THE CONCEPT OF VALUE CHAINS IN AGRICULTURE, CLIMATE ACTION AND ENVIRONMENTAL RESOURCES

GLOBAL ISSUES & LOCAL PERSPECTIVES

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Preface

This book adopts an exegetical approach as well as a pedagogic model, making it attractive agriculture and environmental economics teachers, professional practitioners and scholars. It is eschews pedantry and lays bars the issues in such clarity that conduces to learning. The book elaborates on contemporaneous ***The Concept of Value Chains in Agriculture, Climate Action and Environmental Resources*** issues of global significance and at the same time, is mindful of local or national perspectives making it appealing both to international and national interests. The book explores the ways in which climate change, food security, national security and environmental resources issues are and should be presented to increase the public's stock of knowledge, increase awareness about burning issues and empower the scholars and public to engage in the participatory dialogue climate change, food security, national security and environmental resources necessary in policy making process that will stimulate increase in food production and environmental sustainability.

The Concept of Value Chains in Agriculture, Climate Action and Environmental Resources: Global issues and Local Perspectives is organized in three parts. Part One deals with The Concept of Value Chains in Agriculture, Part Two is concerned with The Concept of Climate Actions and Part Three deals with the Concept of Value Chains and Environmental Resources.

Eteyen Nyong/ Ignatius Onimawo

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Chapter Twenty Five

Resilience and Restoration: Tropical Ecosystems in the Face of Human Impact

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1.0 Introduction to Tropical Ecosystems

The tropical rainforest is renowned as the most biodiverse terrestrial ecosystem on the planet, boasting an unparalleled richness of plant and animal species that surpasses any other ecosystem on Earth (Salami and Akinyele, 2018). It encompasses approximately 40% of the Earth's land surface, are characterized by high temperatures, high levels of rainfall, and exceptionally high levels of biodiversity, hosting more than 50% of the world's plant and animal species (Pitre, 2022). These ecosystems comprise various types, including tropical rainforests, dry forests, savannas, mangrove forests, and coral reefs, each providing habitat for unique and diverse species, regulating the climate, and offering ecosystem services such as clean air and water, soil formation, and pest control (Ayyam., 2019). Moreover, tropical ecosystems support human livelihoods through agriculture, forestry, and tourism, contributing significantly to local and global economies (Baccini., 2020).

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However, tropical ecosystems are facing unprecedented threats, including deforestation, climate change, overexploitation of resources, and pollution, which have far-reaching consequences for biodiversity, ecosystem services, and human well-being (WWF, 2022; Alao and Shuaibu, 2011). The clearance of tropical forests for agricultural purposes, urbanization, and logging has resulted in habitat loss, fragmentation, and degradation, leading to population declines and even extinctions of many plant and animal species (Haddad, 2020). Climate change is exacerbating these impacts, altering ecosystem processes, and disrupting the delicate balance of tropical ecosystems (IPCC, 2021). Furthermore, the overexploitation of resources, such as timber, minerals, and fisheries, is degrading ecosystem services and threatening the livelihoods of local communities (FAO, 2020). In light of these challenges, it is imperative to develop effective conservation and restoration strategies to protect tropical ecosystems and the ecosystem services they provide. This requires a comprehensive understanding of the dynamics of human impact on tropical ecosystems, as well as the development of innovative solutions to mitigate these impacts and promote sustainable management practices (Chazdon, 2020). This study aims to contribute to this effort by investigating the dynamics of human impact on tropical ecosystems and exploring restoration strategies to promote the conservation of these vital ecosystems.

1.1 Definition of Tropical Ecosystem

Tropical ecosystems are found near the equator and are characterized by high temperatures, high levels of rainfall, and high levels of biodiversity. These ecosystems cover approximately 40% of the Earth's land surface and are home to more than 50% of the world's plant and animal species (Rosen, 2000).

Types of Tropical Ecosystems

There are several types of tropical ecosystems, including:

i) **Tropical Rainforests**: These are dense, humid forests that receive high levels of rainfall throughout the year. Examples include the Amazon rainforest and the Congo Basin

ii) **Tropical dry Forests:** These forests are found in areas with a dry season and are characterized by a more open canopy and a greater variety of plant species.

iii) **Tropical Savannas**: These are grasslands with scattered trees and are found in areas with a warm climate and distinct wet and dry seasons.

iv) **Mangrove Forests**: These are coastal ecosystems found in tropical and subtropical regions and are characterized by the presence of mangrove trees.

v) **Coral Reefs**: These are underwater ecosystems found in tropical and subtropical oceans and are characterized by the presence of coral and a diverse array of marine life (El-Regal and Satheesh, 2023)

1.2 Characteristics of Tropical Ecosystems: Biodiversity, Climate, and Vegetation

Tropical ecosystems are characterized by high levels of biodiversity, a warm and humid climate, and a diverse array of vegetation, with features including:

i) **High Biodiversity:** Tropical ecosystems are home to a vast array of plant and animal species, with many found nowhere else on Earth, including iconic species such as orangutans, jaguars, and toucans.

ii) **Warm and Humid Climate:** Tropical ecosystems are found near the equator and are characterized by high temperatures and high levels of rainfall, with average temperatures ranging from 20-30°C and annual rainfall exceeding 2,000 mm.

iii) **Diverse Vegetation:** Tropical ecosystems support a wide range of vegetation types, including tropical rainforests, dry forests, savannas, mangrove forests, and coral reefs, each with unique characteristics and adaptations to the local climate and soil conditions.

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iv) **Complex Forest Structure:** Tropical rainforests, in particular, have a complex structure, with multiple layers of vegetation, including the emergent layer, canopy layer, understory layer, and forest floor, each supporting a unique array of plant and animal species.

v) **High Levels of Endemism**: Tropical ecosystems have high levels of endemism, with many species found only in specific regions or ecosystems, highlighting the importance of conserving these ecosystems to protect unique and threatened species.

vi) **Rapid Growth and Decomposition:** Tropical ecosystems are characterized by rapid growth and decomposition rates, with plants and animals adapting to the warm and humid climate to optimize growth and survival.

vii) **Importance of Disturbance Regimes:** Tropical ecosystems are shaped by disturbance regimes, including natural disturbances such as hurricanes, floods, and droughts, which play a crucial role in maintaining ecosystem diversity and resilience (Tang, Li, Pang, Slate, Giraudoux, Afonso and Zhang, 2024).

1.3 Importance of Tropical Ecosystems: Ecosystem Services, Carbon Sequestration, and Indigenous Communities

Tropical ecosystems are paramount to the planet's ecological integrity, furnishing indispensable ecosystem services, including air and water purification, soil regeneration, and pest regulation (IPBES, 2019), while functioning as a critical carbon sink, with tropical forests alone sequestering approximately 250 billion metric tons of carbon dioxide, equivalent to 30 years of global fossil fuel emissions (Pan, Birdsey, Fang., Houghton, Kauppi., Kurz and Hayes, 2011) and supporting the livelihoods, cultural heritage, and traditional knowledge of indigenous communities, who have maintained a symbiotic relationship with these ecosystems for millennia, relying on them for sustenance, shelter, medicine, and spiritual practices (UNDRIP, 2007; IPCC, 2019), underscoring

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the imperative of conserving and sustainably managing these ecosystems to safeguard biodiversity, mitigate climate change, and promote human well-being. Tropical ecosystems play a critical role in maintaining the health of the planet. They:

i) **Provide habitat for biodiversity**: Tropical ecosystems are home to a vast array of plant and animal species, many of which are found nowhere else on Earth.

ii) **Regulate the climate:** Tropical ecosystems help to regulate the climate by absorbing and storing carbon dioxide and producing oxygen.

iii) **Provide ecosystem services**: Tropical ecosystems provide a range of ecosystem services, including clean air and water, soil formation, and pest control.

iv) **Support human livelihoods:** Tropical ecosystems provide livelihoods for millions of people, including those involved in agriculture, forestry, and tourism.

1.4 Threats to Tropical Ecosystems: Deforestation, Habitat Fragmentation, and Climate Change

a) Deforestation

Deforestation is the clearance of forests, usually as a result of human activities like agriculture, urbanization, and logging. In Nigeria, deforestation is a significant threat to tropical ecosystems, particularly in the Northern Nigeria and Niger Delta region. For example, the clearance of mangrove forests for oil palm plantations has led to the loss of biodiversity and ecosystem services (Adewumi, 2021). The Nigerian government has implemented policies to reduce deforestation, including the National Forest Policy (FRN, 2020), but more needs to be done to address this issue.

b) Habitat Fragmentation

Habitat fragmentation occurs when a large area of habitat is broken into smaller patches, often as a result of human activities like road construction, agriculture, and urbanization. In Nigeria, habitat fragmentation is a significant threat to tropical ecosystems, particularly in the savannas and grasslands. For example, the construction of the Lagos-Ibadan expressway has fragmented habitats and led to the loss of biodiversity (Aransiola, Zobeashia, Ikhumetse, Musa, Abioye, Ijah, and Maddela, 2024). Conservation efforts, such as the creation of wildlife corridors, can help to mitigate the effects of habitat fragmentation.

c) Climate Change

Climate change is a global phenomenon that is having a significant impact on tropical ecosystems. In Nigeria, climate change is altering the distribution and abundance of plant and animal species, and is also leading to changes in ecosystem processes and function (Olaniyi and Omowale, 2022). For example, changes in temperature and rainfall patterns are affecting the growth and yield of crops like maize and cassava, which are important for food security in Nigeria (Adebayo, 2023). Climate change mitigation and adaptation strategies, such as agroforestry and climate-smart agriculture, can help to reduce the impacts of climate change on tropical ecosystems.

d). **Overexploitation of resources**

The overexploitation of resources in tropical ecosystems is a pressing issue, leading to degradation and depletion (Kouassi, Khan, Achille, Omifolaji, and Kebin, 2021). Unsustainable timber harvesting has resulted in widespread deforestation, exacerbating climate change and threatening livelihoods and species (FAO, 2020; IPCC, 2019). Mining and overhunting also contribute to environmental degradation, habitat destruction, and species extinction (WWF, 2020; Ripple, Abernethy, Betts, Chapron , Dirzo, Galetti and Wolf, 2016). A sustainable and equitable approach

to resource management is imperative to mitigate impacts and preserve tropical ecosystems (UNEP, 2020).

e) **Pollution**

Pollution is profoundly impacting tropical ecosystems, triggering changes in soil and water chemistry and declining biodiversity (IPCC, 2019). Atmospheric pollutants from industrial activities, agricultural runoff, and vehicular emissions are acidifying soils and altering nutrient cycles (Kharangate-Lad, 2020). Water pollution from industrial and municipal effluents, agricultural runoff, and mining activities is contaminating freshwater sources, imperiling aquatic life, and undermining human health (WWAP, 2020). The synergistic effects of pollution and climate change are exacerbating ecosystem degradation, with cascading consequences for ecosystem services. To safeguard tropical ecosystems, a multifaceted approach is necessary, encompassing policy interventions, technological innovations, and behavioral change (UNEP, 2020).

2.0 The Impact of human on Tropical Ecosystems

2.1. Deforestation and Land-Use Change: Drivers, and Consequences

Deforestation and land-use change are pervasive issues in Nigeria, with far-reaching consequences for the environment, biodiversity, and human well-being. The drivers of deforestation in Nigeria are multifaceted, including agricultural expansion, urbanization, logging, and infrastructure development (Aiyede, 2020). The conversion of forests to agricultural land, particularly for crops like cassava, maize, and soybeans, has led to widespread deforestation, with an estimated 11.1% of Nigeria's forest cover lost between 1990 and 2015 (FAO, 2020). The consequences of deforestation in Nigeria are severe, including loss of biodiversity, soil degradation, increased greenhouse gas emissions, and negative impacts on local livelihoods. Furthermore, deforestation

has also exacerbated climate change, with Nigeria being one of the countries which is most vulnerable to its impacts. Therefore, it is imperative that the Nigerian government and other stakeholders implement sustainable land-use practices, strengthen forest governance, and promote reforestation efforts to mitigate the effects of deforestation and land-use change.

2.2 Mining and Drilling: Environmental and Social Impacts on Tropical Ecosystems

Mining and drilling activities in tropical ecosystems have devastating environmental and social impacts, threatening the very existence of these fragile ecosystems. The extraction of minerals, oil, and gas has led to widespread deforestation, habitat destruction, and fragmentation, resulting in the loss of biodiversity and ecosystem disruption (WWF, 2020). The release of toxic chemicals, heavy metals, and pollutants into the environment has contaminated water sources, soil, and air, posing significant health risks to local communities and wildlife (UNEP, 2019). Furthermore, mining and drilling activities have also led to social impacts, including displacement of indigenous communities, human rights abuses, and conflict over land and resources. The environmental and social costs of mining and drilling in tropical ecosystems far outweigh any economic benefits, highlighting the need for more sustainable and responsible extractive practices that prioritize environmental protection and social justice.

2.3 Agricultural Expansion:

Agricultural expansion, particularly through monoculture and intensive farming practices, has profoundly impacted tropical ecosystems, leading to widespread deforestation, habitat loss, and ecosystem degradation. The conversion of diverse tropical forests to monoculture crops such as soybeans, palm oil, and sugarcane has resulted in the loss of biodiversity, soil erosion, and water pollution (Carlson and Garrett, 2018). Intensive farming practices, including the use of synthetic fertilizers and pesticides, have further exacerbated these impacts, contaminating soil, water, and

air, and threatening the health and livelihoods of local communities (Padhiary and Kumar, 2024). Moreover, the reliance on monoculture crops has increased vulnerability to pests, diseases, and climate change, highlighting the need for more sustainable and resilient agricultural practices that prioritize ecosystem services, biodiversity, and social equity.

2.4 Urbanization and Infrastructure Development

Urbanization and infrastructure development are rapidly altering tropical ecosystems, leading to widespread habitat destruction, fragmentation, and degradation, with devastating impacts on biodiversity. The expansion of urban areas, roads, and other infrastructure has resulted in the loss of natural habitats, disruption of ecosystem processes, and increased human-wildlife conflict Boakes, Stafford, Bramer, Cvitanović and Hardouin, 2024). Tropical ecosystems, such as forests, wetlands, and coral reefs, are being cleared, filled, or degraded to make way for urban development, leading to the loss of ecosystem services, including air and water filtration, soil formation, and carbon sequestration (Obed and Innocent, 2024). Furthermore, the increased demand for resources, such as water and energy, is exacerbating the impacts of urbanization on tropical ecosystems, highlighting the need for more sustainable and environmentally conscious urban planning and infrastructure development practices that prioritize ecosystem conservation and biodiversity protection.

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Plate 1: Deforestation in Nigeria state
Source: Wikimedia foundation, 2024

Plate 2: Typical Gully cutting in Nanka, Anambra

Source: Chude *et al.*, 2020

Plate 3: *Environmental problems caused by mining*

Plate 4: Agricultural activities

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***Source**: Witchalls, 2022*

3.0 Consequences of Ecosystem Disruption in Tropical Ecosystems

3.1. Loss of Biodiversity: Extinction Risk, Endemic Species, and Ecosystem Resilience

The loss of biodiversity is a pressing global concern, with far-reaching consequences for ecosystem resilience, human well-being, and the planet's ecological integrity. The current rate of species extinction is estimated to be 100 to 1,000 times higher than the natural rate, with many species facing extinction due to human activities such as habitat destruction, pollution, climate change, and overexploitation of resources (IPBES, 2019). Endemic species, which are found only in specific geographic regions, are particularly vulnerable to extinction due to their limited range and adaptability (IUCN, 2020). The loss of biodiversity erodes ecosystem resilience, making ecosystems more susceptible to disturbances, reducing their ability to provide essential services such as air and water purification, soil formation, and climate regulation, and compromising human well-being (MEA, 2005).

3.2 Changes in Hydrological Cycles: Impacts on Water Quality, Quantity, and Human Settlements

Changes in hydrological cycles are having far-reaching impacts on water quality, quantity, and human settlements, particularly in tropical regions. Alterations in precipitation patterns, increased evaporation due to rising temperatures, and changes in land use are disrupting the natural hydrological balance, leading to more frequent and severe droughts and floods (IPCC, 2019). These changes are compromising water quality, with increased sedimentation, nutrient pollution, and contamination from agricultural runoff and urban wastewater (WWAP, 2020). The impacts on human settlements are significant, with changes in water availability and quality affecting human health, food security, and economic development. Furthermore, the increased frequency and

severity of extreme weather events are displacing communities, damaging infrastructure, and straining local resources. Understanding the complex interactions between hydrological cycles, climate change, and human activities is crucial for developing effective strategies to mitigate these impacts and ensure sustainable water management practices that prioritize both human and environmental well-being.

3.3. Soil Erosion and Degradation: Consequences for Agricultural Productivity and Ecosystem Health

Soil erosion and degradation are pervasive problems compromising soil fertility, structure, and function, leading to reduced crop yields, decreased water quality, and increased greenhouse gas emissions (Lal, 2020). Intensive agriculture, deforestation, and climate change are accelerating soil erosion and nutrient depletion in tropical regions (Ghosh and Mandal, 2023). Soil degradation undermines ecosystem services, including carbon sequestration, biodiversity conservation, and water filtration. Implementing conservation agriculture, agroforestry, and soil conservation measures can help mitigate soil erosion and degradation. Sustainable soil management practices prioritizing soil health, conservation, and restoration are crucial for ensuring long-term productivity and health of tropical ecosystems, food security, biodiversity, and human well-being. The impacts of soil erosion and degradation include:

Influence on Agricultural Productivity

Soil erosion and degradation have severe consequences, including reduced crop yields due to decreased fertility, water-holding capacity, and increased soil compaction. Additionally, soil fertility decreases from the loss of essential nutrients, requiring increased fertilizer application, and soil salinization increases, reducing fertility and affecting crop growth, ultimately leading to decreased agricultural productivity, economic losses, and food insecurity.

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Impact on Ecosystem Health

Soil erosion and degradation have severe ecological consequences. The loss of biodiversity occurs as soil biota are depleted, reducing ecosystem services and resilience. Disrupted nutrient cycles also affect ecosystem function, leading to further degradation. Furthermore, soil degradation contributes to climate change by releasing stored carbon and increasing greenhouse gas emissions, creating a self-reinforcing cycle of environmental degradation. These impacts underscore the importance of preserving soil health to maintain ecosystem function and mitigate climate change.

Strategies for Mitigation

Conservation tillage, cover cropping, and integrated soil management practices can mitigate soil erosion and degradation. These strategies promote soil health, fertility, and biodiversity, ensuring sustainable agricultural productivity and ecosystem health. Effective implementation of these practices is crucial for maintaining healthy soils and ecosystems.

Table 1: Distribution of Erosion sites in Southeastern Nigeria

S/No	States	No. of Gully Sites	Condition	Control Measure
1	Anambra	1000	Mostly active	Not successful
2	Abia	300	Some active/some dormant	Not successful
3	Ebonyi	500	Mostly minor gully sites	No records
4	Enugu	600	Some active/some dormant	None
5	Imo	500	Some active/some dormant	Not successful

Source: Chude, Ezendu, Ugadu, and Adiaha (2020)

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3.4. Impacts on Human Health and Livelihoods: Disease, Nutrition, and Economic Well-being

The impacts of environmental degradation and climate change on human health and livelihoods are multifaceted and far-reaching, affecting disease prevalence, nutrition, and economic well-being (Dushyant, 2025).

a) Disease

1. Water-borne diseases: Contaminated water sources increase the risk of water-borne diseases like cholera, diarrhea, and typhoid fever.
2. Vector-borne diseases: Climate change alters the distribution and prevalence of disease-carrying vectors like mosquitoes, ticks, and rodents, increasing the risk of diseases like malaria, dengue fever, and Lyme disease.
3. Heat-related illnesses: Extreme heat events increase the risk of heat-related illnesses, particularly for vulnerable populations like the elderly, children, and those with pre-existing medical conditions (Yadav and Upadhyay, 2023).

b) Nutrition

i) Food insecurity: Climate change and environmental degradation impact agricultural productivity, leading to food insecurity and malnutrition

ii) Micronutrient deficiencies: Changes in dietary patterns and reduced access to nutrient-rich foods increase the risk of micronutrient deficiencies, particularly for vitamins A, D, and E, and minerals like iron and zinc.

iii) Water scarcity: Limited access to clean water exacerbates malnutrition, particularly for children, pregnant women, and individuals with compromised immune systems.

Economic Well-being

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i) Loss of livelihoods: Environmental degradation and climate change impact agricultural productivity, fisheries, and tourism, leading to loss of livelihoods and economic instability.
ii) Increased healthcare costs: The economic burden of environmental health impacts is substantial, with increased healthcare costs, lost productivity, and reduced economic growth.
iii) Food price volatility: Climate-related shocks to food systems lead to price volatility, affecting the affordability and accessibility of nutritious food, particularly for vulnerable populations. (Hossain, Ahmed, Ojea and Fernandes, 2018).

Strategies for Mitigation

1. Climate-resilient agriculture: Implementing climate-resilient agricultural practices, like agroforestry and conservation agriculture, can improve food security and nutrition.
2. Water, sanitation, and hygiene (WASH) interventions: Improving access to clean water, sanitation, and hygiene can reduce the risk of water-borne diseases and improve nutrition.
3. Early warning systems and climate information services: Establishing early warning systems and climate information services can help communities prepare for and respond to climate-related shocks, reducing the risk of disease, malnutrition, and economic instability.

4.0 Restoration Strategies for Tropical Ecosystems

Restoration refers to the process of rehabilitating degraded, damaged, or destroyed ecosystems to their natural state or optimal health. It involves activities like revegetation, habitat reconstruction, soil remediation, and wildlife reintroduction (Salami**.** Akinyele and Odewale, 2014; Society for Ecological Restoration, 2004). The goal is to conserve biodiversity, improve ecosystem services, and enhance ecosystem resilience. Restoration supports human well-being and livelihoods while mitigating climate change. Effective restoration requires a holistic approach, considering ecological, social, and economic factors to ensure sustainable ecosystem recovery.

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4.1. Reforestation and Afforestation Efforts: Success Stories, Challenges, and Policy Implications

Reforestation and Afforestation Efforts

Reforestation and afforestation are critical strategies for restoring degraded forests, promoting biodiversity, and mitigating climate change (Garba., Salami. and Akanbi, 2021)

Success Stories

i) CIFOR, ICRAF, and University of Ibadan collaborated on a workshop on Landscape restoration dynamics and governance for forestry practitioners in Nigeria. Over 50 participants attended, sharing knowledge and experiences. A roadmap and stakeholder network were developed to promote sustainable forest management.

ii) The Forestry Research Institute of Nigeria (FRIN) and the Omo Biosphere Reserve have contributed to Nigeria's restoration efforts. FRIN developed innovative forest restoration technologies, while the Omo Biosphere Reserve serves as a conservation model. Their efforts led to the establishment of over 100,000 hectares of new forests, protecting biodiversity and mitigating climate change.

iii) The Great Green Wall has restored 15 million hectares of land, combating desertification and promoting sustainable land management since its inception in 2007 (GGW, 2020).

iv) Kenya's Green Belt Movement: Kenya has empowered local communities to plant over 50 million trees since 1977.

v) China's Great Green Wall: China has planted over 66 billion trees since 1978, increasing forest cover from 10% to 22%.

vi) India's National Afforestation Programme: India has planted over 2 billion trees since 2000, increasing forest cover by 2%.

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vii) Brazil's Atlantic Forest Restoration: Brazil has restored over 100,000 hectares of degraded forest since 2000.

Challenges

i) **Land tenure and ownership:** Unclear land rights can hinder reforestation efforts.

ii) **Funding and resources:** Reforestation efforts require significant funding and resources.

iii) **Climate change and drought:** Climate change can exacerbate drought conditions, making it difficult for newly planted trees to survive.

iv) **Community engagement and participation:** Reforestation efforts often require community engagement and participation, which can be challenging to achieve.

Policy Implications

i) National and international policies: Governments should establish and enforce policies that support reforestation and afforestation efforts.

ii) Incentives for landowners: Governments can offer incentives, such as tax breaks or subsidies, to encourage landowners to participate in reforestation efforts.

iii) Community-led initiatives: Governments should support community-led reforestation initiatives, which can help ensure local ownership and participation.

iv) Monitoring and evaluation: Governments should establish monitoring and evaluation frameworks to track the effectiveness of reforestation and afforestation efforts. (Thomas, Dargusch, Harrison and Herbohn, 2010).

4.2. Agroforestry and Sustainable Agriculture: Approaches for Maintaining Ecosystem Services

Agroforestry and sustainable agriculture are crucial approaches for maintaining ecosystem services while promoting agricultural productivity and livelihoods. By integrating trees into agricultural landscapes, agroforestry systems can enhance biodiversity, improve soil health, and

reduce erosion, while also providing shade, fuelwood, and other ecosystem benefits. Sustainable agriculture practices, such as crop rotation, organic amendments, and conservation tillage, can further promote ecosystem services by reducing synthetic fertilizer and pesticide use, improving water quality, and supporting pollinators and other beneficial organisms. By adopting these approaches, farmers can contribute to maintaining ecosystem services, including carbon sequestration, water cycling, and soil formation, while also improving their livelihoods and contributing to food security (Nair, 2017).

4.3. Wetland and Coastal Habitat Restoration: Importance for Biodiversity and Human Well-being

Wetland and coastal habitat restoration is crucial for maintaining biodiversity and promoting human well-being. These ecosystems provide essential services, including shoreline stabilization, water filtration, and habitat for numerous plant and animal species. Restoration efforts, such as mangrove reforestation, salt marsh reconstruction, and coral reef rehabilitation, can help to recover degraded habitats, promote ecosystem resilience, and support the livelihoods of communities that depend on these ecosystems. By restoring wetlands and coastal habitats, we can also mitigate the impacts of climate change, reduce the risk of natural disasters, and protect human health and well-being (Sutton-Grier and Sandifer, 2019).

4.4. Community-Led Conservation and Restoration Initiatives: Empowering Local Communities

Community-led conservation and restoration initiatives empower local communities to take ownership of natural resource management, fostering sustainable livelihoods, preserving cultural heritage, and protecting biodiversity (Rytkönen and Hotakainen, 2020). By engaging local communities in decision-making processes, these initiatives promote participatory conservation, build trust, and ensure that conservation efforts align with community needs and values. Successful community-led initiatives, such as community-managed forests, wildlife conservation areas, and

ecotourism projects, demonstrate the effectiveness of collaborative approaches in achieving conservation goals while enhancing human well-being.

5.0 Policy and Community Involvement in Tropical Ecosystem Conservation

5.1. International Frameworks and Agreements: CBD, REDD+, and SDGs

a) Convention on Biological Diversity (CBD)

i) Adopted in 1992, the CBD aims to conserve biodiversity, promote sustainable use of biological resources, and ensure fair and equitable sharing of benefits arising from genetic resources

ii) Key objectives: conservation of biodiversity, sustainable use of biological resources, and fair and equitable sharing of benefits.

b) Reducing Emissions from Deforestation and Forest Degradation (REDD+)

i) Launched in 2008, REDD+ aims to reduce greenhouse gas emissions from deforestation and forest degradation, while promoting sustainable forest management and conservation.

ii) Key objectives: reduce deforestation and forest degradation, promote sustainable forest management, and support conservation efforts.

c) Sustainable Development Goals (SDGs)

i) Adopted in 2015, the SDGs are a set of 17 goals that aim to end poverty, protect the planet, and ensure peace and prosperity for all.

ii) Key objectives: end poverty, protect the planet, ensure peace and prosperity, and promote sustainable development.

d) Implementation and Progress

i) Countries have made progress in implementing these frameworks and agreements, but challenges persist.

ii) Effective implementation requires coordination among governments, civil society, and the private sector.

d) Benefits and Opportunities

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i) These frameworks and agreements offer opportunities for countries to promote sustainable development, reduce poverty, and protect the environment.

ii) Benefits include improved biodiversity conservation, reduced greenhouse gas emissions, and enhanced sustainable development.

5.2. National and Local Policy Initiatives: Protected Areas, Sustainable Forest Management, and Land-Use Planning

National and Local Policy Initiatives

A) Protected Areas

i) Establishment of national parks and wildlife reserves: Protecting biodiversity and ecosystems through the creation of protected areas.

ii) Protected area management: Effective management of protected areas to ensure conservation goals are met.

iii) Community engagement and participation: Involving local communities in protected area management and decision-making processes.

b) Sustainable Forest Management

i) Forest conservation and restoration: Protecting and restoring forests to maintain ecosystem services and biodiversity.

ii) Sustainable forest management practices: Implementing practices like selective logging and reforestation to ensure forest sustainability.

iii) Certification and labelling schemes: Promoting sustainable forest products through certification and labelling schemes.

c) Land-Use Planning

i) Integrated land-use planning: Coordinating land-use planning across sectors to ensure sustainable development and environmental conservation.

ii) Zoning regulations and land-use controls: Implementing zoning regulations and land-use controls to prevent unsustainable land use.

iii) Stakeholder engagement and participation: Involving stakeholders in land-use planning and decision-making processes.

Benefits and Opportunities

i) Conservation of biodiversity and ecosystems: Protecting and restoring natural habitats and ecosystems.

ii) Sustainable development and livelihoods: Promoting sustainable development and livelihoods through sustainable forest management and land-use planning.

iii) Climate change mitigation and adaptation: Reducing greenhouse gas emissions and promoting climate resilience through sustainable land-use practices.

5.3. Community Engagement and Participation: Co-Management, Ecotourism, and Benefit-Sharing

Community engagement and participation are crucial for effective conservation and sustainable development, and can be achieved through co-management, ecotourism, and benefit-sharing initiatives. Co-management involves collaborative decision-making between local communities, governments, and other stakeholders, ensuring that conservation efforts align with community needs and values. Ecotourism provides opportunities for communities to benefit economically from conservation, while promoting cultural exchange and environmental awareness. Benefit-sharing initiatives, such as revenue-sharing from natural resource extraction or tourism, can also help to ensure that communities receive fair compensation for their role in conservation efforts, fostering trust, ownership, and long-term commitment to environmental stewardship (Ogunjobi, Badejo, Meduna, and Halidu, 2010)

5.4. Economic Incentives for Conservation: Payment for Ecosystem Services, Ecotourism, and Sustainable Forest Products

Economic incentives play a vital role in promoting conservation efforts, and initiatives such as Payment for Ecosystem Services (PES), ecotourism, and sustainable forest products have shown promising results. PES programs, which compensate landowners for conserving natural habitats, have been successful in protecting biodiversity hotspots and ecosystem services. Ecotourism, which generates revenue from responsible wildlife viewing and outdoor activities, can create economic benefits for local communities while promoting conservation. Additionally, sustainable forest products certification schemes, such as the Forest Stewardship Council (FSC), provide market-based incentives for responsible forestry practices, helping to reduce deforestation and promote sustainable land-use management (Ogunjobi *et al.*, 2010)

6.0 Emerging Technologies and Approaches in Tropical Ecosystem Conservation

6.1 Remote Sensing and GIS Applications: Monitoring Deforestation, Habitat Fragmentation, and Ecosystem Health

Remote sensing and Geographic Information Systems (GIS) technologies play a crucial role in monitoring environmental changes, including deforestation, habitat fragmentation, and ecosystem health. These technologies enable researchers and conservationists to:

i) Monitor deforestation and forest degradation using satellite imagery and change detection algorithms

ii) Analyze habitat fragmentation and landscape connectivity using GIS and spatial analysis techniques

iii) Assess ecosystem health by tracking changes in vegetation cover, soil moisture, and other environmental indicators

iv) Identify areas of high conservation value and prioritize conservation efforts

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v) Develop predictive models of environmental change and habitat loss using machine learning and statistical techniques.

6.2. Biotechnology and Genomics: Applications for Conservation, Restoration, and Sustainable Use

Biotechnology and genomics offer powerful tools for conservation, restoration, and sustainable use of biodiversity. Applications include:

Conservation

i) Genetic analysis: Understanding population genetics and phylogenetics to inform conservation decisions.

ii) Species identification: Using DNA barcoding to identify species and detect wildlife trafficking.

iii) Cryopreservation: Preserving endangered species' genetic material for future use.

Restoration

i) Genetic restoration: Using genetic analysis to restore populations with optimal genetic diversity.

ii) Assisted colonization: Introducing species to new habitats to enhance ecosystem resilience.

iii) Genetic engineering: Developing genetically modified organisms (GMOs) for restoration and conservation.

Sustainable Use

i) Genetic improvement: Developing genetically improved crops and livestock for sustainable agriculture and forestry.

ii) Bioprospecting: Discovering new medicines, foods, and other products from biodiversity.

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iii) Synthetic biology: Designing new biological systems for sustainable production of biofuels, chemicals, and other products.

Challenges and Opportunities

i) Regulatory frameworks: Developing regulations to ensure safe and responsible use of biotechnology.

ii) Public engagement: Educating the public about the benefits and risks of biotechnology.

iii) International collaboration: Sharing knowledge, resources, and best practices globally to address conservation and sustainability challenges.

6.3. Artificial Intelligence and Machine Learning: Analyzing Ecosystem Dynamics, Predicting Deforestation, and Optimizing Conservation Efforts

Artificial intelligence (AI) and machine learning (ML) are revolutionizing conservation efforts by analyzing ecosystem dynamics, predicting deforestation, and optimizing conservation strategies (Shivaprakash, Swami, Mysorekar, Arora, Gangadharan, Vohra, and Kiesecker, 2022). AI-powered algorithms can process vast amounts of satellite imagery, sensor data, and other environmental Information to identify patterns and trends, enabling researchers to monitor ecosystem health, detect early warning signs of deforestation, and predict areas of high conservation value. ML models can also optimize conservation efforts by identifying the most effective interventions, predicting the impact of different management scenarios, and providing personalized recommendations for conservationists and policymakers, ultimately leading to more efficient and effective conservation outcomes.

6.4. Circular Economy Models and Sustainable Consumption Patterns: Reducing Waste, Promoting Eco-Labeling, and Encouraging Sustainable Livestock Production

Circular economy models and sustainable consumption patterns are crucial for reducing waste, promoting eco-labeling, and encouraging sustainable livestock production. By adopting circular economy principles, businesses and individuals can design out waste, promote recycling and

upcycling, and encourage the sharing and reuse of products. Eco-labeling initiatives, such as certifications and labeling schemes, can help consumers make informed choices about sustainable products, including sustainably produced livestock. Additionally, sustainable livestock production practices, such as regenerative agriculture and agroforestry, can promote soil health, biodiversity, and efficient resource use, while reducing greenhouse gas emissions and waste generation**.**

7.0 Case Studies and Success Stories in Tropical Ecosystem Conservation

7.1 Restoration of the Nigerian Conservation Foundation and Amazon Rainforest: Lessons from Community-Led Initiatives and Large-Scale Restoration Projects

Conservation efforts in Nigeria are crucial for protecting the country's rich biodiversity, promoting sustainable forest management, and supporting local communities Salami, 2022a; Salami, 2022b). The Nigerian government has established several protected areas, including national parks and game reserves, which cover approximately 10% of the country's land area (African Wildlife Foundation, 2020). However, these protected areas are often inadequately managed, and encroachment, poaching, and habitat destruction continue to threaten the country's biodiversity. To address these challenges, conservation organizations, such as the Nigerian Conservation Foundation, are working with local communities to promote sustainable forest management and provide alternative livelihoods (NCF, 2020). Additionally, initiatives such as the REDD+ program are being implemented to reduce deforestation and forest degradation, while also promoting sustainable land-use practices. These efforts require continued support and collaboration among government agencies, conservation organizations, local communities, and other stakeholders to effectively protect Nigeria's biodiversity and promote sustainable development.

The Amazon Rainforest, one of the most biodiverse ecosystems on the planet, faces numerous threats, including deforestation, land degradation, and climate change. Community-led restoration initiatives and large-scale restoration projects offer promising solutions. These initiatives involve local communities in the restoration process, ensuring that their needs and knowledge are

integrated into project design and implementation. Large-scale restoration projects, such as the Amazon Rainforest Restoration Project, aim to restore degraded lands and promote sustainable land-use practices. Lessons from these initiatives highlight the importance of community engagement, sustainable land-use planning, and long-term commitment to restoration efforts.

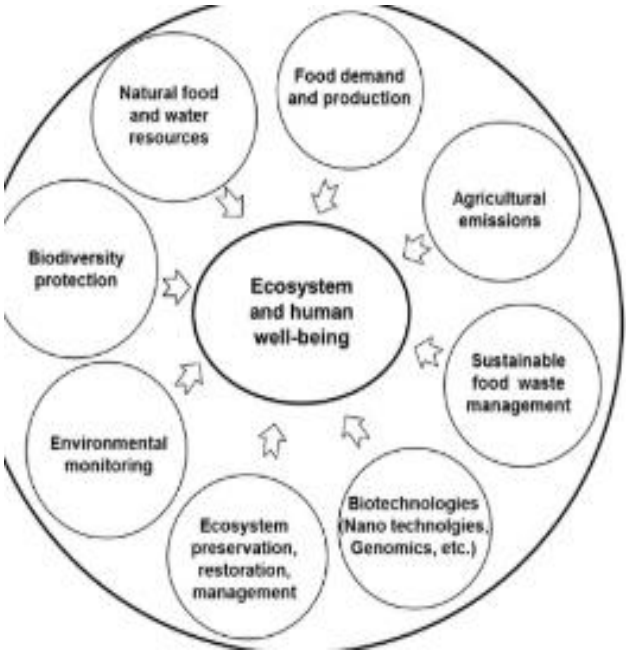

Figure 1: Environmental Impact of Agriculture

Figure 2 Key areas of intervention for forest and landscape restoration

Source: FAO, 2015

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Plate 5: Restored Awba dam (University Ibadan)

Source: Salako, 2020

Plate 6: Multiple landscape restoration interventions in the Brazilian Atlantic Forest

Source: FAO, 2015

7.2 Conservation Efforts in the Congo Basin: Protecting Biodiversity, Promoting Sustainable Forest Management, and Supporting Local Communities

Conservation efforts in Nigeria are crucial for protecting the country's rich biodiversity, promoting sustainable forest management, and supporting local communities. The Nigerian government has established several protected areas, including national parks and game reserves, which cover approximately 10% of the country's land area (African Wildlife Foundation, 2020). However, these protected areas are often inadequately managed, and encroachment, poaching, and habitat destruction continue to threaten the country's biodiversity. To address these challenges, conservation organizations, such as the Nigerian Conservation Foundation, are working with local communities to promote sustainable forest management and provide alternative livelihoods (NCF,

2020). Additionally, initiatives such as the REDD+ program are being implemented to reduce deforestation and forest degradation, while also promoting sustainable land-use practices. These efforts require continued support and collaboration among government agencies, conservation organizations, local communities, and other stakeholders to effectively protect Nigeria's biodiversity and promote sustainable development. The Congo Basin, home to the second-largest tropical rainforest in the world, is a critical region for biodiversity conservation. Conservation efforts in the Congo Basin focus on protecting biodiversity, promoting sustainable forest management, and supporting local communities. Initiatives such as the Congo Basin Forest Fund and the Central African Forest Commission aim to promote sustainable forest management and reduce deforestation. Community-based conservation projects, such as the Baka Pygmy-led conservation initiative, demonstrate the importance of local community engagement and participation in conservation efforts.

7.3 Agroforestry and Sustainable Agriculture in Southeast Asia: Examples from Indonesia, Malaysia, and the Philippines

Southeast Asia, a region with high levels of biodiversity and agricultural production, faces significant environmental challenges, including deforestation and land degradation. Agroforestry and sustainable agriculture practices offer promising solutions. Examples from Indonesia, Malaysia, and the Philippines demonstrate the potential for sustainable land-use practices to promote ecosystem services and support local livelihoods. Initiatives such as the Indonesian government's agroforestry program and the Malaysian Palm Oil Council's sustainability certification scheme promote sustainable agriculture practices and reduce deforestation (Lin, Catacutan., van Noordwijk, Mulia, Simelton, Nguyen and Finlayson, 2021)

7.4 Community-Based Ecotourism in Tropical Ecosystems: Best Practices, Challenges, and Opportunities for Sustainable Development

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Community-based ecotourism initiatives in tropical ecosystems offer opportunities for sustainable development and biodiversity conservation. Best practices, such as community-led tour operations and fair benefit-sharing, ensure that local community's benefit from ecotourism initiatives. Challenges, including inadequate infrastructure and limited market access, must be addressed to ensure the long-term sustainability of community-based ecotourism initiatives. Opportunities for sustainable development, including job creation and income generation, highlight the potential for community-based ecotourism to promote conservation and support local livelihoods **(**Kunjuraman, 2024).

Conclusion

In conclusion, tropical ecosystems are facing unprecedented threats from human activities, including deforestation, habitat fragmentation, and climate change, which are altering the delicate balance of these ecosystems and compromising their ability to provide essential ecosystem services. Understanding the dynamics of human impact on tropical ecosystems is crucial for developing effective restoration strategies that prioritize biodiversity conservation, ecosystem resilience, and human well-being. Restoration efforts should focus on rehabilitating degraded habitats, reconnecting fragmented landscapes, and promoting sustainable land-use practices that balance human needs with environmental protection. Additionally, addressing the root causes of environmental degradation, such as poverty, inequality, and unsustainable consumption patterns, is essential for achieving long-term conservation and restoration goals. Ultimately, a concerted effort from governments, civil society, and local communities is needed to protect and restore tropical ecosystems, ensuring the health and prosperity of both people and the planet.

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