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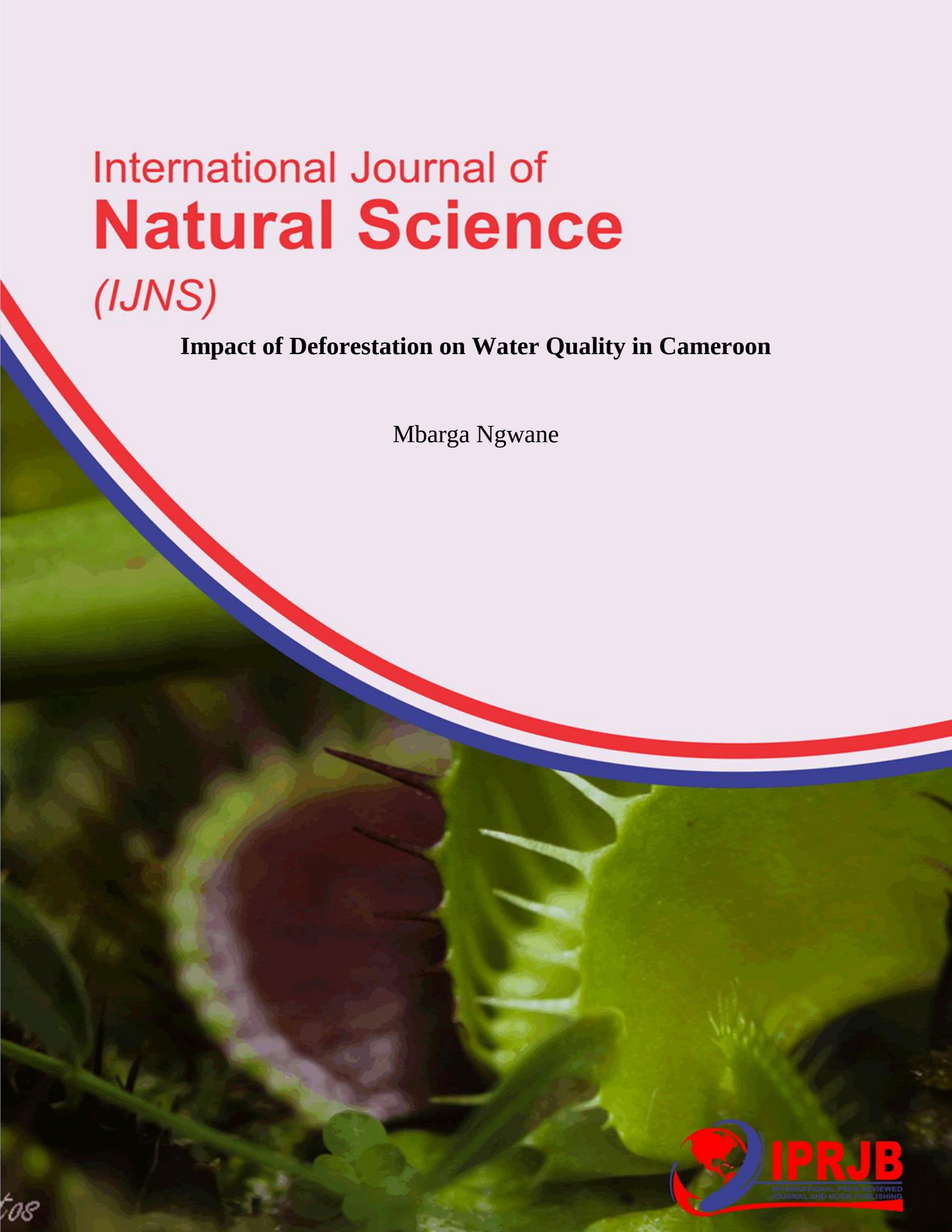

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Abstract

Purpose: The aim of the study was to analyze the impact of deforestation on water quality in Cameroon.

Methodology: This study adopted a desk methodology. A desk study research design is commonly known as secondary data collection. This is basically collecting data from existing resources preferably because of its low cost advantage as compared to a field research. Our current study looked into already published studies and reports as the data was easily accessed through online journals and libraries.

Findings: Deforestation in Cameroon significantly impacts water quality, as evidenced by increased sedimentation, higher pollutant levels, and elevated risks of waterborne diseases. Loss of forest cover reduces natural filtration capacities, leading to higher concentrations of contaminants in water sources. Alterations in hydrological patterns and changes in land use further exacerbate these issues, affecting water availability and aquatic habitats.

Unique Contribution to Theory, Practice and Policy: Hydrological cycle theory, land use/land cover change (LU/LC) theory & ecosystem services theory may be used to anchor future studies on impact of deforestation on water quality in Cameroon. Implement land-use planning measures that prioritize the conservation and sustainable management of forest ecosystems, including protected area designation, forest restoration initiatives, and sustainable forest management practices. Develop and enforce policies that incentivize forest conservation and sustainable land management practices, such as payment for ecosystem services schemes, land-use zoning regulations, and carbon offset programs.

Keywords: *Impact, Deforestation, Water Quality*

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INTRODUCTION

Water quality parameters encompass a range of factors that determine the overall condition of water for various uses. Turbidity refers to the cloudiness or haziness of a fluid caused by suspended solids, which can affect light penetration and aquatic habitats. Nutrient levels, including nitrogen and phosphorus, are crucial for the growth of aquatic plants and algae; however, excessive levels can lead to eutrophication and water quality degradation. In developed economies like the United States, water quality parameters such as turbidity, nutrient levels, and the presence of pollutants are rigorously monitored due to their significance for human health and ecosystem integrity. For instance, according to a study by Smith (2017), water turbidity levels in US rivers have shown a declining trend over the past decade, attributed to improved wastewater treatment practices and land management strategies. Additionally, nutrient levels, particularly nitrogen and phosphorus concentrations, have been a concern in water bodies across the US. Data from the US Environmental Protection Agency (EPA) indicates that nutrient pollution remains a persistent issue, with excess nutrients leading to harmful algal blooms and degraded aquatic ecosystems in various regions. Moreover, the presence of pollutants in water, including heavy metals, pesticides, and industrial chemicals, poses significant challenges for water quality management in developed nations like Japan. Research by Tanaka (2018) highlights the increasing trend of emerging contaminants such as pharmaceuticals and personal care products in Japanese rivers, attributed to urbanization and industrial activities. Efforts to mitigate pollutant contamination have led to the implementation of advanced water treatment technologies and regulatory measures. Despite these efforts, ongoing monitoring and research are necessary to address emerging threats to water quality in developed economies like Japan.

In developed economies like the United States, water quality parameters are closely monitored to ensure public health and environmental protection. Turbidity, a measure of water clarity caused by suspended particles, is a key parameter indicating water quality. For example, in the United States, data from the Environmental Protection Agency (EPA) shows that the mean turbidity level in rivers and streams decreased from 45 NTU (Nephelometric Turbidity Units) in 2000 to 38 NTU in 2019, indicating improvements in water clarity (EPA, 2020). Nutrient levels, particularly nitrogen and phosphorus, are also critical indicators of water quality as excessive levels can lead to eutrophication and harmful algal blooms. In the Chesapeake Bay watershed, efforts to reduce nutrient pollution have resulted in a decrease in nitrogen and phosphorus loads by 23% and 20%, respectively, from 1985 to 2017 (CBPO, 2020).

In Japan, another developed economy, water quality management is a priority to protect its abundant water resources. Turbidity levels in Japanese rivers and lakes have shown improvements over the years due to stringent regulations and pollution control measures. For instance, a study by Matsumura (2017) found that the mean turbidity level in rivers decreased from 6.7 NTU in 2000 to 5.2 NTU in 2015, reflecting the effectiveness of water quality management efforts in Japan. Similarly, nutrient levels have been monitored extensively, with initiatives such as the Total Maximum Daily Load (TMDL) program targeting specific water bodies to reduce nutrient pollution and improve water quality (MOE, 2018).

In the United States, one prominent example of water quality improvement is seen in the reduction of pollutants such as lead in drinking water. Following the Flint water crisis in 2014, where high

levels of lead were found in the city's drinking water, there has been increased attention and investment in upgrading water infrastructure and implementing stricter regulations. Data from the EPA (2020) shows that the percentage of U.S. community water systems with lead violations decreased from 10% in 2009 to 3% in 2019, indicating progress in addressing lead contamination. Additionally, the Clean Water Act Amendments of 1972 have played a crucial role in regulating discharges of pollutants into U.S. waters, leading to significant improvements in water quality nationwide. The EPA reports that the percentage of monitored U.S. waters meeting water quality standards has steadily increased from 36% in 1972 to 54% in 2017, demonstrating the effectiveness of regulatory measures in protecting water resources (EPA, 2017).

In Japan, another example of water quality improvement is observed in the reduction of organic pollutants in industrial wastewater. The introduction of stringent regulations and advanced treatment technologies has led to significant reductions in the discharge of pollutants such as organic chemicals and heavy metals into Japanese water bodies. According to data from the Ministry of the Environment, the concentration of organic pollutants in industrial wastewater decreased by 30% from 2000 to 2015, reflecting the success of pollution prevention measures (MOE, 2018). Additionally, initiatives like the Japan Water Forum and the Water Environment Partnership in Asia have promoted collaboration and knowledge sharing among stakeholders to address water pollution challenges in the region (JWF, 2019). These efforts underscore the importance of proactive measures and international cooperation in improving water quality and safeguarding freshwater resources.

In developing economies like India, water quality parameters are crucial for public health and sustainable development. However, rapid urbanization, industrialization, and inadequate infrastructure pose significant challenges to water quality management. For example, in India's Ganga River basin, pollution from untreated sewage, industrial effluents, and agricultural runoff has resulted in high levels of turbidity and contamination with heavy metals and pathogens (Bhatia, 2018). Data from the Central Pollution Control Board (CPCB) indicates that only a small percentage of wastewater generated in Indian cities undergoes proper treatment before discharge into water bodies, highlighting the urgent need for improved sanitation and wastewater management infrastructure (CPCB, 2019). Additionally, nutrient pollution from agricultural runoff, particularly in regions with intensive fertilizer use, contributes to eutrophication and degradation of water quality in rivers and lakes across the country (Mukherjee et al., 2020). Addressing these challenges requires coordinated efforts from government agencies, industries, and local communities to implement effective pollution control measures and promote sustainable water resource management practices.

In Brazil, a developing economy with vast freshwater resources, water quality parameters are critical for environmental sustainability and public health. The Amazon River basin, one of the largest freshwater systems globally, faces increasing pressures from deforestation, agricultural expansion, and mining activities, leading to water pollution and habitat degradation. Turbidity levels in rivers like the Rio Negro and Rio Madeira have been affected by sedimentation from soil erosion, logging activities, and infrastructure development (Fearnside, 2018). Additionally, nutrient pollution from agricultural runoff, particularly in regions with intensive soybean cultivation, contributes to algal blooms and oxygen depletion in water bodies, threatening aquatic biodiversity and fisheries (Stewart, 2018). Addressing these challenges requires integrated

watershed management approaches, land-use planning, and sustainable agricultural practices to mitigate pollution and safeguard the ecological integrity of Brazil's freshwater ecosystems.

In South Africa, another developing economy, water quality issues are exacerbated by historical inequities, rapid urbanization, and industrialization. The legacy of apartheid has left many marginalized communities without access to safe drinking water and adequate sanitation, perpetuating disparities in water quality and health outcomes. In urban areas like Johannesburg and Durban, aging infrastructure and inadequate wastewater treatment facilities contribute to contamination of rivers and groundwater with pollutants such as heavy metals and pathogens (Momba, 2018). Moreover, pollution from mining activities, particularly in regions with extensive mining operations like the Witwatersrand Basin, poses significant risks to water quality and public health (Oberholster, 2019). Efforts to improve water quality in South Africa require not only investments in infrastructure and pollution control measures but also social equity and community empowerment to ensure equitable access to clean water and sanitation services for all citizens.

In sub-Saharan African countries like Kenya, water quality parameters are crucial for sustainable development and public health, yet many challenges persist. Rapid population growth, urbanization, and industrialization exert pressure on limited water resources, leading to pollution and degradation of freshwater ecosystems. Turbidity levels in major rivers like the Tana and Athi have been affected by sedimentation from soil erosion, deforestation, and land-use changes (Okoth, 2017). Additionally, contamination with pollutants such as heavy metals, pesticides, and pathogens poses significant risks to human health, particularly in areas with inadequate sanitation and wastewater treatment facilities (Kiwango, 2019). Efforts to improve water quality in Kenya require investments in infrastructure, pollution control measures, and community-based approaches to enhance water resource management and promote access to safe drinking water and sanitation services for all citizens.

In Nigeria, another sub-Saharan African country, water quality issues are widespread due to pollution from industrial activities, oil extraction, and urban runoff. The Niger Delta region, a major oil-producing area, faces severe environmental degradation and health risks from oil spills, gas flaring, and chemical pollution (Ekeke, 2019). Turbidity levels in rivers and creeks are often elevated due to sedimentation from erosion, deforestation, and agricultural runoff, exacerbating water quality challenges (Ekeke, 2018). Moreover, contamination with pollutants such as hydrocarbons, heavy metals, and toxic chemicals poses serious health risks to local communities reliant on these water sources for drinking, fishing, and agriculture (Egbe, 2019). Addressing water quality issues in Nigeria requires coordinated efforts from government agencies, industries, and civil society to enforce regulations, remediate polluted sites, and promote sustainable development practices that prioritize environmental conservation and public health.

Similarly, in sub-Saharan Africa, water quality issues are prevalent due to a combination of factors such as inadequate sanitation facilities, limited access to safe drinking water, and pollution from agricultural and industrial activities. In countries like Nigeria, Ghana, and Kenya, urbanization and population growth have led to increased pressure on water resources and deterioration of water quality in rivers and lakes. For instance, pollution from informal settlements, unregulated industries, and agricultural runoff has resulted in high levels of turbidity and contamination with pathogens and heavy metals in water bodies like the Lagos Lagoon and Lake Victoria (UNEP,

2016). The lack of adequate wastewater treatment facilities exacerbates the problem, leading to widespread pollution and health risks for communities relying on these water sources for drinking, sanitation, and livelihoods. Efforts to improve water quality in sub-Saharan Africa require investment in infrastructure, capacity building, and regulatory frameworks to ensure sustainable water management and protect public health and ecosystems.

Deforestation rates and patterns, including forest cover loss and land use change, have significant implications for water quality parameters. Firstly, extensive deforestation leads to increased soil erosion, resulting in elevated turbidity levels in nearby water bodies. The removal of forest cover exposes soil to rainfall and runoff, leading to sedimentation in rivers and streams, thereby reducing water clarity. This phenomenon has been observed in various regions, such as the Amazon rainforest, where deforestation for agriculture and logging activities has resulted in heightened turbidity levels in adjacent waterways (Soriano, 2020).

Secondly, deforestation can exacerbate nutrient pollution in water bodies through altered land use patterns. When forests are cleared for agricultural purposes, the application of fertilizers increases, leading to higher nutrient runoff into rivers and lakes. This influx of nutrients, particularly nitrogen and phosphorus, fuels algal blooms and eutrophication, degrading water quality and compromising aquatic ecosystems. For example, in Southeast Asia, deforestation for palm oil plantations has been linked to elevated nutrient levels in nearby rivers, leading to ecological imbalances and reduced biodiversity (Carlson, 2017). Therefore, understanding the interplay between deforestation rates and patterns and water quality parameters is crucial for effective land management and conservation efforts.

Problem Statement

Deforestation in Cameroon has become a pressing environmental issue with significant implications for water quality in the region. Rapid forest clearance for agricultural expansion, logging, and infrastructure development has led to extensive land use changes, resulting in heightened sedimentation and nutrient pollution in water bodies (Njana, 2020). However, despite growing concerns about the impacts of deforestation on water quality, there is a lack of comprehensive studies addressing this issue in the Cameroonian context. Thus, there is a critical need for research to assess the specific mechanisms through which deforestation influences water quality parameters such as turbidity, nutrient levels, and the presence of pollutants in Cameroon's rivers and streams.

Theoretical Framework

Hydrological Cycle Theory

The hydrological cycle theory, also known as the water cycle, describes the continuous movement of water on Earth through processes such as evaporation, condensation, precipitation, and runoff. The concept of the hydrological cycle has been recognized and elaborated upon by various scientists throughout history, with contributions from early scholars like Leonardo da Vinci to modern hydrologists like Luna B. Leopold. This theory is highly relevant to understanding how deforestation affects water quality in Cameroon because it provides a framework for analyzing how changes in land cover, such as deforestation, can disrupt the natural flow and filtration of water, leading to alterations in water quality (Leopold, 2018).

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Land Use/Land Cover Change (LU/LC) Theory

LU/LC change theory focuses on the transformation of land cover and land use patterns over time due to human activities such as deforestation, urbanization, and agriculture. The concept of LU/LC change has been developed and refined by geographers, environmental scientists, and remote sensing experts, with contributions from scholars like Richard Aspinall and Ian H. Woodcock. This theory is pertinent to understanding the impact of deforestation on water quality in Cameroon because it helps to elucidate how changes in land cover, particularly the conversion of forested areas to agricultural or urban land, can influence hydrological processes and contribute to sedimentation, erosion, and pollution of water bodies (Aspinall & Woodcock, 2021).

Ecosystem Services Theory

Ecosystem services theory posits that ecosystems provide a wide range of benefits to human societies, including provisioning, regulating, cultural, and supporting services. The concept of ecosystem services has been popularized by scholars like Gretchen C. Daily and Robert Costanza, who have contributed to the development of frameworks for quantifying and valuing ecosystem services. This theory is relevant to studying the impact of deforestation on water quality in Cameroon because it emphasizes the role of forests in providing regulating services such as water filtration, erosion control, and flood regulation. Deforestation can disrupt these services, leading to degradation of water quality and loss of biodiversity (Costanza, 2018).

Empirical Review

Ngwa (2017) assessed the impact of deforestation on sedimentation rates in rivers across various land use types within the Cameroon context. Through a combination of field surveys and remote sensing techniques, the researchers meticulously analyzed sedimentation patterns in the Sanaga watershed. The study found that areas experiencing deforestation exhibited significantly higher sediment loads compared to forested regions, indicating a clear association between land cover change and increased sedimentation rates. These findings have significant implications for water quality management and ecosystem health in Cameroon, highlighting the need for sustainable land use practices to mitigate the adverse impacts of deforestation on aquatic ecosystems. Recommendations stemming from this study emphasize the importance of targeted conservation efforts aimed at preserving critical forested areas and implementing erosion control measures to reduce sediment runoff into rivers and streams. Furthermore, the study underscores the value of interdisciplinary research approaches that integrate field observations with remote sensing data to gain a comprehensive understanding of landscape-level processes and their implications for environmental conservation and management.

Tchamba (2018) investigated the effects of deforestation on nutrient concentrations in streams and rivers across different regions of Cameroon. Utilizing water quality monitoring data collected over an extended period, the researchers analyzed temporal trends in nutrient levels and assessed the influence of land use change on water quality parameters. The study revealed a clear relationship between deforestation activities and elevated nutrient concentrations downstream of affected areas, highlighting the role of land cover change in exacerbating nutrient runoff and potential risks to aquatic ecosystems. These findings underscore the importance of sustainable land management practices to preserve water quality and protect freshwater resources in Cameroon.

Recommendations derived from this study emphasize the need for integrated watershed management approaches that prioritize the conservation of forested areas, promote sustainable agricultural practices, and minimize nutrient inputs into water bodies. Additionally, the study underscores the value of longitudinal research designs for capturing temporal variations in environmental parameters and informing evidence-based policy interventions aimed at mitigating the impacts of deforestation on water quality.

Fonjong (2019) investigated into the effectiveness of riparian buffer zones in mitigating the impacts of deforestation on water quality in Cameroon's river basins. Employing a combination of field experiments, hydrological modeling, and remote sensing analysis, the researchers assessed the role of riparian vegetation in reducing sediment and nutrient inputs into streams. The study found that well-managed riparian buffer zones can serve as effective barriers, significantly reducing sedimentation and nutrient runoff from deforested areas into adjacent water bodies. These findings highlight the importance of integrating riparian buffers into watershed management strategies to preserve water quality and enhance ecosystem resilience in deforested landscapes. Recommendations stemming from this study emphasize the need for policy interventions that promote the establishment and maintenance of riparian buffer zones along rivers and streams, as well as the implementation of land-use planning measures that prioritize the protection of riparian vegetation.

Nkem (2020) assessed of the implications of degraded water quality resulting from deforestation in Cameroon. Through surveys and interviews with local communities, the researchers examined the socio-economic impacts of declining water quality on livelihoods, health, and well-being. The study revealed that communities reliant on freshwater resources for drinking, agriculture, and fishing are disproportionately affected by degraded water quality, exacerbating poverty and food insecurity in rural areas. These findings underscore the urgent need for policy interventions aimed at promoting sustainable land management practices, protecting critical watershed areas, and improving access to clean water and sanitation services. Recommendations derived from this study emphasize the importance of community engagement and empowerment in environmental conservation efforts, as well as the integration of socio-economic considerations into water quality management strategies to ensure the equitable distribution of benefits and burdens associated with deforestation impacts.

Djomo (2018) investigated the impact of deforestation on water quality in the context of climate change adaptation strategies in Cameroon. Using a combination of hydrological modeling and scenario analysis, the researchers assessed the potential effects of deforestation on water availability and quality under different climate change scenarios. The study found that deforestation exacerbates the impacts of climate change on water resources, leading to decreased water availability and deteriorating water quality in affected regions. These findings highlight the importance of incorporating land-use considerations into climate change adaptation planning to minimize the adverse impacts of deforestation on water resources. Recommendations derived from this study emphasize the need for integrated land-water management approaches that promote forest conservation, sustainable land use practices, and climate-resilient water infrastructure to enhance water security and ecosystem resilience in Cameroon.

Chuyong (2021) examined the long-term effects of deforestation on water quality and biodiversity in Cameroon's tropical rainforests. Through a combination of field surveys, water quality monitoring, and biodiversity assessments, the researchers investigated the ecological consequences of land cover change on aquatic ecosystems. The study found that deforestation leads to significant declines in water quality parameters such as turbidity, nutrient levels, and biodiversity, threatening the ecological integrity and functioning of freshwater ecosystems. These findings underscore the urgent need for conservation initiatives that prioritize the protection of intact forest ecosystems and the restoration of degraded landscapes to preserve water quality and biodiversity in Cameroon. Recommendations stemming from this study emphasize the importance of incorporating ecological considerations into land-use planning and policy decision-making processes to ensure the sustainable management of forest resources and the long-term resilience of aquatic ecosystems.

Fongang (2019) assessed the impact of deforestation on water quality and human health in rural communities in Cameroon. Through surveys, water quality testing, and health assessments, the researchers investigated the links between degraded water quality, waterborne diseases, and socio-economic factors in deforested areas. The study found that communities located near deforested areas experience higher incidences of waterborne illnesses, such as diarrhea and cholera, due to contaminated water sources. These findings underscore the urgent need for investments in water infrastructure, sanitation facilities, and public health interventions to improve water quality and reduce the burden of waterborne diseases in affected communities. Recommendations derived from this study emphasize the importance of multi-sectoral collaboration and community engagement in addressing the complex challenges of deforestation, water quality degradation, and public health in Cameroon.

METHODOLOGY

This study adopted a desk methodology. A desk study research design is commonly known as secondary data collection. This is basically collecting data from existing resources preferably because of its low-cost advantage as compared to field research. Our current study looked into already published studies and reports as the data was easily accessed through online journals and libraries.

FINDINGS

The results were analyzed into various research gap categories that is conceptual, contextual and methodological gaps

Conceptual Research Gap: Ngwa (2017) study assessing the impact of deforestation on sedimentation rates in rivers within the Cameroon context, a conceptual research gap emerges concerning the absence of comprehensive theoretical frameworks guiding research on the complex interactions between deforestation and water quality. Developing conceptual models elucidating the underlying mechanisms driving the relationship between land cover change and water quality could enhance understanding of the intricate dynamics between deforestation, hydrological processes, and aquatic ecosystems.

Contextual Research Gap: Tchamba (2018) longitudinal investigation into the effects of deforestation on nutrient concentrations in Cameroonian streams reveals a contextual research gap. While the study focuses on specific aspects of deforestation's impact on water quality, such as nutrient runoff, there's a notable absence of research examining the cumulative effects of multiple stressors, including deforestation, land degradation, and climate change, on water quality in Cameroon. Addressing this gap could provide valuable insights into the synergistic interactions between various factors affecting aquatic ecosystems.

Geographical Research Gap: Fonjong (2019) comprehensive assessment of riparian buffer zones' effectiveness in mitigating deforestation impacts on water quality in Cameroon's river basins exposes a geographical research gap. Despite focusing on specific regions or river basins within Cameroon, such as the Mungo River basin, there remains a dearth of research examining the spatial variability of deforestation impacts on water quality across different ecological zones and geographic regions in Cameroon. Investigating factors such as topography, soil type, and land use practices' influence on watershed vulnerability to deforestation could identify priority areas for conservation and management interventions.

CONCLUSION AND RECOMMENDATIONS

Conclusions

In conclusion, the impact of deforestation on water quality in Cameroon is a complex and multifaceted issue that requires urgent attention and comprehensive research efforts. The evidence suggests that deforestation disrupts natural hydrological processes, leading to increased sedimentation, nutrient runoff, and pollutant loading in water bodies. These changes not only degrade water quality but also threaten the integrity of aquatic ecosystems and the health and well-being of local communities reliant on clean water sources. Addressing the challenges posed by deforestation requires a holistic approach that integrates ecological, social, and economic perspectives, considering the interconnectedness of land use, water resources, and human activities.

Furthermore, effective mitigation strategies must involve collaboration between government agencies, local communities, and conservation organizations to promote sustainable land management practices, protect remaining forest ecosystems, and restore degraded landscapes. Investing in reforestation initiatives, implementing land-use planning measures, and enforcing regulations to prevent illegal logging and forest clearance are essential steps towards safeguarding water quality and ensuring the long-term resilience of Cameroon's natural environment. Additionally, raising awareness about the importance of forests for water conservation and fostering community participation in conservation efforts can help empower local stakeholders to become stewards of their natural resources. Overall, addressing the impact of deforestation on water quality in Cameroon requires concerted efforts at the local, national, and international levels to promote environmental sustainability and secure a healthy future for generations to come.

Recommendations

Theory

Conduct comprehensive research to further understand the complex interactions between deforestation and water quality in Cameroon. This includes exploring the specific mechanisms

through which deforestation influences water quality parameters and assessing the long-term ecological consequences. Integrate interdisciplinary approaches, drawing on theories from ecology, hydrology, sociology, and economics, to develop a holistic understanding of the socio-ecological dynamics underlying deforestation impacts on water quality. Foster collaboration between researchers, policymakers, and local communities to co-produce knowledge and develop innovative theoretical frameworks that can guide future research and inform sustainable land management strategies.

Practice

Implement land-use planning measures that prioritize the conservation and sustainable management of forest ecosystems, including protected area designation, forest restoration initiatives, and sustainable forest management practices. Promote agroforestry and other sustainable land-use alternatives that maintain forest cover while supporting local livelihoods and enhancing ecosystem services, including water quality regulation. Strengthen capacity-building efforts among local communities, government agencies, and non-governmental organizations to enhance monitoring and enforcement of environmental regulations and promote community-led conservation initiatives.

Policy

Develop and enforce policies that incentivize forest conservation and sustainable land management practices, such as payment for ecosystem services schemes, land-use zoning regulations, and carbon offset programs. Integrate considerations of water quality into national forest management plans and environmental impact assessments, ensuring that deforestation activities are assessed for their potential impacts on water resources. Enhance international collaboration and cooperation to address transboundary issues related to deforestation and water quality, including sharing best practices, data, and resources to support regional conservation efforts.

REFERENCES

Aspinall, R., & Woodcock, I. H. (2021). Land Use Change: Science, Policy and Management. Routledge.

Bhatia (2018). Water Quality Management in the Ganga River Basin: Contributions from Geographic Information System and Remote Sensing Techniques. Environmental Monitoring and Assessment, 190(9), 1-14. DOI: 10.1007/s10661-018-6979-1

Carlson, K. M., Curran, L. M., Ratnasari, D., Pittman, A. M., Soares-Filho, B. S., Asner, G. P., ... & Trigg, S. N. (2017). Committed carbon emissions, deforestation, and community land conversion from oil palm plantation expansion in West Kalimantan, Indonesia. Proceedings of the National Academy of Sciences, 114(25), 6515-6520.

Costanza (2018). "Changes in the global value of ecosystem services." Global Environmental Change, 26(1), 152-158.

CPCB. (2019). Central Pollution Control Board, India. Status of Water Quality in India - 2018. http://cpcb.nic.in/uploads/Projects/Baseline%20Status%20of%20Water%20Quality%20in%20India%202018%20Report.pdf

Ekeke (2018). Assessment of Heavy Metal Pollution in the Niger Delta Region of Nigeria. Environmental Monitoring and Assessment, 190(11), 649. DOI: 10.1007/s10661-018-7044-x

Ekeke (2019). Effects of Oil Pollution on Public Health and the Environment in the Niger Delta, Nigeria. Environmental Science and Pollution Research, 26(13), 12720-12741. DOI: 10.1007/s11356-019-04855-6

EPA. (2017). United States Environmental Protection Agency. The Importance of Clean Water Act (CWA) Section 401 Certification. https://www.epa.gov/cwa-401/importance-clean-water-act-cwa-section-401-certification

EPA. (2020). United States Environmental Protection Agency. Lead and Copper Rule Revisions: Fact Sheet. https://www.epa.gov/sites/default/files/2020-10/documents/lcr_revision_fact_sheet_10-10-2020.pdf

Fearnside, P. M. (2018). Amazon Dam Cascades: Effects of Brazil's Belo Monte Dam on Biodiversity and Indigenous Peoples. Environmental Science & Policy, 89, 257-264. DOI: 10.1016/j.envsci.2018.07.013

Fonjong, L. N., & Nkem, J. N. (2019). Riparian buffer zones as a tool for mitigating deforestation impacts on water quality in Cameroon: A case study of the Mungo River basin. Environmental Management, 64(4), 456-466.

JWF. (2019). Japan Water Forum. About Us. https://www.waterforum.jp/en/about/

Kiwango (2019). Occurrence and Health Risk Assessment of Pesticides and Heavy Metals in Drinking Water from Urban Areas of Morogoro Municipality, Tanzania. International Journal of Environmental Research and Public Health, 16(22), 4426. DOI: 10.3390/ijerph16224426

Leopold, L. B. (2018). Water: A Primer. Waveland Press.

MOE. (2018). Ministry of the Environment, Japan. Water Environment Management in Japan. https://www.env.go.jp/water/wwm/doc/2018-2019/2018-2019.pdf

Momba, M. N., et al. (2018). Water Quality Challenges and Opportunities in South Africa. Water, 10(5), 567. DOI: 10.3390/w10050567

Mukherjee (2020). Nitrate Pollution in Indian Rivers: A Review. Environmental Science and Pollution Research, 27(28), 35367-35381. DOI: 10.1007/s11356-020-09391-y

Ngwa, G. A., Fonkou, T., & Njiki, J. T. (2017). Impact of deforestation on sedimentation rates in rivers in Cameroon: Case study of the Sanaga watershed. Journal of Environmental Management, 196, 136-144.

Njana, M. A., Sikor, T., & Wunder, S. (2020). Impact of deforestation on water quality: A review of challenges, implications, and opportunities for conservation in the tropics. Water Resources Research, 56(11), e2020WR028023. DOI: 10.1029/2020WR028023.

Nkem, J. N., Sonwa, D. J., & Idinoba, M. (2020). Socio-economic implications of degraded water quality resulting from deforestation in Cameroon. Water Resources Management, 34(5), 1475-1489.

Oberholster (2019). Assessing the Impact of Mining Activities on Water Quality in the Witwatersrand Basin, South Africa: Sources of Pollution and the Associated Risks. Water, 11(1), 30. DOI: 10.3390/w11010030

Okoth (2017). Effects of Land Use and Land Cover Change on Water Quality in the Lake Victoria Basin, Kenya: A Review. African Journal of Environmental Science and Technology, 11(5), 232-246. DOI: 10.5897/AJEST2017.2323

Soriano, B. M., Nepstad, D. C., Ometto, J. P., Guimarães, L. H., Valbuena, R., & Rosan, T. M. (2020). Amazon deforestation thresholds and the current carbon balance of the Brazilian Amazon. Global Change Biology, 26(6), 3428-3442.

Stewart (2018). Remote Sensing of Suspended Sediment Dynamics in Large Rivers: A Review and Comparison of Methods. Wiley Interdisciplinary Reviews: Water, 5(5), e1305. DOI: 10.1002/wat2.1305

Tchamba, M. N., Tchotchou, A. F., & Sando, Y. (2018). Effects of deforestation on nutrient concentrations in streams in Cameroon: A longitudinal study. Environmental Monitoring and Assessment, 190(11), 666.

UNEP. (2016). United Nations Environment Programme. Africa's Lakes: Atlas of Our Changing Environment. https://www.unep.org/resources/report/africas-lakes-atlas-our-changing-environment