

Sustainable Underwater Wireless Sensor Networks for Climate Change and Biodiversity Monitoring in the East African Indian Ocean

Abstract

The East African Indian Ocean supports coral reefs, seagrass, mangroves, fisheries and coastal livelihoods, yet these ecosystems face increasing pressures from ocean warming, acidification, pollution, sedimentation and other climate-related changes. Evidence from the Western Indian Ocean demonstrates threats to marine biodiversity and ecosystem resilience, emphasizing the need for continuous monitoring, conservation and adaptive management. However, conventional marine monitoring is often periodic, spatially constrained and resource-intensive, limiting timely detection of environmental changes and biodiversity loss.

Underwater Wireless Sensor Networks (UWSNs) provide opportunities for continuous and distributed marine monitoring, but their deployment is constrained by limited energy, bandwidth limitations, propagation delays, unreliable acoustic communication and difficult battery replacement. Existing studies have addressed energy-efficient routing, communication protocols, acoustic and optical technologies, and artificial intelligence-enabled underwater networks. However, much of the literature emphasizes network performance, including energy consumption, latency and reliability, rather than integrating Green ICT, circularity, biodiversity monitoring, climate resilience and ecosystem restoration within the East African Indian Ocean context. This study aims to systematically review existing evidence on sustainable UWSNs for climate change and biodiversity monitoring and establish requirements for a future Green and Circular UWSN framework. Specifically, the study will examine technologies and communication approaches used in UWSN-based marine monitoring, identify Green ICT, energy-efficiency and circular-economy practices applicable to underwater sensing, and synthesize research gaps and design requirements for subsequent framework development.

A Systematic Literature Review will be conducted to synthesize peer-reviewed evidence concerning UWSNs, Internet of Underwater Things, artificial intelligence, energy-efficient communication, Green ICT and circularity. The findings will provide an evidence-based foundation for subsequent development and validation of a sustainable UWSN framework integrating low-power sensing, renewable-energy-supported infrastructure, intelligent analytics and circular lifecycle practices. The study aligns with Kenya's National ICT Master Plan, which promotes green ICT and environmental protection, and its emerging-technology agenda emphasizing AI and IoT innovation. It also supports SDG 14 through marine ecosystem protection, restoration, scientific knowledge and marine technology.

Keywords: Green ICT; UWSN; IoT; Climate Change; Biodiversity; Circular Economy; Artificial Intelligence; Marine Ecosystem Restoration; Western Indian Ocean.