FIRST WEST AFRICAN INTERNATIONAL WORKSHOP ON COASTAL LAND SUBSIDENCE

THEME:

Coastal Land Subsidence in Africa: The Emerging Trends

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University of Ghana
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ABSTRACT BOOKLET

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PREFACE

We are pleased to present the Abstract Booklet for the First West African International Workshop on Coastal Land Subsidence, hosted at the University of Ghana, Accra.

Within these pages, you'll find an exciting compilation of abstracts from our oral and poster presenters, each showcasing the latest research, emerging trends, and innovative solutions for mitigating the impacts of coastal land subsidence. This collective effort reflects the shared commitment of researchers, practitioners, and enthusiasts to address the pressing challenges facing Africa's coastal regions.

We extend our warmest appreciation to the host institution; the University of Ghana, members of the planning committee, our presenters, panelists, participants, affiliated partners and most importantly, our funder; The French Development Agency. Your contributions have been instrumental in bringing this workshop to life.
Thank you for joining us on this impactful journey.

Signed

ENGULF Team

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MEASURING AND MONITORING

Monitoring Land Subsidence in Taiwan: An Integrated Approach

Wei-Chia Hung[1,2] Yi-An Chen[1] Shao-Hung Lin[1,3] Kuan-Chung Lin[1,2]

1. Green Environmental Engineering Consultant Co. LTD., Taiwan
2. Department of Civil Engineering, National Yang Ming Chiao Tung University, Taiwan
3. Department of Geosciences, National Taiwan University, Taiwan

During 1992-2022 over pumping of groundwater caused large-scale aquifer-system compaction and land subsidence in the Choshui River Alluvial Fan (CRAF) in Taiwan. How to effectively monitor land subsidence has become a major issue in Taiwan. In this paper, we introduce a multiple-sensor monitoring system for land subsidence in central Taiwan, including 46 continuous operation reference stations (CORS), multi-temporal InSAR (MT-InSAR), a 1000-km leveling network, 36 multi-layer compaction monitoring wells, 7 automatic record extensometers, and 223 groundwater monitoring wells. This system can monitor the areal extent of land subsidence and provide data for studying the mechanism of land subsidence. We also develop High Cost-Performance Ratio GNSS equipment and automatic multi-layer compaction monitoring equipment to monitor different aquifer compaction. We also use the Internet of Things (IoT) technology to control and manage the sensors and develop a big data processing procedure to analyse the data from the system of sensors. The procedure makes land subsidence monitoring more efficient and intelligent.

Keywords: Land Subsidence, IoT, Big data, CNSS, Multi-temporal InSAR, Leveling, Multi-layer Compaction Monitoring Well

Name of Presenter: Dr. Wei-Chia Hung, Green Environmental Engineering Consultant Co. Ltd, Taiwan

Insights into Two Major Threats to Nigeria's Coastal Population: Land Subsidence and Sea-Level Rise

Nigeria's coastal region is increasingly vulnerable to sea-level change driven by anthropogenic climate change. In several cities, this vulnerability is compounded by vertical land movement (land subsidence), which undermines coastal resilience. Despite numerous studies examining Nigeria's susceptibility to sea-level rise, few have focused on land subsidence in key coastal cities, and none have provided a comprehensive review of the combined effects of these phenomena. This study seeks to bridge this gap by synthesizing the available literature on land subsidence and sea-level change along the Nigerian coastline and identifying existing knowledge gaps. Our findings reveal that, based on Interferometric Synthetic Aperture Radar (InSAR) measurements, significant land subsidence is occurring in Lagos, Port Harcourt, and Warri. Local sea-level rise is also reported in these areas. However, the absence of active GNSS stations necessary to calibrate and validate InSAR measurements diminishes confidence in these findings and increases uncertainty. Additionally, there is a notable lack of data on oil and groundwater withdrawals and piezometric trends over recent decades, which is essential for accurately quantifying the relationship between ground fluid extraction and land subsidence. Integrating recent sea-level change measurements with vertical land motion and piezometric data is crucial to improving our understanding of land subsidence in Nigeria and projecting relative sea-level rise. It is imperative to distinguish between global processes such as sea-level rise, which are beyond the control of Nigerian authorities, and local processes like anthropogenic land subsidence, which can be mitigated. This study represents an initial step towards developing effective mitigation and adaptation strategies to address relative sea-level rise in Nigeria. By addressing these critical knowledge gaps and differentiating between global and local processes, we can better inform policy and management efforts to enhance the resilience of Nigeria's coastal regions.

Name of Presenter: Dr. Femi Emmanuel Ikuemonisan, Lagos State University of Education, Nigeria

Land Subsidence and Coastal City Vulnerability: Elevation Data Challenges in Douala Coastland, Cameroon

The Douala coastland, situated on the coast of Cameroon in the Gulf of Guinea, is characterised by its low elevation above sea level and sedimentary geology, rendering it particularly susceptible to erosion, subsidence, and sea level rise. Douala City and its surrounding mangrove forests experience significant rates of coastal erosion, frequent flooding, complete land loss, and evidence of subsidence. This phenomenon raises critical questions and reveals numerous research gaps, such as the need to better understand the current coastal city dynamics, approaches for monitoring and predicting Douala's low coastland changes, and the necessity to understand the combined effects of multiple factors on coastal city vulnerability. Consequently, this study aims to address these knowledge gaps by investigating, understanding, and estimating land subsidence and how elevation contributes to the overall vulnerability of the Douala Coastland. Remote sensing data, InSAR, and spatial and statistical analyses were used to assess the actual land subsidence rates. Various DEMs were employed to estimate vulnerable zones, populations, and infrastructure in the present and short term. The findings indicate an average and median land subsidence rate of 2.7 mm/year and 2.5 mm/year respectively, with 97.87% of the scattered points exhibited land subsidence. The vulnerable areas and populations vary considerably depending on the DEM used, highlighting the fact that an appropriate selection of the DEM is a prerequisite for a more accurate estimation of vulnerable zones and populations. These findings can be used to develop sustainable management strategies for the coastal zone of Douala.

Name of Presenter: Mr. Gergino Chounna Yemele, University of Padova, Italy

Coastal Erosion and Land Subsidence in Lagos Nigeria

The primary causes of coastal subsidence, include soft unconsolidated sediments, groundwater extraction, sea level rise, climate change, and sediment compaction brought on by human activity, are especially dangerous for Lagos State. Significant coastal erosion has been found on many low-lying beaches as a result of research on sea-level rise and coastal erosion by the Nigerian Institute for Oceanography and Marine Research. This erosion is made worse by sand mining and disturbances to natural littoral drift caused by the development of engineering and shipping infrastructure. Furthermore, because almost every home in Lagos has a borehole, the excessive extraction of groundwater to supply the high population density of the state has accelerated subsidence. The issue is made worse by the development of multiple high rise buildings used as offices and residential structures to conserve space, which puts additional strain on the already fragile geological base. Coastal erosion rates of around 100 meters per year have been seen during our most recent erosion monitoring on parts of the eastern side of Eko Atlantic City, including the beaches of Lekki, Okun-Ajah, and Orimedu. Rising sea levels and changed littoral drift have accelerated erosion and increased saltwater intrusion into nearby lands, exacerbating subsidence in these vulnerable locations. Building collapses and infrastructure failures are thus happening more frequently, hence the critical need for better urban planning and monitoring which will contain the anthropogenic and natural variables in order to prevent more loss of life and property.

Name of Presenter: Mr. Daniel Oguwuike Imo, Nigerian Institute for Oceanography and Marine Research

MECHANISMS AND UNDERSTANDING

Land Subsidence Risk Caused by Groundwater Exploitation in Italy

Bonì R.[1], Cigna F.[2], Teatini P.[3], Paranunzio R.[2], Zoccarato C.[3]

1. Department of Science, Technology and Society (STS), University School for Advanced Studies (IUSS) Pavia, Italy;

2. National Research Council (CNR), Institute of Atmospheric Sciences and Climate (ISAC), Italy;

3. Department of Civil, Environmental and Architectural Engineering (ICEA), University of Padua (UNIPD), Italy

Several regions in Italy have been identified with high to very high levels of subsidence susceptibility and hazard. Utilizing satellite Synthetic Aperture Radar (SAR) imagery and Interferometric SAR (InSAR) techniques, a number of subsidence hotspots have been detected. Among these hotspots are the Po River area, Tavoliere, Volturno, Gioia Tauro, and the Florence-Prato-Pistoia plains. The SubRISK+ project (https://www.subrisk.eu) introduces innovative approaches by offering new products and tools derived from Earth observation. Its goal is to improve the understanding of subsidence risks in major urban areas of Italy, promoting the sustainable utilization of groundwater resources and supporting urban development. The project is funded by the European Union – Next Generation EU, in the framework of the Research Projects of Significant National Interest (PRIN) - National Recovery and Resilience Plan (PNRR) call 2022. The project activities will be performed across national, regional, and local scales. The use of advanced groundwater flow and geomechanics model for a "hotspot city" case study will allow to quantify the effects of groundwater exploitation and estimate uncertainties in land subsidence. In this work, the preliminary regional scale results for the Emilia Romagna region (Italy) will be presented.

Name of Presenter: Dr. Roberta Bonì, University School for Advanced Studies Pavia, Italy

Coastal Erosion and Land Subsidence in Lagos, Nigeria: An Overview

Rasheed Olatunji MORUF

Department of Fisheries and Aquaculture, Bayero University, Kano, Kano State- Nigeria

The emerging trends in coastal land subsidence in Nigeria are increasingly influenced by both natural and human-induced factors, particularly due to climate change, urbanization, and resource exploitation. Coastal erosion and land subsidence are interconnected, often amplifying one another, which accelerates land loss, especially in low-lying coastal regions. As land subsides, its reduced elevation makes it more vulnerable to wave action, intensifying coastal erosion and rapidly eroding the shoreline. Coastal erosion, a natural process that reshapes beaches, can push them either landward or seaward. This review examines the causes and impacts of coastal erosion on selected communities in Lagos State, Nigeria, highlighting the variability of erosion across different locations. The main perceived causes include heavy rainfall, severe storms, rising sea levels, land subsidence, human development activities, and even cultural beliefs, such as the anger of the gods. The detrimental effects, ranging from loss of homes and property to groundwater contamination, community relocation, and threats to tourism, differ across communities. These areas are marked by low resilience to coastal erosion, making them highly vulnerable to the future impacts of climate change.

Name of Presenter: Dr. Rasheed Olatunji Moruf, Bayero University Kano, Nigeria

Assessing Future Flood Risks in African Coastal Cities: The Role of Land Subsidence and Climate-Driven Sea Level Rise

Africa's coastal cities are increasingly threatened by flooding due to climate change-induced sea level rise (SLR), compounded by localized land subsidence. This study estimates future relative SLR, inundation hazards, and exposure for 20 African coastal cities by integrating high-resolution land subsidence data with IPCC SLR projections under different emission scenarios. Using Interferometric Synthetic Aperture Radar (InSAR), we map spatially variable subsidence rates, revealing significant sinking (greater than -5 mm/yr) in cities like Alexandria, Lagos, and Luanda. Our results show that subsidence amplifies relative SLR, leading to heightened flood risks, especially in rapidly sinking areas. These findings underscore the need to incorporate satellite-based subsidence data into coastal risk assessments and climate adaptation strategies. Addressing these risks is crucial for safeguarding vulnerable populations and infrastructure in Africa's coastal cities.

Name of Presenter: Mr. Oluwaseyi Adeola Dasho, Virginia Tech, USA

Coasts at Risk?! – Towards Solving Challenges in Flood Hazard and Relative Sea-Level Rise Impact Assessments in Data-Sparse Coastal Lowlands

Coastal lowlands in the world are increasingly exposed to coastal, pluvial and fluvial flooding as well as relative sea-level rise, highlighting the need of comprehensive hazard and impact assessments. For many coasts and deltas, however, the absence or unavailability of high-quality data often challenges to generate comprehensive information about these flood hazards as well as areas, population and assets at risk. Especially as both sea-level rise impact and flood inundation are closely related to land elevation, the quality of these assessments largely relies on vertical accuracy and proper datum referencing of the elevation data used. Here, we present a workflow for increasing the quality of globally available data on coastal elevation by conducting a globally consistent vertical datum conversion of elevation data to continuous local mean sea level. This will allow to increase the reliability of flood hazard and sea-level rise impact assessments where those uncertainties have not or inadequately been addressed so far. We apply our workflow to recently published global digital elevation models and validate them for several key coastal lowlands such as large river deltas, and show the improvement of the performance of global digital elevation models for impact assessments in data-sparse regions. We also show how a first-order assessment of single and multiple flood-type hazards can be conducted for data-sparse, inaccessible coastal lowlands such as the Ayeyarwady Delta in Myanmar. Our investigations are based on only freely available datasets of satellite imagery, global precipitation estimates, satellite-based river discharge measurements, elevation, land use, and population data. The workflow design is highly flexible and allows for the integration and combination of numerous datasets while performing at low computational capacities. As such, our approaches support the evaluation of flood-prone areas on regional and local scale for data-sparse coastal lowlands worldwide, allowing to attribute different types of flood hazards and making use of improved elevation data. Our work serves as a basis to integrate vertical land motion dynamics for deriving implications on relative sea-level rise, elevation change and changes in flood exposure. Therewith, it contributes to achieve a holistic understanding of these interconnected processes which is needed to develop effective risk adaptation and mitigation strategies.

Name of Presenter: Ms. Katharina Seeger, University of Cologne, Germany

IMPACTS AND HAZARDS

Revisiting the Impact of Relative Sea-Level Rise on the Venice Lagoon (Italy)

Luigi Tosi[1], Marta Cosma[1], Cristina Da Lio[1], Sandra Donnici[1], Massimiliano Ferronato[2], Annamaria Mazzia[2], Pietro Teatini[2], Claudia Zoccarato[2]

1. Institute of Geosciences and Earth Resources - National Research Council, Italy
2. Department of Civil, Environmental and Architectural Engineering, University of Padova, Italy

The notoriety of subsidence in Venice has been known worldwide since the 1960s when a catastrophic tidal wave flooded a large part of the city. Since then, much has been done to defend Venice from the effects of land subsidence and global sea-level rise. The regulation of groundwater exploitation, the raising of the city floor, the construction of mobile gates at the inlets, and other works have meant that today most of the city is protected from flooding. While there continues to be great concern about the fate of Venice at the end of the century given the SLR projections, attention has now shifted to the impact of the relative sea-level rise on the lagoon's environment. Accelerated global sea-level rise and land subsidence are seriously threatening the diversity of tidal morphologies that, due to their geomorphological heterogeneity and high biodiversity, support some of the most valuable ecosystem services and have made the Venice lagoon a distinctive landscape. It is therefore important to revisit the concept of the impact of relative sea-level rise on Venice and its lagoon, taking into account the vulnerability of tidal morphologies. This work provides a retrospective overview of land subsidence in Venice and then proposes a new concept of the vulnerability of lagoon morphology to relative sea-level rise. This topic is part of the RESTORE project (PRIN2022PNRR) funded by Next Generation EU, Mission 4, Component 1, Investment 1.1, CUP B53D23033630001.

Name of Presenter: Dr. Luigi Tosi, National Research Council of Italy

Satellite-Based Mapping of Coastal Land Subsidence and Sea-Level Rise Under Future Climate Scenarios for Predicting Coastal Hazards Across West Africa

Sea-level rise and coastal and subsidence are part of the challenges of climate change in most coastal places across the world. These have had major implications because the coastal zone is home to a huge human population, significant natural resources, and a variety of ecological services. To mitigate the effects of climate change, good coastal planning is required to improve the adaption process. Using the CMIP6 models, this study tries to forecast an estimate of the rate of sea-level rise along the Gulf of Guinea in several time slices, such as 2030, 2050, and 2100 for RCP scenarios, as recommended by the IPCC. The Bruun model was used to calculate shoreline recession along West Africa's coasts, and GIS applications were utilized to build inundation models and investigate SLR impact scenarios on land, population, economic activity (GDP), urban extent, agriculture, and wetlands across the region. If no steps to adapt to sea-level rise are done, all of the sea-level rise scenarios will result in increased flooding in the twenty-first century. However, there are many uncertainties, and the number of people expected to be displaced by flooding along West Africa's coasts in 2100 ranges from 3–10 million for the low (50 cm) scenario to up to 15 million for the high (80 cm) scenario. The study therefore recommends the need for more support in research and educational awareness on the impacts of climate change in West Africa, to alleviate the associated coastal hazards and their consequences.

Name of Presenter: Dr. Samuel Olumide Akande, Federal University of Technology Akure, Nigeria

Land Use/Land Cover Change Analysis in Ibeju-Lekki Coastal Fishing Community, Lagos

Evidence indicates a degrading human-land interrelationship in which negative changes in landscape quality keep diminishing the natural environment's productivity and the coastal areas are particularly of concern. This research adopted three (3) temporal periods based on Landsat imageries available to conduct a 36-year multi-temporal land use change analysis from multi-spectral remote sense data for available periods (1984, 2002, 2020). Landsat imageries were accessed at the United States Geological Surveys/ Earth Resources and Observation Science (USGS/EROS) website and multispectral and multitemporal analyses were carried out to determine the study area's land use changes. Imageries were synchronized with Google Earth and ground truthing to validate the classification and change detection/statistics were generated from land use/land cover change maps. The land use change statistics for the Ibeju-Lekki coastal area from 1984 to 2020 indicated a 50% loss of water body, available forested lands were reduced by approximately 14%, while cultivated lands lost 62%. Although minor urban development increased by 48%, land used for major urban development has tremendously increased by 175%. This analysis implies dynamic urban growth at the Ibeju Lekki coastline, which has displaced some artisanal fisheries activities. Urban land uses such as industrial, residential and commercial are major anthropogenic activities that have taken over part of the fishing fields and disrupted artisanal fishing in the study area. Marine Spatial Planning of the study area is therefore recommended.

Name of Presenter: Mrs. Temitope Adejoke Adewale, Lagos State University of Education, Nigeria

Land Use Land Cover Changes Impacts on Estuarine and Coastal Ecosystems Along the Lower Pra River Basin of Ghana

Coastal ecosystems are distinct habitats for plants and other organisms which play crucial role in the well being of humans, as they help regulate the Earth's temperature and remove carbon from the atmosphere. Estuarine and coastal ecosystems (ECSs) serve as buffer zones, particularly during tidal waves and heavy precipitation. However, most ECSs are vulnerable to climate change which is exacerbated by anthropogenic activities, thus modifying natural environment and inducing changes in land use land cover (LULC). This study analyzed LULC trends along the lower basin of the Pra river from 2003 to 2023 using Landsat imagery and supervised classification techniques. Adjoining shoreline change rates were also analyzed from 1974 to 2024 using ortho photos and topographic datasets and DSAS. Results of the LULC analysis revealed significant change in ECSs, including a dramatic decline in forest cover from 58.6% to 25.2% and a rapid expansion of settlements/bare lands from 46.4% to 61.3%. An average shoreline recession rate of 0.1 m/yr was recorded over the entire area, however, average accretion rate of 0.61 m/yr was recorded within 1.4 km near the estuary. Large deposition of sediment was observed in the area, possibly from illegal mining activities, which has altered the original path of the estuary from Shama eastwards toward the Anglo Township. This may explain the recent flooding of the Anglo Township during tidal waves; a situation that could be reverse by strategic dredging. The findings study highlights the need for policy formulation for sustainable ecological management practices to conserve this important ecosystem.

Name of Presenter: Prof. Cynthia Borkai Boye, University of Mines and Technology, Ghana

The Contribution of Coastal Land Subsidence to Potential Sea-Level Rise Impact in Data-Sparse Settings: The Case of Ghana's Volta Delta

Deltas are highly valuable environmental systems, ensuring various livelihoods through their ecosystem services. However, human impact and climate change stressors are impacting deltas immensely. Consequently, many deltas, including Ghana's Volta Delta, are facing increasing risks, especially as hazards are increasing in magnitude and impacting coastal livelihoods. To provide a better understanding of coastal hazards in the Volta Delta, this study assessed the Delta's subsidence regime and its consequences for the potential impact of sea-level rise (SLR). Using the Interferometric Synthetic Aperture Radar (InSAR) technique and Global Navigation Satellite System (GNSS) surveys, vertical land motion (VLM) was documented. Interferograms of Sentinel-1 data from 2016 to 2020 indicated subsiding rates of up to -9.2 mm/yr. By combining local VLM information with recent SLR projections and elevation data, this study updates those projections and provides local assessments of potential Relative SLR (rSLR) impact. According to these locally improved scenarios, up to 45 % of the Delta will fall below local sea level by 2100, of which close to 10 % is explained by the integration of local VLM data alone. Depending on the climate change scenarios used, land subsidence will increase the deltaic area at risk by 4.31 % (96.27 km2) to 10.18 % (227.64 km2) and consequently exacerbate its exposure to coastal inundation. To avert the projections, the study recommends robust monitoring regimes; alternative freshwater sources to groundwater; reduced sediment trapping and river obstruction; and the need to stall ongoing oil and gas prospecting and subsequent extraction in the Voltain Basin.

Name of Presenter: Dr. Selasi Yao Avornyo, University of Ghana

MODELLING AND MITIGATION TECHNIQUES

Modelling Land Subsidence Accounting for Uncertainties

Pietro Teatini, Claudia Zoccarato, Yueting Li

Dept. of Civil, Environmental and Architectural Engineering – University of Padova, Italy

A main factor controlling land subsidence due to subsurface fluid withdrawal is the bulk compressibility cb of the aquifer systems. This is generally largely unknown and heterogeneously distributed. In the majority of the case studies, cb values are available at a few locations and depths only, as provided by oedometric laboratory tests on undisturbed soils samples, interpretation of transient pumping tests, and compaction measurements recorded by extensometric stations. How much the uncertainty associated to our knowledge of cb can affect the predictions of geomechanical modelling? Recent numerical approaches have been focused on incorporating this spatial uncertainty in the simulation outcomes. This contribution reviews a few exemplificative case studies where different methodologies have been used. Facies model has been used to simulate land subsidence in the Chaobai plain, to the north of Beijing, China, where the hydrogeologic system of alluvial fan are characterized by a heterogeneous distribution of various lithological units. A Data Assimilation technique is implemented to reduce uncertainty in predicting land subsidence caused by hydrocarbon production from an off-shore reservoir in Italy taking advantage of the increasing availability of in-situ measurements over time (bathymetric surveys, GNSS records, compaction of markers at depth). A sparse-grids-based Bayesian framework is developed to infer cb of the over-exploited aquifer system in the Alto Guadalentin valley, Spain, using Interferometric Synthetic Aperture Radar (InSAR) ground displacement datasets.

Name of Presenter: Prof. Pietro Teatini, Chair of Unesco LaSII/ Co-chair of ENGULF Project/ University of Padova, Italy

Assessing the Impact of Sea Level Rise, Precipitation, and Subsidence on Flooding Trends in Coastal Communities of Ghana

Coastal areas in Ghana are increasingly vulnerable to erosion and flooding, driven by both climatic changes and human activities. This study integrates high-resolution data from Unmanned Aerial Vehicles, satellite imagery, and Digital Elevation Models with hydrological modelling via the malstroem (Bluespots) model to assess coastal dynamics along Ghana's central and eastern coasts. Aerial surveys using a DJI Phantom 4 drone and satellite data from 1974 to 2023 illustrated short to midterm shoreline changes. In Mumford, while erosion rates appeared modest, a significant 53.33% of the coastline is eroding, intensified by sand mining and infrastructural developments like the new landing site. Conversely, Atiteti exhibited more drastic retreats, with 93.33% of its coastline affected due to both natural and anthropogenic factors. These findings underscore the necessity for region-specific coastal management strategies. Persistent Scatterer Interferometric Synthetic Aperture Radar (PSInSAR) analyses and bathtub model projections based on Shared Socioeconomic Pathways highlighted considerable flood risks. Under the high-emission scenario SSP 5-8.5, projections suggest that up to 47% of Atiteti could be submerged by 2100, exacerbated by geological and human-induced subsidence. The malstroem model simulations further revealed that, in Mumford, flooding risks increase significantly with even moderate rainfall (100 mm), expected to inundate up to 55,000 sqm by 2040 and over 60,000 sqm by 2060 due to subsidence. Atiteti showed a progressive increase in flood areas without plateauing, even at high rainfall levels (300 mm), emphasizing the impact of its flatter terrain and inadequate drainage. This comprehensive analysis highlights critical vulnerabilities and the urgent need for robust, data-driven policies and adaptive strategies to enhance the resilience of these key coastal regions against severe environmental threats.

Name of Presenter: Mr. Michael Kwame-Biney, University of Ghana

Building Coastal Resilience in Africa: Nature-Based Solutions

Africa's coastal regions are increasingly vulnerable to the impacts of climate change, land subsidence, and rising sea levels. These challenges threaten both ecosystems and the communities that rely on coastal resources for their livelihoods. In response, nature-based solutions (NbS) are emerging as a sustainable approach to mitigate the risks and build resilience. This presentation explores the potential of NbS, such as mangrove restoration, wetland conservation, and dune stabilization, to enhance coastal resilience in Africa. Drawing from case studies and research within the ENGULF Research Programme, it highlights the role of ecosystems in reducing vulnerability to flooding, erosion, and subsidence. By integrating NbS into coastal management, African nations can protect biodiversity, safeguard livelihoods, and strengthen their adaptive capacity to environmental change. The presentation will also address the socio-economic benefits of these solutions, including cost-effective alternatives to traditional infrastructure, and the importance of community involvement in implementing and maintaining these strategies. Ultimately, this work underscores the critical need for collaborative efforts that link scientific research, policy, and local action to ensure the sustainability of Africa's coastal ecosystems and communities.

Name of Presenter: Ms. Chinomnso Chinazum Onwubiko, University of Cape Coast, Ghana

Projecting And Mitigating Land Subsidence in Sinking Deltas

Land subsidence is a critical issue affecting deltaic regions globally, intensifying the effects of climate change and sea-level rise. In this presentation we discuss methodologies for projecting and mitigating land subsidence in sinking coastal-deltaic areas around the world. We will analyse how the factors contributing to subsidence, including groundwater extraction and sediment compaction, can be simulated using advanced modelling models to enhance our understanding of spatio-temporal, and non-linear, subsidence dynamics. Through integration with observations the models are validated and used as predictive tools to create projections of future land subsidence following different scenarios. Apart from projections these tool can furthermore be utilized to test and evaluate the potential effects of different mitigation strategies, including sustainable groundwater management and sediment replenishment. This enables the creation of science-informed management strategies that aim to reduce human-induced accelerated subsidence and thereby increase resilience of deltaic regions. We highlight the need for researchers, policymakers, and practitioners to engage in cross-disciplinary and sectoral collaboration to effectively address the challenges of coastal land subsidence and implementing effective solutions for sustainable development in sinking deltas and lowly elevated coastal zones.

Name of Presenter: Philip Minderhoud, Co-chair of ENGULF Project/ Wageningen University and Research, Netherlands

POSTER PRESENTATION SESSION

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11.	**Mr. Nanabanyin Kwame Okwentsie Ekumah**	Modelling the Morphodynamics of Fuveme Beach Within the Volta Delta, Ghana

Inter-Relationship of Sea Level Rise and Coastal Erosion: Evidence of Climate Change in Lagos, Nigeria

Sub- Saharan Africa is one of the world's fastest urbanising regions and is currently experiencing an annual urban population growth rate at 4.1%. The global share of African urban residents is projected to grow from 11.3% in 2010 to 20.2% by 2050. The risk of African harbour cities such as Lagos from the threat of rising sea levels due to climate change has been highlighted by various studies. However, fewer studies have been undertaken to ascertain climate change impacts on individual cities. The Lagos State Climate Risk Assessment is a study dedicated to ascertaining and quantifying Lagos' exposure to climate risk. From the report, it was revealed that various parts of the city were affected based on three factors viz: proximity, severity, and frequency of climate hazard occurrence. This report served as one of the tools for developing the adaptation element of the Lagos Climate Action Plan: Second Five-year Plan 2020 – 2025. This study aims, therefore to provide empirical reasoning supported with GIS and statistical analytical methods supported to assess the evidence of climate change in sea level rise and coastal erosion along coastal local governments in Lagos State. From the vulnerability assessment, 6,983 features were identified to be vulnerable to the impacts of climate change across the coastal local government areas in the State. Empirical evidence during fieldwork revealed that features along shoreline, particularly shoreline along the Atlantic Ocean in areas such as Alfa Beach, Okun Ajah, Idasho, Idotun and Ilege have the highest degree to threats from coastal erosion and sea level rise. In this study, actual measurements and GIS analysis were carried out for the period of three years to show the extent of erosion and how land was actually being lost to the sea. The result is to prove that the shoreline has been eroded gradually over the years with proven evidence from actual measurements, GIS analysis & pictures, therefore, proper infrastructure development to prevent flooding and further coastal erosion should be carried out by appropriate agency of Government.

Name of Presenter: Mr. Adedoyin Lasisi, Ministry of Environment, Nigeria

GIS and Remote System Analysis of Flooding as a Natural Disaster Due to Land Use/Land Cover, Soil Variation, Drainage System and Drainage Pattern, and Precipitation: A Case Study of Lake Eleyele – River Ona

The re-occurence of flooding as a natural disaster and its impacts to the environment globally cannot be over emphasized. This study assessed the impacts of flood in Lake Eleyele – River Ona due to land use/land cover, soil variation, precipitation, drainage system and drainage pattern through the use of enhanced, georeferenced, and classified 5 year 2014, 2019 and 2024 time series 30m spatial resolution (LandSat 7and LandSat 8) and 4km spatial resolution of CHRS datasets for April - July using ArcGIS 10.8, Erdas Imagine, Google Earth softwares and Microsoft Excel. The results of the study shows that the study area in Year 2014 experienced increase in mean precipitation rate from April 205mm3 to 272mm3 in May followed by a decrease from 173mm3 June to 137.5mm3 in July. Also in Year 2019, April experienced mean precipitation of 199.5mm3 with the highest at 236mm3 in May and sharp decrease of 110mm3 in June and 111mm3 in July. Furthermore, in Year 2024, April had mean precipitation of 89.5mm3 and 217mm3 in May, highest in June at 251mm3 and decrease in July at 203.5mm3. Increase in mean precipitation in each time frame of Year 2014, Year 2019 and Year 2024 resulted in high water accumulation of Lake Eleyele and water flow of River Ona which affected drainage system and pattern of River Ona, thus making the study area susceptible to flooding. This resulted in noticeable change in fauna movement, human activities and settlement, and change in land use/land cover.

Name of Presenter: Ms. Adepeju Eunice Willoughby, National Open University of Nigeria

Coastal Land Subsidence Using Community Participation Resilience (Cpr) Index.

Coastal land subsidence poses significant threats to communities worldwide, necessitating effective resilience strategies. This study investigates the impact of community participation on coastal land subsidence resilience, focusing on quantifying the relationship between participation and resilience. A mixed-methods approach combines survey data from Lagos coastal residents, focus groups, and expert interviews in three subsidence-prone areas of Lagos coast by purposive sampling method. Results will explain community participation has it influences or significantly enhances resilience. Regression analysis will explain the level of participation and correllation with resilience. This study will develop a Community Participation-Resilience (CPR) index, enabling policymakers to quantify and predict resilience gains from community engagement. Findings will inform evidence-based strategies for enhancing coastal land subsidence resilience, emphasizing the critical role of community participation in adapting to this growing global challenge.

Name of Presenter: Mr. Ayodele Oduwole, University of Lagos, Nigeria

Assessing Perceptions and Willingness to Pay for Marine Plastic Litter Reduction in Montserrado County: Implication for Coastal Land Resilience

In the lack of suitable coastal management strategies, the problem of marine plastic litter contamination is complex, cross-sectoral, and persistent. Marine plastic litter is an enormous risk to the world's seas, ecosystems, and economies (Abalansa et al., 2020; Senko et al., 2020; S. Sharma et al., 2021). Marine plastic pollution is a growing environmental threat, particularly in coastal regions where its accumulation affects and undermines the stability and resilience of coastal land. This study explores public perceptions of marine plastic litter and examines the willingness of coastal communities in Montserrado County to pay for its reduction. Using a structured survey of residents, the study aims to assess the level of awareness regarding the impacts of marine plastic waste and identify the financial commitment individuals are willing to make to support mitigation initiatives. The findings highlight a critical link between public perception and action, revealing that while many individuals recognize the environmental harm caused by marine plastic, there is variability in their readiness to contribute financially to reduction efforts. This variability is affected by socioeconomic characteristics and information accessibility. The study also discusses the implications of these findings for coastal land resilience, emphasizing the need for comprehensive, community-driven policies that not only address pollution but also strengthen the capacity of coastal areas to withstand environmental pressures. The research concludes with recommendations for integrating public engagement with sustainable coastal management strategies to enhance environmental and socio-economic resilience.

Name of Presenter: Ms. Balatrice Gifty Kerkula, University of Cape Coast, Ghana

Assessing Physico-Chemical Factors, Heavy Metals and Zooplankton Diversity in a Southwest Nigerian River: Implications for Ecosystem Health

By [1]Eunice Opeyemi Idowu and [2] Titilayo Deborah Aderibigbe

1 & 2 Ekiti State University, Department of Zoology and Environmental Biology, Faculty of Science, Ado Ekiti, Ekiti State, Nigeria

The aim of this study is to determine the physico-chemical parameters, heavy metals and zooplankton of Elemi River. Physico-chemical parameters, heavy metals and zooplankton were determined using the American Public Health Association (APHA) standard methods. The Results showed monthly variations in the parameters; The mean values of the physico-chemical parameters recorded were: Temperature 27.88±1.24 °C, pH 6.69±0.23, EC 137.73±17.79s/cm, Turbidity 11.71±0.99 NTU, TDS 97.74±12.85 mg/L, TSS 78.89±7.59 mg/L, DO 5.17±0.28 mg/L, BOD 21.08±3.70 mg/L, COD 62.22±9.90, mg/L, Alkalinity 37.21±2.76 mgCaCO3/L and Total Hardness 58.50±7.99 mg/L. Mean values of the heavy metals recorded were: Copper 0.03±0.01 mg/L, Iron 0.15±0.02 mg/L, Zinc 0.02±0.01 mg/L, other metals values were Calcium 26.17±3.32 mg/L, Magnesium 11.31±2.22 mg/L, and Nutrients; Phosphate 0.60±0.08 mg/L, Nitrate 1.46±0.15 mg/L. For Zooplankton; Chlamydomonas sp has the highest percentage abundance of 35.93% followed by Nanochloropis sp 14.71%, diatoms 13.86%, Euglena sp 9.52%, Pheaodactylum sp 12.55% and the least was Amoeba sp (13.43%). The results showed that all the physico-chemical parameters and heavy metals values recorded were within the permissible limit of set standards of FEPA except turbidity, BOD and Fe which were above the permissible limit. The relationship between physico-chemical parameters, heavy metals and zooplankton in River Elemi ecosystem is intricately linked to water quality and ecological health. Improvement in the water quality and species diversity management, in this river is required.

Keywords: Assessement, Physico-Chemical Parameters, Heavy metals, Zooplankton

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Name of Presenter: Prof. Eunice Opeyemi Idowu, Ekiti State University, Nigeria

Geo-Environmental Assessment of Land Subsidence in a Mining Town

Underground mining is considered safer than surface mining because it neither removes fertile topsoil nor leaves exposed pits. However, the removal of soil and rocks beneath the earth can have geological impact on the stability of the surface. This poses significant risks, such as the collapse of buildings or underground tunnels. Monitoring land subsidence is therefore critical for ensuring the safety of construction in mining areas. Obuasi, a historic mining town in Ghana with over a century of underground mining, faces the potential risk of residual land subsidence, a gradual surface settling that may take decades to become noticeable. Although incidents of subsidence-related disasters have been rarely recorded, the long history of mining, coupled with recent incidents of illegal mining activities, suggests a high likelihood of unnoticed subsidence which should be mitigated to prevent structural failures. Measuring subsidence requires elevation data over time from sources such as Spirit Levelling, GPS/GNSS, satellite-based Synthetic Aperture Radar (SAR), and LiDAR, an aerial laser scanning technology for high-accuracy surface modeling. Additionally, geo-environmental factors like soil type, soil moisture and depth of underground water contribute to subsidence and should be considered. This study aims to identify land subsidence hotspots and its concomitant geo-environmental factors in Obuasi, using LiDAR, SAR and other satellite-based observation technologies.

Name of Presenter: Mrs. Harriet Atsufui Ahorsu, Kwame Nkrumah University of Science and Technology, Ghana

Comparative Assessment of Water Quality in Three Coastal Lagoons Along Ghana's Eastern Coast

John K.senu[1], Joseph Aggrey-Fyn[1], Paul K. Mensah[1], Dennis K Adotey[2]

1. Department of Fishery and Aquatic sciences, University of Cape Coast
2. National Nuclear research Institute, Ghana Atomic Energy Commission

Ghana has been experiencing a significant loss of its vegetated coastal Ecosystem, approximately 8.1 km² annually, attributed to various anthropogenic activities. Assessment of water quality tests of Keta, Laloi and Gao lagoons were studied for seven months to evaluate their relative contribution to their current state using APHA. Water pH, temperature, EC and TDS were measured in situ whilst, NO3-, SO42 , PO43-, Na, K, Mg and Ca were measured using IC. The least pH measured was 6.73 ± 0.07 in Keta and the maximum was 7.10 ± 0.11 in Laloi lagoons. During the study temperature was steady and increased (26.00 ±0.17 - 27.4 ± 0.98) among the three coastal lagoons. Salinity values varied at different sites, 1.11 to 33.36 ‰, EC and TDS ranges 4.93 ± 29.51 to 44.45 ± 10.19 mS/cm) and 2.49 ± 10.40 to 28.74 ± 7.09 mg/L in Gao and Laloi lagoons respectively. Nutrient and organic matter were among the frequent source of pollution in all the lagoons. Mean sulphate, phosphate and nitrate concentrations of 816.95 ± 2647.13 to 8634.14 ± 79.57; 12.74 ± 2.41 to 18.24 ± 20.04, and 4.88 ± 1.16 to 13.97 ± 3.69 mg/L, 4.88 ± 1.16 Gao and Laloi respectively. TOC displayed high percentage values (1.26 to 3.01%). The three lagoons studied were connected; however, Gao Lagoon is exposed to dramatic deterioration in its water and sediment quality due to different wastes discharged. The study, however, suggested enforcing the controls on waste discharged into lagoons.

Name of Presenter: Mr. John Kudjoe Senu, University of Cape Coast, Ghana

Allometry, Condition and Morphometry of Three Cichlid Species from Lake Alau, Semi-Arid Zone, Nigeria.

Fish food supply from inland waters are plummeting due to the effect of global environmental changes. Therefore, this study aimed to analyse the growth pattern, condition and morphometry of three cichlid species in Lake Alau, Nigeria. A total of 50 specimens each of Coptodon zillii, Oreochromis aureus and Sarotherodon melanotheron were examined using 9 morphometric measurements. Slope value (b) estimated for C. zillii was found to be 2.069, for O. aureus 1.518 and for S. melanotheron was 1.914. The regression equation calculated for C. zillii was Log W = 2.069 – 0.291 Log L, for O. aureus was Log W = 1.518 + 0.093 Log L and for S. melanotheron was Log W = 1.914 – 0.320 Log L. The condition factor was 2.32±0.63, 1.87±0.50 and 1.71±0.20 for C. zillii, O. aureus and S. melanotheron, respectively. The three cichlid species exhibited negative allometric growth pattern, and good physiological condition in Lake Alau. Coefficient of variation values estimated revealed a low intra-group variation (CV<25%) for all characters in C. zillii and S. melanotheron. Mean size of all the morphometric parameters show significant higher values in O. aureus compared to C. zillii and S. melanotheron. The study establishes the growth pattern, condition and morphometry of C. zillii, O. aureus and S. melanotheron in Lake Alau, Nigeria. This will assist in conservation and management of these stock for sustainable use of the people.

Name of Presenter: Mrs. Mayowa Omobola Awoyale, Nigerian Institute for Oceanography and Marine Research

Assessing the Flood Risks Associated With Intense Rainfall in the Coastal Area of Lagos State, Nigeria

Salami Moses. A Nigerian Institute for Oceanography and Marine Research
Corresponding author: salami_ma@niomr.gov.ng

This study examined variability and trends in the magnitude/frequency of intense rainfall between the years 2000 and 2021 in the coastal area of Lagos, and determined the flood risks associated with magnitude/frequency of intense rainfall in the coastal area of Lagos. These were with the view to determining the flood risks associated with increasing frequency and magnitude of intense rainfall in the study area. Descriptive and inferential statistics were used to analyse the various datasets. The flood risk assessments were analysed and mapped using Multi-criteria analysis (MCA) on ArcGIS, software. The results of the coefficient of variation showed that moderate rainfall is more reliable than very heavy rainfall in Ikeja and Lekki respectively. In terms of trends, the frequency of very heavy rainfall significantly declined in Ikeja and Lekki at 95% level of significant ($r = -0.49$, $r = -0.42$). However, moderate rainfall increased but not statistically significant ($r = 0.21$, $r = 0.23$). In term of variability, moderate rainfall is more stable than very heavy rainfall. The magnitude/frequency of rainfall show a positive relationship in the area, and these patterns suggest that very heavy rainfall may not sufficiently explain reported increased flood cases in the area as this may be attributed to other anthropogenic influences. The research findings indicate that coastal settlements in the study area are vulnerable to high flood risks, driven by the increasing frequency and magnitude of intense rainfall events.

Keywords: Climate change, Hazards, Coastal area, GIS, Rainfall.

Name of Presenter: Mr. Moses Adelakun Salami, Nigerian Institute for Oceanography and Marine Research

Modelling the Morphodynamics of Fuveme Beach Within the Volta Delta, Ghana

Nanabanyin Okwentsie Ekumah [1,2*], Paul Kojo Mensah [1,3], Emmanuel Acheampong [1,2], Emmanuel Kwadzo Brempong [1,2,4], Philip-Neri Jayson-Quashigah [5], Godson Hoenyedzi [6], Frederick Sam [7], Donatus Bapentire Angnuureng [2]

1. Department of Fisheries and Aquatic Sciences, University of Cape Coast, Cape Coast, Ghana
2. Africa Centre of Excellence in Coastal Resilience, Centre for Coastal Management, University of Cape Coast, Cape Coast, Ghana
3. Institute for Water Research, Rhodes University, Makhanda, 6140, South Africa
4. LEGOS, OMP, UMR 5566 (CNES-CNRS-IRD - University of Toulouse), Toulouse, France
5. Institute for Environment and Sanitation Studies, University of Ghana, Legon, Ghana
6. Hydrological Services Department, Accra, Ghana
7. Department of Physics, University of Cape Coast, Cape Coast, Ghana

*Corresponding author email: nanabanyin.ekumah@ucc.edu.gh

Magnitudes of coastal erosion have been rising globally due to climate change and anthropogenic activities. Intense erosion and flooding, which have displaced people at various coastal areas have mainly been attributed to the reduction of fluvial sediment and the lack of appropriate understanding of the sediment budget. The Fuveme coastline on the eastern side of Ghana has been experiencing regular erosion and flooding since the mid-1880s. A seasonal breach in the sand spit at Fuveme causes overtopping, and tidal waves to transport water and sediment in a multidirectional pattern. Using drone surveys of one year and numerical modelling approaches, this study assessed the geomorphic variabilities and sediment motion along the coastline of Fuveme. Aerial photographs of the beach were collected from October 2021 to October 2022. Sediment and wave dynamics were assessed using MIKE 21 model between May 2022 – July 2022. The results showed significant sediment exchange with shoreline erosion, sediment volume changes as a consequence of the overtopping/flooding and the hydrodynamic conditions that are resident on Fuveme Beach. Over the study period, sediment volume deposition was prevalent on the beach, yet the average shoreline eroded by 18.02 ± 0.25 m in a year, representing shoreline recession. The dominant direction of sediment transport was eastward with a mean direction of 41.01°. Further studies are recommended to ensure a deeper understanding of Fuveme Beach dynamics and for better coastal management purposes in the Volta Delta as a whole.

Keywords: Accretion; Erosion; MIKE 2l model; Sandbar breaching; Sediment transport.

Name of Presenter: Mr. Nanabanyin Kwame Okwentsie Ekumah, University of Cape Coast, Ghana

Application of Satellite Radar Interferometry Techniques for Monitoring Land Subsidence, A Case Study

Sea level rise as a result of climate change contributes immensely to coastal erosion and flooding in most low-lying coastal regions of West Africa. Coastal erosion and flooding lead to loss of livelihood, valuable lands and assets situated along coast. This condition is exacerbated by subsiding coast resulting from natural and anthropogenic factors as observed by some authors lately in some delta regions including the Volta delta of Ghana. Land subsidence is a crucial environmental challenge which poses serious dangers to human settlements, ecosystems, and infrastructure. This study aimed at assessing land subsidence in the Keta area using Differential Synthetic Aperture Radar Interferometry (DInSAR) and Persistent Scatterer Interferometry (PSI) techniques spanning a 2-year period. 31 sets of Sentinel-1 SLC-IW data in 24-day intervals were downloaded from the Alaska Satellite Facility portal. The Sentinel-1 SAR dataset was processed using Sentinel Application Platform (SNAP) software adopting the SNAP2StaMPS Python workflow to generate high-resolution interferograms which significantly revealed land displacement and subsidence with uplift patterns over the study period. The results indicate varying uplift with values up to 6 mm/yr and subsidence rates across the region, with certain areas experiencing more pronounced subsidence of approximately 27 mm/yr. The study confirmed the occurrence of subsidence within the study area which could be attributed to natural geological processes of mass settling and human factors such as excessive extraction groundwater. The findings call for pragmatic strategies for continuous monitoring to mitigate the environmental and infrastructural impacts of land subsidence in this vulnerable coastal region.

Name of Presenter: Mr. Onesimus Begua Addo, University of Mines and Technology, Ghana