

## **ABSTRACT**

The coastal zone refers to the interface between the land and sea. This very important environment comprises a range of coastal lands and aquatic systems that support a wide range of critical habitats and unique biodiversity. The coastal zone is home to a large percentage of the human population. About 60% of the world's megacities are situated in the coastal zones and 40% of all the people on the planet live within 100 kilometers of the coastal zone. Several infrastructural systems that form the backbone of our society can be found within the coastal zone. The coastal zone exhibits the closely interconnected and interdependent relationships between humans and coastal resources. This interconnectedness amplifies the most urgent questions of limits and equilibrium, sustainability and conservation, as well as exploitation and development in today's world. Managing coastal zones presents several challenges as they are complex and fragile environments that are continually changing.

Coastal zones have been shaped in the past by the dynamic interaction of marine, terrestrial and atmospheric processes. However, in recent times, extreme climatic events, sea-level rise and increasing human activities are increasing the coastal system's vulnerability, making it susceptible to coastal hazards. Although variations in sea levels are natural responses to climate change, geodetic variations, movements of the seafloor, and other earth processes, human actions such as drainage of wetlands and withdrawal of groundwater may also contribute to the rise in sea levels through coastal land subsidence. Local anthropogenic activities such as coastal resources exploitation and extraction; infrastructural developments to accommodate increasing coastal population and industries; destruction of coastal vegetation (e.g. mangroves); upstream watershed management (e.g. construction of dams on major rivers for hydropower generation and irrigation); dredging of waterways for shipping and commerce; beach sand mining; and the construction of ports and coastal defense structures (e.g. groynes, seawalls, revetments) have opened up the coast to energetic wave attack, reduced sediment inflow into the littoral system, blocked sediment transport pathways, reduced beach sand volumes or rendered the coastal systems less resilient to naturally fight coastal hazards.

The increasing human development and encroachment on the strip of land that separates human activities from the shoreline's dynamic processes is denying the shoreline the much-needed space for it to naturally evolve. This has resulted in a "coastal land squeeze" situation. The continuous struggle for space between humans and the shoreline disturbs the equilibrium state of the coastal environment and accelerates changes in the coastal zones, which results in terrible consequences with environmental and economic implications.

Twenty-five (25) coastal erosion hot spots have been identified along the coast of Ghana that are eroding at varying rates and intensity due to the significant geomorphological variability. The eastern coast, where the Volta Delta is located, is the most vulnerable. Coastal communities that are the front-line of the direct effect of the coastal erosion hazard are experiencing the impacts in various forms. Coastal erosion has displaced households, destroyed sources of livelihood, damaged properties and almost wiped out an entire community (Fuvemeh in 2021). Challenges in the coastal zone are projected to accelerate under increasing sea-level rise. This will expose low lying vulnerable coastal communities to coastal erosion hazards. The impact of sea-level rise on coastal infrastructure will be high since it has not been factored into the design and maintenance of several coastal infrastructures. Under IPCC projected sea-level rise scenarios, landmark features such as the Christianborg Castle, Independence Square and Kwame Nkrumah Mausoleum located in Accra will erode between 50 and 150 years' time with 2002 as the baseline year. It is, therefore, not surprising that the Office of the President was relocated from the Christianborg Castle in Osu-Accra to its present location (Jubilee House). Future projections again suggest that between approximately  $4.7 \times 10^6$  m<sup>2</sup> and  $8.2 \times 10^6$  m<sup>2</sup> of coastal land will be eroded in Accra alone by the year 2252 (2002 as baseline year) over an estimated length of about 40 kilometres. Present and future coastal erosion challenges call for the development of pragmatic management strategies based on research.

Sustainably managing coastal erosion is progressively becoming a huge challenge in Ghana. We find ourselves in this current management quandary mainly because of the local 'political' and 'economic' pressures, which are backed by limited science and policy intent. Ghana has resorted to 'fighting' coastal erosion instead of managing it – a war we may never win. The approach adopted to manage coastal erosion is mainly the hard engineering method – i.e., construction of groynes (shore-perpendicular structures used to maintain eroding up-drift beaches or to restrict longshore sediment transport) and revetments (shore

parallel structures constructed to protect coastal properties). The hard engineering approach seeks to resist the natural coastal system dynamics instead of enhancing their resilience. Using groynes have the potential to accelerate coastal erosion in adjacent down-drift areas, which may require the need for additional hard structures that are practically inappropriate. Placement of revetments will decrease the release of sediments from the sections they protect, which impact negatively on the sediment budget along adjacent shorelines and increase erosion on the adjacent beaches.

This business-as-usual 'one solution fits all problems' approach is not sustainable, environmentally unfriendly, and difficult to maintain. The temporary success stories are just a postponement of the problems or a transfer of the problems to the adjacent shoreline. Shifting the status quo and changing the paradigm from 'fighting with nature' to 'building with nature' should be the basis upon which we can develop sustainable and effective strategies for coastal erosion management in Ghana. There is an urgent need to develop a new coastal management culture based on consistent shoreline statutes assessment due to the emerging global geophysical changes and a set of coastal management policies driven by research.

This lecture seeks to discuss the coastal processes in the coastal zone that result in coastal erosion, and how the continuous struggle for space between anthropogenic activities and shoreline evolution has exacerbated coastal erosion problems in Ghana. The lecture will present Ghana's approach to managing coastal erosion and present my research work on coastal erosion dynamics, innovative approaches to monitor coastal erosion as well as methods developed for shoreline evolution trend analysis in data-sparse coastal nations.

## PROFILE

**Personal Details:** Professor Kwasi Appeaning Addo is a Professor in Coastal Processes in the Department of Marine and Fisheries Sciences, University of Ghana. He comes from Akyem Begoro in the Fanteakwa North District of the Eastern Region, Ghana. His parents, the Late Mr. Samuel Yaw Addo and Mrs. Mercy Gyamfuah Addo are both from Begoro. He is the third of five siblings with two elder brothers and two younger sisters. Professor Appeaning Addo is married to Dr. (Mrs.) Irene Appeaning Addo, a Senior Research Fellow at the Institute of African Studies, University of Ghana and a Professional Architect and they are blessed with three children – Kwabena Appeaning Addo, Amma Gyamfuah Appeaning Addo, and Adwoa Agyapomaa Appeaning Addo. He enjoys gardening as a hobby and loves listening to classical music during his leisure hours. He is a Presbyterian and worships with the Calvary Congregation of the Presbyterian Church of Ghana in Haatso-Accra where he served as a Presbyter from 2014 to 2018.

**Educational Background:** Professor Kwasi Appeaning Addo started his primary education at the Effiduase Methodist Primary and the Koforidua Methodist Primary 'C' Schools respectively. He continued at the Nana Kwaku Boateng Experimental School also in Koforidua where he wrote the Common Entrance Examination in 1981. He then proceeded to the Koforidua Secondary Technical School (SECTECH) for both his Ordinary and Advanced Levels and completed in 1986 and 1988 respectively. He did his post-Advanced Level National Service at the Okrakwadwo Health Center in the Eastern Region. He then proceeded to the Kwame Nkrumah University of Science and Technology for his undergraduate studies in Geomatic Engineering in 1989 and completed in 1993. He had his post-Undergraduate National Service at the Assin District Assembly in Assin Fosu in 1994, where he also became the Central Regional President of the National Service Personnel Association.

In the year 2000, Professor Appeaning Addo enrolled for his MPhil Studies in Geomatic Engineering at the Kwame Nkrumah University of Science and Technology. During his Masters' studies, he developed a research interest in coastal processes and its impact on coastal zone management and planning. In 2004, he was awarded a GETFUND Scholarship to pursue his PhD studies in coastal processes at the School of Civil and Geosciences, the University of Newcastle upon Tyne in the United Kingdom. Professor Appeaning Addo had certificate training in the Exclusive Economic Zone Management and Operational Course in 2012 and in Maritime Boundary Delimitation and UNCLOS Article 76 (CARIS LOTS) in 2013. He also had training in teaching in higher institutions at the University of Newcastle upon Tyne in 2005.

**Professional Background:** Professor Appeaning Addo began his career as a Geomatic Engineer in 1994 at the RUDAN Engineering Limited, a private consultancy firm in Accra where he was involved in executing Geomatic Engineering projects all over Ghana. In 1999, he joined the Accra Polytechnic (now Accra Technical University) as a lecturer in the Department of Building and Civil Engineering. While lecturing at

the Accra Technical University, he took up a part-time lectureship in Physical Oceanography and Coastal Geomorphology in the Department of Oceanography and Fisheries in the then Faculty of Science (now Department of Marine and Fisheries Sciences), School of Biological Sciences, College of Basic and Applied Sciences, University of Ghana, in 2008. He was appointed full-time faculty member in 2010 to teach Physical Oceanography at the graduate level, as well as Coastal Engineering and Coastal Geomorphology at the undergraduate level. Through hard work and the Grace of God, Professor Kwasi Appeaning Addo was promoted to Senior Lecturer in 2013, Associate Professor in 2015, and Professor in 2020.

**Membership of Professional Bodies:** Professor Kwasi Appeaning Addo has served as a member of several bodies including the Ghana Institution of Engineers, Ghana Institution of Surveyors, Remote Sensing and Photogrammetry Society, Society of Wetlands Scientists, American Geophysical Union, Union for African Population Studies, Partnership for Environment and Disaster Risk Reduction, and the University Teachers' Association of Ghana.

**Research and Areas of Expertise:** Professor Appeaning Addo's research focus has been on nearshore coastal processes, shoreline dynamics and coastal erosion complex interactions; shorelines and river systems linkages; new approaches (drone and video) in coastal systems monitoring; sea-level rise and subsidence interrelationships; nature-based solution; integrated and sustainable green ports concepts; and in recent times sargassum pathways. Through his research, he has emerged as one of the leading coastal geomorphologists in Africa today. His contribution to the field of coastal processes and shoreline dynamics has provided an understanding of the coastal systems in Ghana and the Bight of Benin. He collaborates extensively with several researchers in Ghana and abroad to undertake his research works.

Professor Appeaning Addo's research work in coastal erosion dynamics in Ghana and West Africa has gained global recognition and impacted significantly on coastal erosion management. It has received several citations, including the Intergovernmental Panel on Climate Change (IPCC). He is the 8th most cited researcher in coastal erosion studies globally and has granted interviews on his research work on high-profile media platforms such as the British Broadcasting Corporation (BBC), Aljazeera, Deutsche Welle (DW), Le Monde Afrique and the Ghana News Agency (GNA). He was also featured in a scientific documentary on climate change, which was shown during the plenary session at the 2015 Paris Climate Conference (COP21). He has to his credit 94 journal publications including Nature Climate Change, book chapters and books. He has presented the results of his research work in several conferences, seminars, and workshops globally as a keynote speaker, presenter or discussant. He has also consulted for several organizations (local and international) on coastal erosion-related issues.

### **Some Innovative Research Works of Prof Kwasi Appeaning Addo**

1. His pioneering work in developing a methodology by combining satellite remote sensing, photogrammetry, and in-situ approaches in shoreline evolution studies in data-sparse environments, opened a new chapter in this area of research globally.

The approach he developed has been used in several countries for coastal erosion and shoreline morphology studies. It has also become the main source of reference in coastal erosion studies in several data-sparse countries.

2. His ground-breaking methodology in monitoring dynamic coastal systems using Unmanned Aerial Vehicle (drone) has revealed the potential of using drone technology as a tool for effective communication of coastal hazards and coastal disaster management. The Canadian Geographic in 2016 described his work as an "innovative research in a developing country".

Again, his research work using a drone in Ghana was used to develop teachers' workbooks for teaching in schools in Canada. A presentation on the drone research was well received and applauded by a scientific audience at the School of Geography and the Environment, the University of Oxford in the United Kingdom in 2016. This same research gave Prof. Appeaning Addo the recognition and subsequent invitation as the first African Associate Editor of the prestigious Science Advances Journal in 2019.

3. His research work on the negative effects of using hard engineering coastal defense structures to manage coastal erosion made a strong case for a rethink of developing alternative approaches to

managing coastal erosion using localized soft engineering approaches. This has enhanced advocacy on managing coastal erosion with nature in the West Africa sub-region and beyond.

4. His work with colleagues from the Netherlands for the first time developed an integrated approach to sustainable port development for developing nations that embrace engineering, ecosystem services, and governance under the 'Green Port' concept. This innovative 'African-specific' design framework that integrates and optimizes ports' environmental, economic, and public benefits is inclusive, serving both commercial and socio-economic objectives.

Professor Appeaning Addo has succeeded in placing his research at the service of society and within the scope of the much-needed fusion between coastal processes and human activities, especially under sea-level rise challenges. Through his research work, he has informed various societal concerns related to marine spatial planning, sea-level rise, subsidence, coastal threats, coastal erosion dynamics, and coastal resource assessment. The issues addressed by his research are highly relevant in this critical time of climate change, especially given the necessity of developing and promoting adaptive capacities to sea-level rise along the vulnerable coasts of Ghana, the Bight of Benin, and West Africa.

**Grant Support:** Professor Appeaning Addo has attracted significant grants from various funding agencies to the University of Ghana to support his research work. These include International Development Research Center (IDRC), British Council, Global Challenges Research Fund (GCRF), DANIDA, Climate and Development Knowledge Network (CDKN), National Geographic, Norwegian Government, Dutch Research Council (NWO) – WOTRO, Delta Alliance, United Nations Development Program (UNDP), Past Global Changes Bern-Switzerland (PAGES), Paleontological and Scientific Trust (PAST), International Union for Quaternary Research (INQUA), DGIS-UNESCO-IHE Programmatic Cooperation (DUPC) and International Union for Conservation of Nature (IUCN).

**Teaching/Theses Supervision/Theses Examination:** Before taking up appointment at the University of Ghana as a lecturer in 2010, Professor Appeaning Addo had teaching experience at the Accra Technical University. He also obtained significant teaching experience at the University of Newcastle upon Tyne in the United Kingdom, where he was a practical/laboratory demonstrator for the School of Civil and Geosciences. He was a Visiting Scholar to the University of Southampton in 2016 to teach coastal processes focusing on 'Cliffed and Rocky Coasts' as well as 'Coastal monitoring using drones' in the Erasmus Mundus MSc in Coastal and Marine Engineering and Management (CoMEM) program. Since 2019, he has been a Guest Lecturer in Coastal Engineering at the Africa Center of Excellence in Coastal Resilience (ACECoR) at the University of Cape Coast. Professor Appeaning Addo has examined 45 graduate students' theses (PhD, MPhil, and MSc) in Ghana, South Africa, Ivory Coast, Benin, and France since 2010. He has contributed to theses supervision at the undergraduate and graduate levels.

Professor Kwasi Appeaning Addo has been a member of 32 graduate supervisory committees in the University of Ghana, the University of Abomey-Calavi in Cotonou-Benin, the University of Bordeaux in France, the Technical University of Delft in the Netherlands, and UNESCO-IHE in the Netherlands since 2008. He measures the successful learning of his students when they develop self-motivation and a strong desire to succeed. Therefore, it is not surprising that some of his PhD graduates are Research Fellows and Lecturers in Universities in Ghana and beyond and are continuing research activities within the coastal environment. He has supervised two (2) Post-Doctoral Research Fellows at the University of Ghana. Professor Appeaning Addo is also an External Assessor for promotion for the Kwame Nkrumah University of Science and Technology, Kumasi; University for Development Studies, Tamale; Koforidua Technical University; Accra Technical University, and Center for Scientific and Industrial Research as well as Oceanography and Coastal Management Program Assessor for the National Accreditation Board.

**Extension Activities:** Professor Appeaning Addo has served as a member of statutory boards and ad-hoc committees in the University of Ghana since 2010. He has also served in several capacities at both national and international levels. He was the Head of the Department of Marine and Fisheries Sciences from 2015 to 2018, Acting Chair of the International Programmes Office (IPO) Advisory Board in 2021, member of the University Academic Board, the College of Basic and Applied Sciences (CBAS) Academic Board, the Office of Research and Innovation (ORID) Board, the School of Graduate Studies Board, the Regional Institute for Population Studies (RIPS) Management Committee, and currently the Director of the Institute for Environment and Sanitation Studies (IESS). He is also a member of the Governing Council of the Methodist University College and the Group of Experts for the Third Cycle of the Regular Process for Global Reporting

and Assessment of the State of the Marine Environment, including Socioeconomic Aspects (Regular Process);

He also serves as an Associate member of UNESCO Land Subsidence International Initiative (LaSII) and member of the following bodies: the Expert Group of the High-Level Panel for Sustainable Ocean Economy involving 14 Heads of State; the International Pool of Marine Experts, United Nations (UN) Ocean Affairs and the Law of the Sea; and the Scientific Committee of the World Bank WACA project in Ghana. Additionally, he is the Technical Advisor to the Scientific Committee of the West African Coast Observation Mission (WACOM) and Convener of the Sargassum Network in West Africa. Professor Appeaning Addo was an Advisor to the Cabinet Sub-Committee on Coastal Erosion – Republic of Ghana in 2010; and a Member of the Laboratory Equipment and Appointments Committee of the University of Environment and Sustainable Development – Somanya in 2019 and 2020