

MASTER OF SCIENCE
ENVIRONMENTAL MANAGEMENT

ECONOMIC VALUE AND UTILIZATION OF WILD FOREST RESOURCES IN MANTJOLO FOREST, ESWATINI

Samkelisiwe Phetsile DLAMINI
PAU-UI-0632

ENVIRONMENTAL MANAGEMENT

Mantjolo Forest in Eswatini is an important supply of natural products. The objective of this study was to identify the types of resources present in Mantjolo Forest, identify who harvests them, determine their economic importance. The goal was to provide insights into the economic potential of forest resources. A quantitative research approach was adopted, prioritizing objectivity, generalizability, and statistical analysis. This design facilitated a thorough understanding of the economic value and applications of the resources found in Mantjolo Forest. The study used purposive sampling to identify research participants who would provide the maximum amount of information related to our research question. The research had 41 participants. These methods were utilized to ensure reliable and significant data regarding the research question. The results of the study revealed that the majority of the resource harvesters were male, thus indicating a gender gap in terms of resource use. Households and businesses (of various types), the main sites of resource use, include a broad range of demographics. Timber and bushmeat are recognized as both forest products that provide use value to the local population and resources that are likely marketable, indicating their considerable economic importance. In contrast, other resources, such as mushrooms, honey, wild foods and even water and firewood, were not as well identified or used by the respondents. The data revealed that timber is the most significant resource in Mantjolo Forest, representing 78.6% of the total economic value. 8.4 percent (honey) and 6.8 percent (bushmeat). The remaining resources, including mushrooms, wild foods, and wild herbs as well as insects, have much less commercial value. The study revealed that a large number of households that engaged in gathering forest resources had between four and six members, reflecting a distinct range of family sizes. Most of these identified participants were unaware of any formal or informal regulations governing the processing or sale of forest products and that strongly affected sustainability and quality control over the natural resources found within the forest. These findings uncover and emphasize the need to consider regional differences in conservation and economic policies as opposed to generalized ones. This study offers a comprehensive understanding of the economic value and use of wild forest resources in Mantjolo Forest, Eswatini, providing important insights for future research and policy development. The study recommends resource management and conservation implementing sustainable resource management practices is crucial given the economic significance and use of timber and bushmeat, forest resource management succeeds xiii through active partnerships between communities and their stakeholders and diversification of economic prospects: business activities should move beyond natural resource extraction because natural resource harvesting generates substantial income, but the region needs to pursue multiple economic opportunities like agroforestry and other businesses.

Keywords: Mantjolo Forest, Economic value, Wild Forest resources.

INVESTIGATING VISITORS' KNOWLEDGE AND APPRECIATION OF ECO-LABELING AND ECO-CERTIFICATION AT OLUMIRIN WATERFALLS, OSUN STATE, NIGERIA

**JUSLEINE AVE-AMPI- OBIMA
PAU-UI-0747**

ENVIRONMENTAL MANAGEMENT

Using the convenience sampling technique, 212 visitors were selected from the Olumirin water falls. Information on tourists' sociodemographic characteristics, including age, gender, marital status, education and religion, was obtained. The scores computed from a well-validated scale for each case for awareness of EC and EL awareness of EC and EL were used to determine the respondents' interest in eco-certified and eco-labelled products, the perceived benefits of EC and EL and their willingness to use eco-labelled and eco-certified products. The determinants of the willingness to use eco-certified and eco-labelled products and the determinants of the willingness to pay for eco-certified and eco-labelled products were obtained. The data were analysed via descriptive statistics and multiple regression at $\alpha_{0.05}$. The majority were aged ≤ 30 years, with an average of 27.42 years. They were mostly female (50.47%), single (72.6%) and Christian (79.3%). The dominant profession was students (59.0%), with 71.7% identified as having tertiary education. The majority were aware of organic foods (80.2%) and eco-friendly souvenirs (57.5%) among eco-certified products; waste management (81.6%) and organic and local dining (64.2%) for eco-certified services; and protection of natural space (83%) and waste reduction or recycling (75.5%) in the environmental category. The level of awareness was high among slightly more than half (53.3%) of the respondents. Approximately 77.8% had favourable perceptions of eco-certification and ecolabelling, while 65.1% had high interest in eco-certified and eco-labelled products. Most perceived beneficial products are organic food ($M = 2.49$) and renewable energy ($M = 2.37$); services such as eco-friendly gardening services (mean = 2.30) and sustainable lodging (mean = 2.24); and environmental services such as the protection of natural spaces (mean = 2.46) and eco-friendly walking paths (mean = 2.34). Organic foods (72.5%, $M = 50.86$) and eco-labelled wellness products (69.8%, $M = 42.05$) were used. The most preferred services were waste management (71.2%, $M = 49.84$) and educational ecotourism programs (60.8%, $M = 52.50$). With respect to environmental aspects, awareness-raising with respect to sustainability and ecology (74.5%, $M = 55.87$) and ecosystem restoration (71.2%, $M = 55.25$) were the highest. Organic foods (72.5%), waste management (71.2%) and waste reduction or recycling (74.1%) had the strongest support and attracted the greatest degree of willingness to use. Male ($\beta = 9.85$) and Christian ($\beta = 10.20$) individuals indicated greater willingness to use, whereas married individuals indicated lower willingness ($\beta = -13.16$). Males ($\beta = 9.85$) and Christians ($\beta = 10.20$) are more willing to pay for eco-certified products, whereas married individuals ($\beta = -13.16$) and those who perceive fewer benefits ($\beta = -1.05$) are less willing. There is a high level of awareness, perception, and interest in eco-certified and eco-labelled products. Willingness to pay was significantly greater among males and Christians, whereas married individuals and those perceiving fewer benefits were less inclined to pay for such products.

Key Words: Ecolabels, Sustainable tourism, Olumirin Water Falls

IMPACTS OF LAND USE CHANGE ON SPATIOTEMPORAL DYNAMICS OF SOIL ORGANIC CARBON STOCKS IN KAHUZI BIEGA NATIONAL PARK, DEMOCRATIC REPUBLIC OF CONGO

Merlin Munguakonkwa CIZUNGU

PAU-UI-0478

ENVIRONMENTAL MANAGEMENT

Soil organic carbon stocks (SOCS) represent the largest terrestrial pool and play a significant role in the context of current climate change. It represents not only the major carbon reservoir in forest ecosystems but also a very sensitive component to human perturbation, such as land use/land cover (LULC) change. In Kahuzi Biega National Park (PNKB), in the Democratic Republic of Congo (DRC), anthropic pressure on forest resources damages the park forest and may affect the SOCS in the park. The present study aimed to analyse the impact of observed land use/land cover change on the soil organic carbon storage potential in the high-altitude sector of the park. It maps LULC changes for 1996, 2011, 2019, 2024 and predicts changes for 2030. It also investigates SOCS spatiotemporal dynamics as well as the effects of variations in vegetation structure and soil physicochemical parameters on the SOCS between 2018 and 2024. Supervised classification with maximum likelihood using Landsat imagery was used to analyse changes in LULC, soil composite and undisturbed samples, taken to a depth of 30 cm in five identified land uses: primary-secondary transitional forest (PSTF), secondary forest (SF), forest fallow (FF), forest plantation (FP) and cultivated land (CL), were analysed in the laboratory and vegetation data were collected for PSTF and SF, including diameter at breast height, species identification and counts of individuals by species. Statistical analyses, such as descriptive statistics, paired tests, analysis of variance and Pearson correlation, assessed the effects of land-use change on SOCS, vegetation and soil parameters. The results revealed consistent losses of vegetation (-541.33km²) and bare land (-32.18km²) and a slight water body (-1.76km²) areas converted into agricultural (211.15km²) and built-up (364.12km²) areas from 1996-2024 and a similar trend in the future. There was also a significant increase in SOCS in SF (from 105.9t C/ha to 111.9t C/ha), whereas SOCS decreased in other land uses from 2018-2024. The soil physicochemical parameters also vary significantly, and the vegetation structure shows a progressive evolution in SF but a regressive evolution in PSTF. Strong correlations were observed between SOCS and soil organic carbon ($r=0.91$), nitrogen ($r=0.59$), bulk density ($r=-0.47$), C/N ratio ($r=0.52$) and C/clay ratio ($r=0.52$), emphasizing the significant role of soil properties in the SOCS under land use change. These findings provide important insight for the management of the PNKB, highlighting the impact of LULC change on the park's soil organic carbon sequestration potential. These findings emphasize the importance of proper land use effects, forest conservation and sustainable practices to prevent soil carbon loss due to population growth and human activities. They can guide policy makers, PNKB managers, scientists and local communities in the drafting and implementation of integrated management and restoration plans to support conservation efforts, improve community well-being and fight against climate change.

Key Words: Land Use, Carbon, Soil, Forest, Deforestation, Park, Impact.

TRENDS AND ASSESSMENT OF WATER AND SEDIMENT QUALITY IN MANGROVES: A CASE STUDY OF AKODO-ISE, IBEJU-LEKKI LOCAL GOVERNMENT AREA, LAGOS STATE

Zafiarisoa Thérèse AGATHE
PAU-UI-0749

ENVIRONMENTAL MANAGEMENT

This study explored the state of an urban mangrove facing two distinct and interconnected pressures from urbanisation and population growth, in Akodo-Ise, a community in the heart of Lagos State. It was carried out during a rainy period. Only two mangrove species were found on the site, inhabited by *Rhizophora mucronata* and *Rhizophora mangle*. The aim was to contribute to the databases on mangroves in Nigeria, and in particular in Lagos State. Water parameters were measured, from the seafront to the inner mangrove. To assess sediment parameters, samples were taken at two depths, 0-15 cm and 16-30 cm. The concentration of nutrients and heavy metals Fe, Pb, Zn, Cu, Cd and Ni was assessed in the sediments, and the loss of mangrove area between 2013-2023 was also determined by acquiring and processing satellite images. The water quality results showed a pH ranging from 6.76 to 7.38 with a temperature between 26.80°C and 27.70°C and a salinity between 1.70 and 7.60 ‰. Heavy metals concentrations (mg/kg) ranged from (0 to 215.80) for Pb, (733.10 to 4061) for Fe, (2.45 to 29.50) for Zn, (1.58 to 3.50) for Cu and (3.50 to 95.10) for Ni. It was found that only Fe indicated a very high level of contamination in the environment, whether in the seafront, intermediate or the inner mangrove areas. The loss of mangrove was estimated at 98.63 ha over the period 2013-2023. The trend in heavy metal concentration is complex. The sampling point and depth could influence the concentration. However, the surrounding human activities are the main factors contributing to the variation in concentration and to any form of degradation in terms of loss in surface area. In order to address these challenges, the development of ecotourism projects in mangrove is strongly recommended, alongside an in-depth study of the ecosystem dynamics of mangrove in the region is also crucial to ensure its sustainable management.

Key Words: assessment, degradation, contamination, mangrove, management, Nigeria

CARBON FOOTPRINT IMPLICATIONS OF HOUSEHOLD ENERGY CHOICES IN KITWE, ZAMBIA

Michael CHUNGU
PAU-UI-0750

ENVIRONMENTAL MANAGEMENT

Global warming and climate change are two of the most pressing global issues currently being faced. Carbon emissions have been understood to be contributing significantly to these global phenomena, with residential energy use significantly contributing to both local and global carbon emissions, mainly in rapidly urbanizing cities. This study examined the carbon footprint implications of household energy choices in Kitwe, Zambia. The study explored the primary energy sources used by households in Kitwe, analysed the factors that influence household energy choices, and quantified the carbon emissions resulting from household energy use. Using a cross-sectional survey design, data was collected from 300 households across three socio-economic strata. Structured questionnaires, energy consumption records, and direct observations were used to gather the data. Results showed that in Kitwe, 99% of households use charcoal, while 95.3% use grid electricity. Additionally, only 13.3% of households use solar energy, 1% use liquefied petroleum gas (LPG), and 0.7% rely on generators. Income, cost, availability, and reliability were found to be key determinants of household energy choices. Further, results showed that the main use for charcoal was cooking and heating whereas grid electricity was mainly used for lighting and appliances. Carbon footprint estimation, based on emission factors, indicated that on average, a Kitwe household emits approximately 2,076.254 kilograms of CO₂ per year from its household energy use. Charcoal-dependent households were found to have significantly higher carbon emissions than those relying more on electricity, with charcoal contributing approximately 1,697.700 kg CO₂/year whereas electricity only contributes approximately 371.397 kg CO₂/year. Using one-way ANOVA tests, we found that charcoal, electricity and total household carbon footprints vary significantly across Kitwe townships. Further multivariate regression analysis showed a relationship between firewood and electricity usage and total household energy carbon footprint. This study underlines the pressing need for policies that encourages climate-friendly energy alternatives, improves grid electricity reliability, as well as increase access to sustainable energy options. By leveraging on these solutions, Kitwe can reduce its household energy carbon footprint and thus help Zambia to achieve its climate change mitigation goals.

Key Words: Carbon footprint, Kitwe, Energy sources, Carbon emissions, Household energy, Climate change mitigation

CLIMATE CHANGE PREDICTION AND IMPACT ASSESSMENT ON EROSION IN THE RUZIZI PLAIN, SOUTH-KIVU, DEMOCRATIC REPUBLIC OF CONGO

**Asifiwe Esther KULIMUSHI
PAU-UI-0751**

ENVIRONMENTAL MANAGEMENT

Effective soil erosion adaptation and mitigation strategies in the Ruzizi plain require an extensive understanding of how soil conservation practices scenarios and climate change influence soil erosion dynamics. This study evaluated the impact of expected climatic projections on future rates of soil erosion by the year 2100 in the Ruzizi plain, compared with a current representative baseline (year 2023). The study used the Revised Universal Soil Loss Equation (RUSLE) model combined with GIS and remote sensing techniques. Future rainfall erosivity is predicted by assessing a composite of 52 global Climate models (GCMs) from the Coupled Model Intercomparison Projects (CMIP6) WorldClim dataset against observed precipitation data to identify the best-performing model across two shared socio-economic pathways (SSP2-4.5 and SSP5-8.5). The findings revealed that the slope length and steepness factor contributed significantly to soil erosion, particularly in the western and southeastern regions, where values reached 9.36. The Soil erodibility was found to be greater in the southeastern part of the study area because of the increased silt content, with K-factor values ranging between 0.025 and 0.040 t ha h/ha/MJ/mm. Rainfall erosivity (R-factor) exhibited spatial variability, with values predominantly ranging between 3,500 and 4,500 MJ mm/ha/h/year, contributing to increased soil loss in high-rainfall areas. The C-factor revealed that vegetation covers significantly influenced soil erosion patterns, with well-vegetated areas experiencing lower erosion rates. Soil conservation measures were evaluated, with terracing reducing erosion by 83.5%, while strip cropping and contouring showed moderate efficiency. Climate projections under SSP2-4.5 indicate a slight reduction in total annual soil loss (TASL) to 147379.38 t/year, reflecting moderate rainfall changes. In contrast, SSP5-8.5 projects a significant increase in precipitation of more than 100%, leading to an estimated 38% increase in soil loss, reaching 223456.73 t/year compared with the current TSAL (161976.23 t/year). These results underscore the need for adaptive land management, effective conservation practices, and climate resilience efforts to mitigate future soil degradation in the Ruzizi plain.

Key Words: Soil erosion, RUSLE equation, GIS and RS, Soil conservation practices effect, Climate change scenarios.

SUSTAINABLE ECOTOURISM IN PROTECTED AREAS: A CASE STUDY OF GASHAKA GUMTI NATIONAL PARK, SERTI, TARABA STATE, NIGERIA

Melae Abosede Eyitayo
PAU-UI-0752

ENVIRONMENTAL MANAGEMENT

This study investigated sustainable ecotourism in Gashaka Gumti National Park, Taraba State, Nigeria, emphasizing its potential as a catalyst for sustainable development. Using a mixed-methods approach, 215 members of the local community, visitors, and stakeholders were given questionnaires to complete to gather quantitative data. Qualitative data were also gathered through participant observations and interviews. Descriptive statistics, content analysis, multinomial logistic regression, and chi-square tests were used to examine the data. According to the findings, tourism is seasonal, with most visitors visiting between November and March. Even so, tourism activities are still sporadic, with the majority of visitors partaking in a variety of activities such as hiking, cultural excursions, and wildlife viewing. Although organized, park management efforts to promote sustainable tourism practices face several obstacles, and local community involvement in tourism is still limited. The majority of respondents said that tourism had no adverse consequences on the park's environment, such as habitat degradation or disturbance to wildlife. However, the absence of an efficient waste management system has been overlooked for too long, as contemporary activities such as burning rubbish endanger human health and the environment. Furthermore, there was no connection between tourism and the depletion of natural resources, and the park's carrying capacity was controlled to prevent overshooting. Moderate income growth and few job chances for locals are two socioeconomic advantages of tourism. However, stakeholder participation in park administration and infrastructure development is still insufficient. The parks sustainability is further hampered by issues such as youths in the community engaging in illicit mining and a lack of knowledge about environmental preservation. Significant correlations between environmental protection and sustainable tourism practices were validated by statistical studies ($\chi^2 = 27.178$). Learning opportunities related to conservation and cultural exchange were more likely to be reported by respondents who thought that coordinated initiatives in sustainable tourism were in place. Additionally, the economic advantages of tourism have been shown to lower poverty and stop illicit activity, underscoring its potential for community development. This study highlights the necessity for better waste management systems, increased community involvement, and environmental conservation awareness campaigns. Strengthening Gashaka Gumti National Park's infrastructure and expanding people's economic options are advised to promote sustainable ecotourism. By taking these steps, tourism may be guaranteed to have a positive impact on socioeconomic development, environmental preservation, and sustainability in general.

Key Words: Sustainability, Ecotourism, Protected area, National Park.

DOCTOR OF PHILOSOPHY
ENVIRONMENTAL MANAGEMENT

ENVIRONMENTAL AND SOCIOECONOMIC SUSTAINABILITY OF INDUSTRIAL GOLD MINING IN MALI

Zan Mary KONARE
PAU-UI-0590

ENVIRONMENTAL MANAGEMENT

Gold mining is a significant generator of revenue in numerous developing nations, particularly across Africa. However, the realities of gold mining are complex; these operations are notorious for their high demands on energy and materials but are also linked to various forms of pollution, social unrest, and instability. In light of these challenges, particularly concerning environmental degradation and the necessity for sustainable development, life cycle sustainability assessment (LCSA) has emerged as a promising methodological framework to achieve integration of the gold mining sector to the sustainability framework. This research aims to enhance the practical application of LCSA within the gold mining sector, thus fostering greater sustainability in its operations. This research focuses on an objective to assess the life cycle sustainability performance of industrial gold mining in Mali to understand whether gold mining in Mali contributes to the sustainable development of the country. To support this objective, life cycle assessment (LCA), life cycle costing (LCC), and social life cycle assessment (S-LCA) were utilised independently before being integrated within the LCSA framework, with insights drawn from primary data collected from company representatives, workers, and local communities alike. The analysis of the sustainability dimensions of gold mining reveals a comprehensive score of 0.70, highlighting significant disparities across the different aspects assessed. The most sustainable dimension, the economic aspect, had a score of 0.40, indicating relatively strong performance in this area. In contrast, the environmental and social dimensions scored 0.20 and 0.10 respectively, suggesting more considerable room for improvement. An alarming finding is the magnitude of human carcinogenic toxicity linked to the gold mining process, exacerbated by factors such as electricity production and the use of harmful substances such as sodium cyanide and hydrogen peroxide. Furthermore, mining operations contribute to various environmental concerns, including fossil resource depletion and global warming, which necessitate urgent attention. Interestingly, water consumption was noted as having a positive impact, albeit within a context that essentially highlights negative repercussions. Economically, the sector shows robust cost-effectiveness, with operating costs making up the lion's share at 54.8%, followed by investment and energy costs. Socially, the company's performance is commendably rated as good in 85.2% of cases; however, significant challenges persist, including excessive working hours, corruption, and instances of discrimination, reflecting broader societal issues demanding address. Therefore, whereas gold mining clearly holds economic potential, it also presents critical environmental and social challenges that require targeted interventions. The results revealed that advances have been made to help the scientific community become familiar with the methodological application of LCSA, and practitioners identifying the technologies and/or products with the greatest impact on the sustainability of gold mining systems. These advances also support policy-makers in implementing potential improvements in decision-making processes related to gold mining. It was recommended that more case studies be carried out, taking into account the specific challenges identified during this research.

Key Words: Life cycle sustainability assessment, Environmental impact, Gold mining, Mali.

VULNERABILITY OF RURAL HOUSEHOLDS TO FLOODING IN GICUMBI DISTRICT, RWANDA

ANGE JOSIANE UWAYISENGA
PAU-UI-0724

ENVIRONMENTAL MANAGEMENT

Floods have become recurrent events in Rwanda, causing diverse effects on rural households. However, little is known about the effects of floods encountered by people and their coping strategies, which are crucial for reducing vulnerability. The primary objective of this study was to investigate flood impacts and vulnerability of rural households to flooding in Gicumbi, one of the districts most exposed to climate hazards in the Northern province of Rwanda. The coping strategies of households were also examined. A mixed-method approach was used, combining both quantitative and qualitative data. Six areas of the district - Byumba, Kageyo, Miyove, Nyankenke, Rukomo and Ruvune were selected for the study. A structured questionnaire was administered to a random sample of 399 heads of households across the six areas, to elicit information on rural households' vulnerability to flooding. In addition, qualitative data were gathered through key informant interviews of 30 purposely selected participants, offering deeper insights into rural households lived experiences of floods. One focus group discussion, involving 12 participants from the six areas, was conducted to validate key components of vulnerability to flooding. The vulnerability of households to flooding was assessed using the Livelihood Vulnerability Index (LVI) approach, while descriptive and inferential statistics were employed to examine the impacts of flooding, identify the main factors contributing to vulnerability, and analyse coping and adaptation strategies. About 57% of respondents were aged 36–60 years, 72.6% were men and 68.9% were married. The primary income sources included crop farming (43.3%), daily wage work (32.5%) and mixed farming (14.2%). A greater proportion (57%) of household heads had primary education, 31.3% had no formal education, and 11% had secondary education. The majority (78.4%) lived in poorly constructed houses, with over 50% lacking proper latrines. In Kageyo, 61.7% of households were severely affected by floods, while moderate impacts were experienced in Rukomo (65.6%), Byumba (60.2%), Ruvune (49%), Miyove (47.7%) and Nyankenke (46.5%). Common flood impacts included crop destruction, insufficient food, lack of safe drinking water, and absenteeism from work or school. Households in Nyankenke were the most exposed to floods with an impact index of 0.705, while those in Miyove were the most sensitive (0.537). Overall, households in Miyove were the most vulnerable to flooding (0.123), while those in Byumba were the least (0.058) with the highest adaptive capacity (0.498). Vulnerability to flooding was linked to factors like heavy rainfall, high-risk areas, inadequate latrines, food insecurity, poor crop diversity, limited water access, poor housing, reliance on one income, high dependency ratios, and low community participation. Adaptation strategies such as construction of drainage channels, radical terracing, tree planting, sandbags placement and digging of trenches were adopted by 62% of households. Households relied on savings (16.5%), sold assets (31.5%), or loans (20.3%) when farming was disrupted. Early warning ($p < 0.001$) and flood risk awareness ($p = 0.009$) elicited positive coping strategies. Public agents can play key role in strengthening flood resilience and reducing household vulnerability through improved adaptation strategies, early warning systems, and addressing food insecurity, poor social networks and poor housing.

Key Words: Climate change, flood hazards, rural households, vulnerability, flood impacts, coping strategies

SUSTAINABLE MANAGEMENT OF WATER HYACINTH IN WOURI ESTUARY, LITTORAL REGION OF CAMEROON

WIRNGO HERMANN YUVEN
PAU-UI-0692

ENVIRONMENTAL MANAGEMENT

Coastal areas such as Wouri Estuary offer unique ecological services and serve as a source of livelihood through fishing, sand mining, and recreational activities. The presence of foreign objects such as water hyacinth in Wouri Estuary were causing environmental challenges, affecting fish and other aquatic organisms resulting in biodiversity loss due to reduction in entry of sunlight, gas exchange, visibility in water creating a microhabitat. Hence, the need for sustainable management of water hyacinth in Wouri Estuary. Previous studies in Wouri Estuary focused on the socio-economic impacts of water hyacinth, however, the extent of water hyacinth distribution and utilization as biogas substrates has not been fully explored in the area. This study aimed to assess the distribution, management strategies and potential utilization of water hyacinths in River Wouri Estuary as a substrate for biogas production. The distribution of water hyacinths over the past 40 years was investigated using ArcGIS and ENVI. The seasonal changes of water hyacinth were carried out with the transect sampling method. Current techniques and challenges in the management of water hyacinths were assessed through interviews with key informants. The quadrant measurement was used to estimate the water hyacinth biomass in River Wouri Estuary. Equal volumes (700 mL) of water hyacinth (WH) and poultry-based inoculum (INC) were prepared (that is 100% WH: 0% INC, 90% WH: 10% INC, 80% WH: 20% INC and 0% WH: 100% INC). Eight substrates were placed in 1-liter plastic containers and incubated in a water bath at $37 \pm 2^\circ\text{C}$ for 106 days. The substrates were subsampled before and after the incubation period for analysis of the moisture, volatile solid and ash contents using standard methods. The volume of biogas produced from each digester was collected in plastic bags and measured every three days using a Ritter volume measurer. Water hyacinth was found in River Wouri all year round. Over the past four decades, the population of the weed has been relatively stable, with the lowest quantity (3.42 hectares) observed in 2002 and the highest quantities (35.61 and 36.74 hectares) in 2012 and 2022. The average quantity of water hyacinth biomass in Wouri Estuary was 29.36 kg per square metre. The spread of water hyacinth in the rainy season was greater than dry season. However, the vegetative growth in the dry season was greater than that in the rainy season. Composting, harvesting to dump and making handicrafts were the three existing management practices. The cumulative quantity of methane produced were 10.23, 11.84, 5.88, and 0.71 LCH_4/kgVS , for 100% WH: 0% INC, 90% WH: 10% INC, 80% WH: 20% INC and 0% WH: 100% INC respectively. The viability of the water hyacinth in River Wouri Estuary has been established. The plant has great potential for biogas production, serving as a means of managing it through utilization. This could be a sustainable means of managing the weed in River Wouri, while generating biogas.

Key Words: Water hyacinth (*Eichhornia crassipes*), distribution, seasonal changes, management, weed, anaerobic digestion, biogas, inoculum, methane

SPATIO-TEMPORAL PATTERN, EFFECTS, AND DRIVERS OF LANDUSE/ LANDCOVER CHANGE IN THE OSUN RIVER BASIN, NIGERIA

BABAREMU KUNLE OLUFEMI
PAU-UI-0689 ENVIRONMENTAL MANAGEMENT

Changes in land use and land cover (LULC) have been shown to produce both positive and negative impacts on various environmental elements, significantly influencing the urban landscape. This study aims to quantitatively estimate the spatiotemporal pattern of landuse/landcover change (LULCC), its effects on Urban Heat Island (UHI), ecosystem services provisions, surface runoff and sediment yield in the Osun River Basin. The specific objectives included; analysing the spatiotemporal; change in land use and landcover, urban morphological changes and landscape fragmentation, and changes in Urban Heat Island (UHI) between 1984 and 2023 in the Osun River basin. The study incorporated concepts such as Land use Land cover change, Ecosystem services, Ecosystem Service Valuation (ESV), Urbanization, Urban Fragmentation, Climate Change and Urban Heat Island, and Hydrologic Response Unit. These concepts informed the study's objectives and facilitated data analysis and result interpretation. A mixed-methods approach utilizing secondary data, specifically satellite imagery and climate data, was employed. Satellite images were sourced from the USGS Earth Explorer, while climate data was retrieved from the CHIRPS satellite database. Statistical analysis and graphical representation were done using SPSS and MS-Excel. Spatial analysis and mapping utilized ArcGIS 10.8 and QGIS 3.32, urban fragmentation analysis was performed with Fragstats 4.2, and hydrologic response analysis was executed using SWAT plus, integrating DEM, LULC, climate, gauging station, and soil data. The evaluation of temporal LULC changes elucidated the interplay between anthropogenic actions and environmental factors, highlighting socio-economic influences over the last 40 years, with a commendable accuracy rate of 81.42% and a kappa coefficient of 0.74, indicating robust land use classification correlation. The Kruskal-Wallis H test results, with a significance value ($p > 0.05$) at Sig. = 0.406, provided inadequate evidence to refute the null hypothesis, which posits no significant differences in land cover types over time. Fluctuations in landscape metrics (PN, PD, and LPI) were detected among various LULC classes throughout the four-decade period. The MANOVA analysis indicated significant variation ($p < 0.05$) across decades of study [PN (Sig. = 0.000, $F = 63.927$); PD (Sig. = 0.000, $F = 28.625$); LPI (Sig. = 0.000, $F = 203.766$)]. Moreover, the R^2 values for each dependent variable [R^2 (PN = 0.941; PD = 0.877; LPI = 0.981)] underscored the significant variability within LULC classes over time, reflecting pronounced inter-decade variation. Analysis of LST and UHI across sub-basins from 1984 to 2023 indicated no statistically significant differences ($p > 0.05$) in UHI and LST across the sub-basins over the years [UHI (Sig. = 0.406, $H = 4.000$); LST (Sig. = 0.406, $H = 4.000$)]. No discernible correlation was found between changes in built-up areas and UHI alterations ($X^2 = 15.000$, Sig. = 0.241). The decline in ESV from 1984 to 2023, quantified by a total change of approximately \$-213,335,740, corresponds to a negative percentage change (C%) of approximately -6.72%. Lastly, the assessment of model efficacy regarding hydrologic response (precipitation, surface runoff, and basin outflow) indicated moderate model performance, evidenced by NSE (-6.9 to 0.47), CC (-0.214 to 0.711), COD (14.64% - 40%), and PBIAS (-0.1911 - 3.299), with variability in parameter performance. The findings from this study highlight the impact of land use and land cover changes (LULCC) on environmental and hydrological dynamics within the Osun River Basin over the past four decades.

Key Words: Land use/Land Cover, Urban Heat Island, Land Surface Temperature, Ecosystem Services, Hydrologic Response.

CHANGING PATTERN OF ECOSYSTEM SERVICES IN THE AREA OF LAMBARENE IN GABON (1988-2022)

DJEPH WYLPHENE KOUMBA BINAME
PAU-UI-0694

ENVIRONMENTAL MANAGEMENT

Ecosystem services, including provisioning, regulating, supporting, and cultural benefits, are vital for human well-being, ensuring food security and socioeconomic stability. However, there is a big knowledge gap in Gabon, especially in Lambaréné, when it comes to the measurable values of these services and how they relate to changes in land use and land cover (LULC). This makes it harder to make policy and protect the environment. This study examines LULC dynamics in Lambaréné from 1988 to 2022, assessing their impact on ecosystem services and local communities. Using a mixed-methods approach, satellite imagery (1988–2022) was analysed via remote sensing and GIS to quantify urban expansion, vegetation loss, and changes in waterbodies using the Support Vector Machine algorithm. Ecological landscape metrics, such as the Shannon Index, were calculated to evaluate biodiversity trends and spatial fragmentation. Spatial modelling projected short-term (2032) and long-term (2062) LULC changes based on historical trends. Household surveys assessed community dependency on ecosystem services and socio-economic influences. Results reveal significant urban expansion, with built-up areas increasing from 204.73 hectares (1988) to 736.54 hectares (2022), accompanied by a decline in vegetation cover (4,057.40 to 3,488.86 hectares). Water bodies remained stable. The Shannon Index peaked in 2013 but dropped to 0.74 by 2022, indicating biodiversity loss. Rapid urbanisation (2003–2013) caused severe vegetation degradation and landscape fragmentation. Projections suggest built-up areas will grow by 18% (2032) and 35% (2062), exacerbating ecosystem service decline. Household surveys highlight strong local reliance on ecosystem services (51.1% of respondents). Provisioning services (e.g., fish, firewood) correlated strongly with household size ($r = 0.68$, $p < 0.05$), while cultural services (e.g., religious site visits) moderately correlated with income ($r = 0.52$, $p < 0.05$). Regression analysis confirmed household size and income as key determinants of ecosystem dependency ($r = 0.63$). Economic constraints forced trade-offs between essential provisioning services and cultural practices. This study underscores the urgent need for sustainable urban planning and ecosystem conservation to mitigate urbanisation's impacts on Lambaréné's fragile ecosystems. The findings advocate for policies integrating ecosystem service valuation into land-use decisions. Future research should prioritise the economic valuation of services, incorporate traditional ecological knowledge, and employ high-resolution imagery to refine LULC assessments.

Key Words: Ecosystem Services; Land Use and Land Cover (LULC) Changes; Satellite Imagery and GIS Mapping; Support Vector Machine (SVM); Lambaréné.

DEVELOPMENT OF POROUS POLYETHYLENE AND POLYSTYRENE CALCIUM COMPOSITES FOR ORGANIC POLLUTANT REMOVAL AND ENVIRONMENTAL SENSING

**AYODUNMOMI ESTHER OLOWOFOYEKU
PAU-UI-0306 ENVIRONMENTAL MANAGEMENT**

Organic contaminants, including petroleum hydrocarbons, industrial solvents, and oils, pose significant environmental and health risks due to their persistence, bioaccumulation, and long-range transport, leading to oxygen depletion, air and soil pollution, groundwater contamination, and toxic effects on ecosystems and humans. Conventional remediation strategies, such as skimming and chemical dispersants, are often inefficient, costly, and environmentally invasive; hence suitable alternatives are needed. The aim of this study was to develop porous polyethylene and polystyrene-calcium composites with enhanced organic contaminant adsorption and photoluminescence properties for effective pollutant removal and real-time environmental monitoring. Calcium carbonate was modified with oleic acid at concentrations ranging from 0 to 2.5 wt.% using ethanol as a solvent, followed by evaporation at 70 °C to increase hydrophobicity, which was confirmed by contact angle measurements. The modified calcium carbonate was then incorporated into polyethylene and polystyrene matrices via melt blending using a twin-screw extruder with a composition of 60 wt.% filler and 40 wt.% polymer. A subset of these composites was subjected to citric acid treatment (1 M, 48 h) to induce porosity, and the associated weight loss was quantified along with structural modifications. Scanning electron microscopy (SEM) was used for morphology, Fourier transform infrared spectroscopy (FTIR) was used for functional group analysis, Shore D hardness was used for rigidity, and ASTM D570-based tests were used for contaminant adsorption in various liquids (olive oil, n-hexane, and diesel). Additionally, the photoluminescence properties were evaluated under UV excitation (255 and 405 nm), with time-dependent quenching studies in oil for potential sensing applications. Statistical analysis was conducted via ANOVA and Dunnett's post hoc test ($p < 0.05$). The oleic acid-treated calcium carbonate exhibited an oily texture, especially at high concentrations, with FTIR confirming successful surface coating through characteristic additional oleic peaks and increased contact angles (up to 170.70°). SEM imaging revealed pore structures up to 50 μm wide and increased roughness in the citric acid-treated composites when compared with the pure polymer samples. FTIR analysis confirmed the presence of both polymer and filler materials with significant peaks for CO₃²⁻ at 1395 cm⁻¹ and 2900 cm⁻¹ for polyethylene and polystyrene polymers, respectively. Hardness testing showed that oleic acid-treated samples had reduced rigidity due to the lubrication effects, with TE 3 and TPS3 having the lowest Shore hardness (50.9 and 60.7, respectively) compared to untreated pure polyethylene (55.6) and pure polystyrene (78.3). Contaminant adsorption tests confirmed enhanced uptake of both polar and nonpolar liquids, with TPS3 demonstrating 33.10% adsorption for olive oil and 20.80% for both hexane and diesel, whereas TE 3 showed 18.75% for olive oil, 18.40% for hexane, and 12.50% for diesel. Photoluminescence studies revealed that oleic acid treatment induced spectral shifts, with emission peaks stabilizing post-citric acid treatment. Under UV excitation, polyethylene calcium carbonate composites displayed emission peaks at 405 and 570 nm, while polystyrene-calcium carbonate composites exhibited sharper spectral shifts. TPS3 showed reduced emission intensity at 405 nm excitation in response to olive oil, highlighting its potential for proactive contaminant monitoring. Polyethylene and polystyrene composites were developed through melt blending with calcium carbonate fillers and modified with oleic acid and citric acid. Oleic acid treatment increased hydrophobicity and enhanced photoluminescence, whereas citric acid treatment increased porosity, improved hydrophilicity,

and aided the adsorption of the organic contaminants tested. Structural characterization through SEM, FTIR, and Shore hardness testing confirmed adequate filler incorporation and increased surface roughness. The composites demonstrated potential for environmental monitoring through photoluminescence studies. Among the samples, TPS3 showed superior sensitivity and stability for contamination detection, suggesting its potential for applications in pollutant adsorption and smart environmental sensing.