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Climate Change Impact on Tropical Forest Ecosystem and Biodiversity: The case of sub-Saharan Africa

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Abstract

The tropical ecosystem is the richest ecosystem in the world. It is characterized by dense forests, thick vegetation, rich mangroves and extensive water bodies. Climate change affects the tropical ecosystem and the services it renders, that surrounding communities are largely dependent upon, thereby threatening development and economic stability. Local climate variability can have consequences for the social, economic, and personal conditions, and by extension influence the lives and livelihoods of people in this region. Scientists estimate that more than half of the world's plant and animal species live in tropical rainforest region and yet they cover 6% of the world's surface. The sub-Saharan Africa is one of such tropical ecosystem where the effects of climate change are particularly being felt because of over reliance and overexploitation of its natural capitals. This paper therefore takes a critical look at the existing and potential dangers posed by the changing climate on the tropical forest ecosystem in sub-Saharan Africa.

Keywords: Tropical ecosystem, sub-Saharan Africa, Climate change, rainforest

Introduction

Climate change refers to a shift in the mean state of the climate or in its variability persisting for an extended period - decade or longer (International Panel Climate Change, 2001). The main characteristics of climate change are increases in average global temperature (global warming); changes in cloud cover and

precipitation particularly over land; melting of ice caps and glaciers and reduced snow cover; and increases in ocean temperatures and ocean acidity – due to seawater absorbing heat and carbon dioxide from the atmosphere (United Nation Framework Convention on Climate Change, 2017). IPCC (2001) projected that if greenhouse gas emissions, the leading cause of climate change continue to rise, the mean global temperatures will increase by $1.4 – 5.8^0$C by the end of the 21st century. In so doing, ecosystems and access to natural resources such as fertile land and water would be greatly affected and hence negatively affecting the people (IPCC, 2007).

Climate Change Impact on the Ecosystem

Ecosystems are collections of macro and microscopic biota that form critical life support systems. While scientific conceptualizations and empirical work on Loss and Damage has focused primarily on human impacts (Warner and van der Geest, 2013; Wrathall et al., 2015), little attention has been given to the loss of ecosystem services and the cascading impacts on human societies resulting from this (Zommers et al., 2014).Yet, according to the IPCC's Fifth Assessment Report, "evidence of climate-change impacts is strongest and most comprehensive for natural systems" (IPCC, 2014). Degradation of ecosystems is occurring worldwide due to overexploitation and because of insufficient recognition of the vital importance of the services that ecosystems provide to human well-being (World Water Assessment Program, 2015; MA 2005). Climate change has the potential to exacerbate ecosystem degradation and reduce the efficiency of ecosystem services (Staudinger et al., 2012; Bangash et al., 2013; Lorencová et al., 2013). The Millennium Ecosystem Assessment defines ecosystem services as the benefits that people obtain from ecosystems (MEA 2005).

Services Provided by the Ecosystem

Ecosystem	**Examples**
Provisioning services	food, water, fuel and wood or fiber

• Regulating services	climate, flood and disease regulation and water purification
• Supporting services	soil formation, nutrient cycling and primary production
• Cultural services	educational, recreational, aesthetic and spiritual

Adapted from: MEA, 2005

Climate Change Impact on Biodiversity loss

Biological diversity is generally taken to mean the combination of genetic variation, species richness, taxonomic diversity, and ecosystem diversity (IUCN/UNEP/WWF, 1991). Biodiversity at all levels is currently being lost at an unprecedented rate. Highest levels of biodiversity are in the tropics, particularly the tropical forests, and estimates for the total number of species range between 5 and 30 million, less than 2 million of which has been described (Wilson, 1988). Current rates of extinction from the tropical forest biome alone have been estimated as between 1 and 11% (Groombridge, 1992). Principal causes of biodiversity loss worldwide include habitat destruction, pollution, invasive species, and over-exploitation of resources such as fisheries and deforestation.

Potential Climate Change impacts on Biodiversity and Forest Ecosystems

Level	**Pattern of Impact**
Cell	-Reduction in stomata conductance -Increase in photosynthesis -Increase in transpiration
Organism	-Phenology – changes in physiological cycles e.g. blooming, flowering, fruiting etc. -Migration -Insect emergence

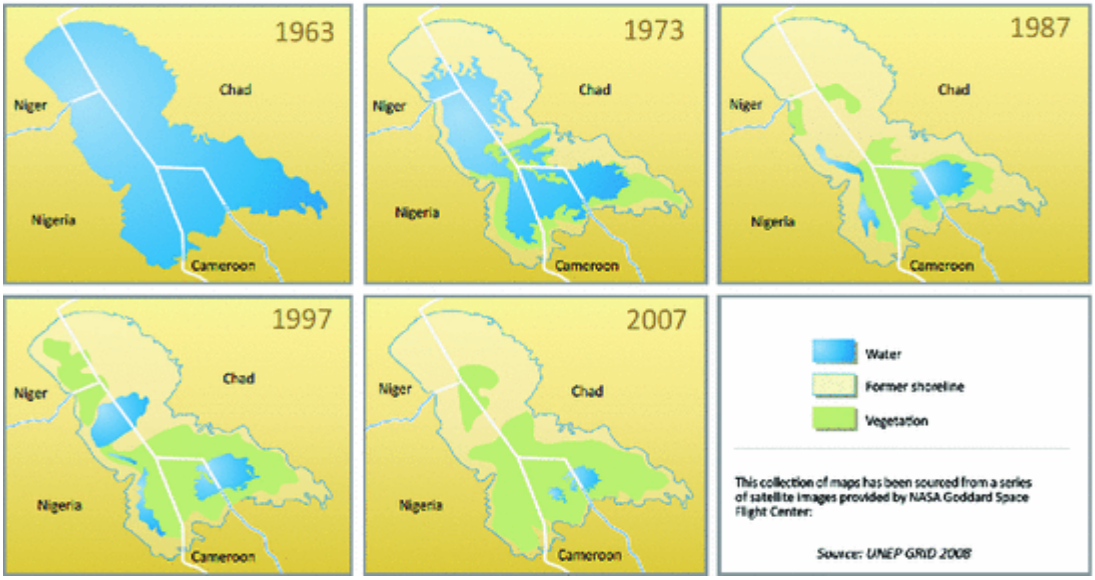
	-Reduction in cropping seasons
Species	-Changes in species distribution and abundance -Changes in morphology and reproduction -Shift in plant and animal ranges -Invasions -Extinction
Ecosystem	-Changes in species composition and ecosystem structure -Changes in ecosystem processes and service provision -Decoupling of species interaction e.g. predator-prey -Shift in entire ecosystem

Source: IPCC 2007

The Lake Chad Situation

Lake Chad—centred in Western Chad and straddling the Niger, Nigeria and Cameroon borders—was home to abundant fisheries and livestock herds. Temperature increase, rainfall unpredictability, and land use changes have negatively affected the Lake Chad basin. Once among Africa's largest lakes, the lake has shrunk from 25,000 sq. km in 1963 to around 1,000 sq.km (UNEP, 2008). The lake once supported a vital traditional culture of fishing and herding. As the lake receded, farmers and pastoralists shifted to the greener areas, where they compete for land resources with host communities (Salkida, 2012). The decline of Lake Chad illustrates how changing climate patterns interacting with other anthropogenic modifications, conflict and poor governance result in losses and damages to ecosystems and societies.

Figure 2.The Drying of Lake Chad



Source UNEP (2016)

Possible Solution

When it comes to tackling climate change, there are basically two types of measures. These include **adaptation** and **mitigation** measures. Mitigation attends to the causes of climate change, while adaptation addresses its impact.

Adaptation Measures

Adapting to climate change entails taking the right measures to reduce the negative effects of climate change (or exploit the positive ones) by making the appropriate adjustments and changes. These adjustments and changes range from technological options such as increased sea defenses to behavioral change at the individual level, such as reducing water use in times of drought. Other strategies include early warning systems for extreme events, better water management, various insurance options and biodiversity conservation (UNFCCC, 2006c).

A significant move by the UNFCCC process was to enable least developed countries to identify their immediate priorities for adaptation options via the National Adaptation Programmes of Action(NAPA) which identify their urgent and immediate adaptation needs – those for which further delay could increase vulnerability or lead to increased costs at a later stage. Over 40 least developed countries have received funding under the Convention to prepare their NAPAs which draw on existing information and community-level input to prioritize adaptation plans. Many countries have

already submitted their NAPAs to the UNFCCC secretariat. Priority adaptation projects identified by NAPAs include:

• Improved forecasting for farming, extreme events and disaster management;

• Improved water management for drinking and agriculture through understanding water flows and water quality, improved rainwater harvesting and water storage and diversification of irrigation techniques;

• Improved food security through crop diversification, developing and introducing drought, flood and saline tolerant crops, improving livestock and fisheries breeding and farming techniques, developing local food banks for people and livestock, and improving local food preservation;

• Better land and land use management through erosion control and soil conservation measures, agroforestry and forestry techniques, forest fire management and finding alternative energy sources to wood and charcoal, as well as better town planning;

• Coastal zone management including coral monitoring and restoration and improving coastal defences through afforestation, reforestation, set-back areas and vegetation buffers;

• Capacity-building to integrate climate change into sectoral development plans, involving local communities in adaptation activities, raising public awareness and education on climate change, and enabling representation at international meetings;

• Promotion of sustainable tourism.

Mitigation Measures

According to FAO (2009), some of the options to mitigate climate change in the agricultural sector (and by extension the ecosystem) are:

Reducing emissions of carbon dioxide, methane and nitrous oxide: Agriculture releases to the atmosphere significant amounts of CO2, CH4, or N2O. The fluxes of these gases can be reduced by more efficient management of carbon and nitrogen flows in agricultural ecosystems, leading to less carbon dioxide, nitrogen and methane released.

This option includes:

• Adopting improved cropland management practices: Minimal soil disturbance (minimum and zero tillage) and improved grazing management (e.g. stocking rate management, rotational grazing, and enclosure of grassland from livestock grazing)

can reduce emissions from volatilization of organic soil Carbon. Integrated nutrient management can reduce emissions by reducing leaching and volatile losses, improving nitrogen use efficiency through precision farming and improving fertilizer application timing.

• Improving livestock feeding practices: Using specific agents or dietary additives, improvements in forage quality and quantity, seeding fodder grasses or legumes with higher productivity and deeper roots, reducing fuel load by vegetation management, can increase efficiency of the digestive process thus reducing emissions from enteric fermentation.

• Avoiding drainage of organic soils: Draining organic soils for cultivation leads to higher GHG emissions. Therefore maintaining a shallower water table, together with avoiding deep ploughing and cropping row crops and tubers can reduce emissions.

• Reducing deforestation and forest degradation: Committing forests for reducing emissions from deforestation and forest degradation (REDD) and adopting sustainable management of existing forests can reduce emissions.

• Adopting improved aquaculture management: Selection of suitable populations of aquatic species, improved energy efficiency, increasing feeding efficiency, switching to herbivorous or omnivorous aquaculture species will reduce emissions from input use.

Removing emissions: GHGs can be absorbed from the atmosphere through sinks. A sink is any process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas or aerosol from the atmosphere.

This option includes:

• Improved agronomic practices: Use of cover crops, avoiding use of bare fallow and incorporation of crop residue to generate higher inputs of carbon residue, leading to increased soil carbon storage (systems that retain crop residues tend to increase soil carbon because these residues are precursors of soil organic matter).

• Improved soil & water management: Increased available water in the root zone can enhance biomass production, increase the amount of above-ground and root biomass returned to the soil, and improve soil organic Carbon concentration (for example: construction of soil or stone bunds, drainage measures, irrigation).

• Agro-forestry, afforestation/reforestation, forest restoration: Carbon storage can be increased through: combining crops with trees for timber and fodder; establishing shelter belts and riparian zones/buffer strips with woody species systems; and conversion from non-forest to forest land use and from degraded forests to fully carbon stocked forests. Replanting mangroves in aquaculture areas Replanting mangroves in aquaculture areas will create carbon sinks.

Conclusion

Loss of biodiversity will most likely reduce ecological resilience and ability to adapt to climate change. The maintenance of biological diversity and resilience is vital for the mitigation of global climate change impacts.

References

Bangash RF, Passuello A, Sanchez-Canales M, Terrado M, López A, Elorza FJ, Ziv G, Acuna V, Schuhmacher M (2013) Ecosystem services in Mediterranean river basin: climate change impact on water provisioning and erosion control. Sci Total Env 458:246–255

FAO (2009). Food Security and Agricultural Mitigation in Developing Countries: Options for Capturing Synergies. http://www.fao.org/docrep/012/i1318e/i1318e00.pdf

Groombridge B (ed) (1992). Global biodiversity: Status of the earth's living resources. Chapman and Hall, London

IPCC (2001). Climate Change 2001: Sysnthesis Report. R. Watson (Ed). Cambridge, U.K., and New York: Cambridge University Press.

IPCC.(2007). Fourth Assessment Report. Intergovernmental Panel on Climate Change Secretariat. Geneva, Switzerland.

IPCC (2014) Climate change 2014: impacts, adaptation, and vulnerability. Part A: global and sectoral aspects. In: Field CB et al (eds) Contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change, vol 1. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Pres

IUCN/UNEP/WWF (1991).Caring for the earth: A strategy for sustainable living.

Lorencová E, Frélichová J, Nelson E, Vačkář D (2013) Past and future impacts of land use and climate change on agricultural ecosystem services in the Czech Republic. Land Use Policy 33:183–194

MEA (Millennium Ecosystem Assessment), 2005. Ecosystems and human well-being: current state and trends. Island Press, Washington DC

Salkida A (2012) Africa's vanishing Lake Chad.Africa Renewal, April 2012, p 24. chttp://www.un.org/africarenewal/magazine/april2012/africa%E2%80%99svanishing-lake-chad. Accessed 21 Nov 2015

Staudinger M, Grimm NB, Staudt A, Carter SL, Stuart III FS, Kareiva P, Stein BA (2012) Impacts of climate change on biodiversity, ecosystems, and ecosystem services: technical input to the 2013 National Climate Assessment (pp i–A). United States Global Change Research Program

UNEP (2008) Lake Chad: almost gone. An Overview of the State of the World's Fresh and Marine Waters - 2nd Edition - 2008. http://www.unep.org/dewa/vitalwater/article116.html

UNEP (2016) Loss and damage: the role of ecosystem services. United Nations Environment Programme, Nairobi, Kenya

UNFCCC (2006c). Background paper on Impacts, vulnerability and adaptation to climate change in Africa. UNFCCC Secretariat. Bonn, Germany. <http://unfccc.int/files/adaptation/adverse_effects_and_response_measures_art_48/appli

cation/pdf/200609_background_african_wkshp.pdf>
UNFCCC (2017). Climate Change: Impacts, vulnerabilities and adaptation in developing countries. 48pp. <http://unfccc.int/resource/docs/publications/impacts.pdf>
Warner K, van der Geest K (2013) Loss and damage from climate change: local-level evidence from nine vulnerable countries. Int J Global Warming 5(4):1–20
Wilson E.O (ed) (1988). Biodiversity: National Academy Press, Washington DC.
Wrathall DJ, Oliver-Smith A, Fekete A, Gencer E, Reyes ML, Sakdapolrak P (2015) Problematising loss and damage. Int J Global Warming 8(2):274–294
WWAP (United Nations World Water Assessment Programme) (2015) The united nations world water development report 2015: water for a sustainable world. UNESCO, Paris
Zommers Z, Wrathall D, van der Geest K (2014) Loss and damage to ecosystem services UNU-EHS Working Paper Series, No. 12. Bonn, United Nations Institute for Environment and Human Security

Sparks, D. L. (1996).*Methods of soil analysis*, part 3. Chemical methods, SSSA book series No. 5.

Zia, M. S., Khali, S., Aslam, M. and Hussain, F. (2003). Preparation of compost and its use for crop production.*Science Technology Development*, 22: 32-44.