Nigeria are the extension of National Parks and Reserves and the compilation of the flora and fauna of Nigeria. The Nigerian Biodiversity Strategy and Action Plan (NBSAP) reviews the status of biodiversity conservation in Nigeria in an attempt to

fill the gaps identified in the country, study programme, and develops strategies and action plans to bridge the gaps in the conservation effort.
The Government's mission is that Nigeria's rich biological endowment together with the diverse ecosystems would be secured, and its conservation and management assured through appreciation and sustainable utilisation by the Year 2010. Nigeria will continue to be active in the international arena while at the local level infrastructural, human, and institutional capabilities will be developed to ensure equitable sharing of biodiversity benefits over time.

To achieve this goal, the Nigerian strategy will be based on:

a) The inventory, identification, and rehabilitation of all threatened and endangered species of fauna and flora;
b) Increasing the network of protected areas to include all ecosystem types consistent with internationally accepted classification;
c) Promotion and enhancement measures for both in situ and ex-situ conservation through identification, inventories, evaluation, monitoring, research, education, public awareness, and training;
d) Increasing the nation's biodiversity management capability (human, infrastructural, institutional, and technological);
e) The development of economically and culturally sound strategies to combat biodiversity loss;
f) Protection and promotion of policy guidance for bioprospecting and indigenous knowledge (intellectual property right); and
g) The rehabilitation of degraded ecosystems.

The Federal Environmental Protection Agency (FEPA) Act of 1988, amended in 1992, established the agency with the responsibility for protecting and developing the environment in general and environmental technology, including initiation of policy about environmental research and technology. The agency’s duties include:

a) Advising the federal government on national environmental policies and priorities and scientific and technological activities relating to the environment.
b) Preparing periodic master plans for the development of environmental science and technology and advising the federal government on their financial implications.
c) Promoting co-operation with similar local and international organisations in environmental science and technology connected with the protection of the environment.
d) Co-operating with federal and state ministries, local government councils, statutory bodies, and research agencies on matters and facilities relating to environmental protection.

e) Carrying out other activities that are considered necessary or expedient for the full discharge of the functions of the agency outlined in the Act.

The Federal Environmental Protection Agency, just like the river basin development authorities with a framework replicated in different states and local councils across the country, has lofty objectives. However, these institutions lack the structures and support to achieve their set-out objective, which is a major reason accounting for the poor management of soil, water, and other environmental resources across the country.

3.2.1 Constraints to Bio-resource Management in Nigeria

Bio-resource management in Nigeria is of utmost importance and immense support. The major constraints are:

- The dearth of trained manpower.
- Lack of appropriate technology.
- Inadequate funds for implementation.
- Lack of succession plans.
- Political bureaucracies.

4.0 CONCLUSION

Biodiversity is the degree of variation of life forms within a given ecosystem, biome, or an entire planet. It is also a measure of the health of ecosystems. Greater biodiversity implies greater health and as it is in part, a function of climate, it is of great need to be judiciously managed.

SELF-ASSESSMENT EXERCISE

What is the social necessity of efficient management and conservation of Bio-resource?

5.0 SUMMARY

In this unit, you have been exposed to the fact that;

- The management of bio-resources is an integral aspect of natural resource management which carters for all abiotic wellbeing to sustain biotic components
- In Nigeria, the government had set up various agencies to manage natural resources within its Territory.
- The government’s focus is that Nigeria’s rich biological endowment together with the diverse ecosystems would be

secured, and its conservation and management assured through appreciation and sustainable utilisation.

- The duties of the federal environmental protection agency are well enumerated.
- There are many constraints to bio-resource management in Nigeria

6.0 TUTOR MARKED ASSIGNMENT

1) Define bio-resource management
2) Explain the status of bio-resource management in Nigeria
3) State the purposes of the Nigerian Conservation Foundation (NCF)
4) Where are the locations of NCF projects
5) State Nigeria projections on bio-resource management
6) What are the duties of the Federal Environmental Protection Agency
7) Identify the Nigerian constraints to bio-resource management.

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UNIT 2 BIO-RESOURCE LEGISLATION

CONTENTS

1.0 INTRODUCTION

Biological diversity has been defined by the World Wildlife Fund as "the wealth of life on earth, the millions of plants, animals, and microorganisms, the genes they contain, and the intricate ecosystems they help build into the living environment." This means that biological diversity needs to be considered and measured at three distinct levels. First, biological diversity at the species level has to be analyzed across the full range of organisms on the earth, from bacteria and protists through the multicellular kingdoms of plants, animals, and fungi. Second, on a finer scale, it is necessary to study genetic variation within species, both among geographically isolated populations and among individuals within single populations. Third, variation within the biological communities must be detected, as well the interactions among these three levels There is simply not enough money, labour, and expertise to identify, count, and map the distribution of every species in every taxon at a global scale in time frames that can assist current conservation decisions. Thus, conservation biologists have been engaged for some time in attempting to find non-census indicator methods that can rapidly and reliably identify areas with disproportionately high levels of biodiversity.

Uncontrolled logging and tree felling are the order of the day in many parts of the southern states of Nigeria. This carries with it the loss of precious biological diversity. This unit will look at the bio-resource legislations in Nigeria.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- discuss legal status on bio-resource
- explain the bio-resource legislations in Nigeria
- explain ways to protect and conserve biodiversity.

3.0 MAIN CONTENT

3.1 Bio-resource Legislations

There are legislations regarding bio-resource. They are related to private and public property rights. They can define protection for threatened ecosystems, but also some rights and duties (for example, fishing and hunting rights). They define species that must be protected because they may be threatened by extinction. The U.S. Endangered Species Act is an example of an attempt to address the "law and species" issue.

Domestication and plant breeding methods are not new, but advances in genetic engineering have led to tighter laws covering the distribution of genetically modified organisms, gene patents, and process patents. The goals of the Convention on Biological Diversity (CBD), introduced in Rio de Janeiro during the 1992 Earth Summit, are:

a) The conservation of biological diversity,
b) The sustainable use of its components, and
c) The fair and equitable sharing of the benefits arising out of its commercial use.

The convention emphasises the Sovereignty of Nations over their bio-resources and their rights to share in the benefits that accrue from commercialised bio-products, thereby regulating access to genetic resources and ensuring benefit sharing among stakeholders. The overall priority of the Convention on Biodiversity is ensuring global biodiversity conservation and sustainable development.

Biodiverse countries that allow bioprospecting or collection of natural products, expect a share of the benefits rather than allowing the individual or institution that discovers/exploits the resource to capture them privately. Bioprospecting can become a type of biopiracy when such principles are not respected. Sovereignty principles can rely upon what is better known as Access and Benefit Sharing Agreements (ABAs). The Convention on Biodiversity implies informed consent between the source country and the collector, to establish which resource will be used and for what, and to settle on a fair agreement on benefit sharing. Though uniform approval for use of biodiversity as a legal standard has not been achieved in many countries. The most active area of biodiversity prospecting is in the search for medical compounds. In some countries, a large percentage of prescriptions are filled with drugs whose active ingredients are extracted or derived from plants. Examples of some important recent discoveries of plants with medical properties are *Okubakaaubrevilleli*, which exhibits anti-microbial and immune-stimulating activities and *Dysoxylulumlenticellars*, which shows promise in treating cardiac ailments, etc.

3.1.1 Bio-resource Legislation in Nigeria

Without doubt Nigeria is richly endowed with diverse flora and fauna. These vital resources are presently threatened by increased population pressure and intensified human development activities. These activities are of major concern to managers who realise that natural resources are the backbone of industry.

Several laws, regulations and policies have evolved in Nigeria post-independence to address issues related to bio-resource resource ownership, exploitation, protection and management. Though technologies and capabilities are being developed to protect endangered ecosystems, especially watersheds, freshwater and high forests in Nigeria, conservation of biodiversity requires the development and application of appropriate technology, particularly in research, ex-situ conservation, and others. Such technology is not yet operational in Nigeria, though, there are hopes of implementation shortly.

There is no Land Use Policy in the country other than a Land Use Act. States are being encouraged to derive their legislation from the national framework. A national forest and wildlife law is being developed with the involvement of all stakeholders.

There is no forest certification practice in the country. However, public involvement in forest certification is being articulated in the proposed revised policy which will encourage private sector and NGO participation. Issues relating to reports on Nigerian Farmers' Rights Legislation and Policy Database show that there is no legislation found on Patent Laws in Nigeria, neither is there the Plant Breeders' Right Legislation.

3.1.1 Ways to Protect and Conserve Biodiversity

Biodiversity is more than simply the collection of plants and animals on earth; it is about local ecosystems and promoting healthy conditions for organisms to thrive. While protecting the rainforests sounds like a daunting task, there is a lot you can do to promote and preserve local biodiversity at home.

1) Support local farms

Regularly buying from small local farmers at stands or markets helps to keep dollars in the local economy and supports agricultural efforts to conserve biodiversity. When at markets, it is important to know the lingo—'organic' is ideal for you and the planet, but farmers who practice 'Integrated Pest Management' can offer high-quality products with nearly no chemical intervention. Community Supported Agriculture is another great way to eat in-season fresh, local food while also financially supporting local farmers.

2) Save the bees

Bees are important to preserving biodiversity – and they are increasingly under attack from varroa mites. You can help save them by planting nectar-producing wildflowers in your backyard or even building bee boxes for local bees to call home. When embarking on DIY home projects, be mindful about the products you use, as standard backyard pesticides can be harmful or deadly to bees.

3) Plant local flowers, fruits and vegetables

Research the flora, fruits, and veggies native to your area, and plant a variety in your backyard or a hanging garden. To aid in this effort, support local nurseries that specialise in native species. Nurseries can be great sources of information about plant maintenance and care. They should also be able to tell you where they source their plants from—the more local, the better. By supporting local wildlife, you're helping to preserve the biodiversity of your area and support its local ecosystem.

4) Take shorter showers

Biodiversity depends on the abundance of local freshwater. Taking five-minute showers and turning the water off while washing your hands, doing the dishes, or brushing your teeth are all easy ways to conserve water.

5) Respect local habitats

Plants growing in the parks and nature preserves near you often play an important role in preserving the local ecosystem. When you're outdoors, protect local biodiversity by sticking to the walking path or hiking trail. Help your children and pets to do the same!

6) Know the source

Check the products you buy and the companies you support to ensure that your buying habits are not contributing to the destruction of habitat elsewhere. Look for labels such as FSC (Forest Stewardship Council) or Rainforest Alliance Certified. Both organisations are committed not only to the conservation of the Earth's resources but also to advocating for the human rights of the native peoples who inhabit the land many products are sourced from.

4.0 CONCLUSION

There are relationships between law and ecosystems which have been for decades now and they have consequences for biodiversity. Law regarding species is more recent while Laws regarding gene pools have been in existence but were not popular until recent times, mainly due to needs to preserve or conserve. In Nigeria, some of these issues are lacking and those in place lack popular enforcement. Protecting the rainforests sounds like a daunting task, there is a lot you can do to promote and preserve local biodiversity at home.

SELF-ASSESSMENT EXERCISE

What are the challenges and risks of a growing bio-economy?

5.0 SUMMARY

Having gone through this unit, you are aware that:

- Bio-resource legislation can define protection for threatened ecosystems, endangered species as well as some rights and duties.
- There are global agreements committing countries to conserve their biodiversity, develop resources for sustainability and share the benefits resulting from their use.
- Presently, there is no Land Use Policy, no Forest Certification Practice, there is no legislation found on Patent Laws neither is there the Plant Breeders' Right legislation in Nigeria.
- Ways to protect and conserve biodiversity at home is very achievable.

6.0 TUTOR-MARKED ASSIGNMENT

1. Discuss the legal status of bio-resource legislations.
2. Explain the bio-resource legislations in Nigeria.
3. State the ways to protect and conserve biodiversity.

7.0 REFERENCE/FURTHER READING

Adeoti, O. (2007). Challenges to managing water resources along the hydrological boundaries in Nigeria. Water Policy, 9, 105–118

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UNIT 3 APPROACHES TO BIODIVERSITY MANAGEMENT

CONTENTS

1.0 INTRODUCTION

You have been intimated with the concept ‘biodiversity’ particularly, its definitions and benefits to humans and natural endowments. Emphasis has also been placed on effective management of bio-resources with many strategies employed. In this unit, however, efforts will be made to further stress the approaches that are being adopted to control and manage biodiversity.

2.0 OBJECTIVES

It is hoped that at the end of this unit you will be able to:

- discuss in-situ approach
- explain ex-situ approach
- explain restoration and rehabilitation approach
- discuss land-use approach
- discuss policy and institutional approach.

3.0 MAIN CONTENT

3.1 In-Situ Approach

This approach is very popular among ecologists and conservationists who use it to protect habitats and ecosystems. Simply, the approach uses methods and tools to protect species, genetic varieties, and habitats in the wild. It ensures that the cherished varieties or species of plants do not go into extinction. The usefulness of the species not withstanding both the beneficial and the less beneficial are collectively protected.

3.2 Ex-Situ Approach

This approach is concerned with the deliberate and selective removal of plants, animals, and microbial species, and genetic varieties from their original environment. What the agriculturalists and species-orientated biologists do is attributable to this approach. The ultimate goal for the use of this approach is for the maintenance of samples of species.

3.3 Restoration and Rehabilitation Approach

As the name implies, the approach combines the use of the earlier described approaches, that is, insitu and ex-situ to achieve its objective. The combined approaches are used to re-establish species, genetic varieties, communities, populations, habitats and ecological processes. Ecological restoration is concerned with the reconstruction of natural and semi-natural ecosystems on degraded lands.

This approach therefore, includes the reintroduction of most native species, while ecological rehabilitation is concerned with the repair of ecosystem processes.

3.4 Major- Land-Use Approach

This approach is popular with the tools and strategies as used by those in agriculture, forestry, fisheries and wildlife management and tourism. This is because these fields make use of extensive land and in the process incorporate protection, sustainable use, and equity criteria and guidelines as management objectives and practices.

These approaches dominate most landscapes and the near shore coastal zone and so offer the greatest reward for investments in biodiversity management.

3.5 Policy and Institutional Approach

The main focus of this approach is the establishment of easements and the arrangements between public agencies and private interests that are seeking to establish landscape characteristics favourable to biodiversity. The approach works by limiting the use of incentives and tax policies to foster particular land use practices and to create and enforce land tenure arrangements that promote effectiveness and sustainability.

3.6 Multi-stakeholder Approach

Multi-stakeholder processes are an important tool for creating lasting solutions for biodiversity conservation. Essentially, they are a process by which different interest groups – whether they be governments, businesses, agriculturalists, or real estate developers – consult to create a plan to achieve a particular objective. Though multistakeholder processes may vary widely in scope and scale, they have certain elements in common. Typically, they are based on the democratic principles of transparency and participation.

Transparency, as used in a social science context, means that all negotiations and dialogue take place openly, information is freely shared, and participants are held responsible for their actions before, during, and after the process. The ethic of participation recognises that without all stakeholders present, solutions will not accurately address real-life pressures, and thus may not succeed. Rural people, and particularly those who are native to the land where they live (indigenous or aboriginal people), are important stewards of biodiversity (see box: "Indigenous Peoples, Local Communities and Biodiversity"). Unfortunately, very often it is precisely these people who are left out of the conversation over land rights and resource management. Stakeholders who have more capital (business) or prominence (government) frequently overshadow the voices of the rural poor. The people who have lived on the land for many generations hold invaluable storehouses of information about native varieties of plants and animals, microclimates for growing specific crops, and uses of medicinal herbs. Often these same people are dependent upon these resources for survival and have developed complex systems for maintaining the biodiversity that benefits their day-to-day lives.

Indigenous peoples and local communities (ILCs) have a special relationship with nature in general and local plants and animals in particular, which makes them important partners of the Convention on Biological Diversity. Indigenous peoples and local communities have lived in harmony with nature and looked after the Earth's biological diversity for a long time. Their diverse cultures and languages represent much of humanity's cultural diversity. Respect for, and promotion of, the knowledge, innovations, and practices of ILCs will be central to our efforts to save life on Earth. An interesting example to illustrate the important role of indigenous peoples in maintaining biodiversity can be found in the wet tropics of far northeastern Australia. The traditional Aboriginal people of the rain forests, called the Yalanji, have practiced fire management in the wet tropics for thousands of years. As a direct result of creating clearings in the jungle, grazing animals such as the kangaroo and wallabies moved into the forests from the western plain.

The fire management practices of the Yalanji also encouraged the re-growth of different species of plants and fungi in these clearings.

4.0 CONCLUSION

Biodiversity management requires deliberate effort at making the species and varieties of the bioresources in a particular environment. The evolving effective strategies that are being used include the in-situ approach, the ex-situ approach, the restoration and rehabilitation approach, the major land-use approach, the policy, and institutional approach, and the multi-stakeholder approach.

SELF-ASSESSMENT EXERCISE

What are Biosphere Reserves?

5.0 SUMMARY

Having gone through this unit, you should be in the position to acknowledge that:

- In-situ approach uses methods and tools to protect bio-resources in the wild
- Ex-situ approach is concerned with the deliberate and selective removal of plants, animals and microbial species from their original environment
- Restoration and rehabilitation approach includes the reintroduction of most native species and the repair of ecosystem processes
- Major land-use approach incorporates protection, sustainable use and equity criteria and guidelines as management objectives and practices.
- Policy and institutional approach aids the agencies and pirate interests that are seeking to establish landscape characteristics favourable to biodiversity.

6.0 TUTOR-MARKED ASSIGNMENT

1. Distinguish between in-situ and ex-situ approaches in biodiversity management.
2. Explain the restoration and rehabilitation approach of biodiversity management.
3. Explain the multi-stakeholder approach of biodiversity management.

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