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International Journal of Engineering Technology Research & Management
Published By:
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INTEGRATING GEOGRAPHIC INFORMATION SYSTEM (GIS) IN MANGROVE FOREST CHANGE IN PANABO CITY, DAVAO DEL NORTE

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ABSTRACT
This paper will explore the application of GIS technology in the assessment and monitoring of mangrove forest changes in Panabo City, Davao del Norte, Philippines. Mangrove ecosystems are usually recognized as vital resources that coastal protect, conserve biodiversity, and mitigate climate. Unfortunately, these ecosystems are drastically endangered because of the high rate of urbanization, shifting land use patterns, and environmental degradation. This study utilizes GIS-based methodologies for analyzing changes in the coverage of mangrove forests across both the temporal and spatial scales of the past two decades. Loss, restoration, and fragmentations of mangroves will be studied through satellite imagery, remote sensing data, and field surveys. The results will be derived from severely degraded mangrove areas and evaluations for the efficacy of conservation. Application of GIS in management of mangrove forests opens the door to a better-aided understanding of ecological trends for well-informed data-driven decision-making toward the more sustainable conservation of mangrove forests in Panabo City. It also implies that it could serve as a model tool for environmental monitoring in conditions replicating those other coastal areas commonly experience with similar ecological threats.

Keywords:
Geographic Information System, Mangrove Forest, Ecosystem, Biodiversity

INTRODUCTION
Mangroves are a plant community consisting of many species (Tomlinson 1986; Primavera 2009; Spalding et al. 2010; Duke 2011; Lebata-Ramos 2013), and characterized by ecological tolerance because they can exist in the most harsh conditions encountered in hypersalinity and with high solar radiation (Adame et al. 2021). This ecosystem that connects two environments-tidal marine and terrestrial-is rated among the most productive globally (Sreelekshmi et al. 2021). Ecosystems of mangroves are known to play a significant role in the support of marine biodiversity in the tropics and subtropics, as well as being important elements of global biogeochemical functions and climate change mitigation (Wang and Gu 2021).
Mangrove forest at Barangay J.P. Laurel, Panabo City, contributes to community welfare in two major aspects. First it provides for the basic components of an ecosystem: plants and animals, minerals, soils, and water. Second, it provides for crucial life support services which are essential to human requirements and nearly irreplaceable for all practical purposes (Sumabal and Martinez, 2012). While the mangrove forest remains in good condition, there are signs of tree cutting and significant disturbances. Due to its location, the mangrove forest is not frequently monitored and is often overlooked. As a result, many illegal settlers and pond developers have encroached upon the forest in Barangay J.P. Laurel (DENR 2011).
As indicated in the evaluation of the City Environment and Natural Resources (CENRO)-Panabo (2021-2026), natural mangrove forest covers around 90.67 hectares along Barangays J.P. Laurel. Generally, the city's mangrove forests are still in healthy condition but some reported cases of illegal cutting and minor encroachment activities inside the mangrove zonation have occurred.
Overall, the city's mangrove forests remain in good condition; however, there have been a few instances of cutting and minor disturbances inside the mangrove areas. Overall, an increasing rate of mangrove loss globally caused by uncontrolled urbanization, climate, and unwise land use patterns presents a clear case of the need for monitoring and managing mangrove habitats.
Employing GIS technology allows scientists and policymakers to analyze alterations in mangrove cover overtime, assess the impacts of human activities, and design conservation practices wisely. When combined

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with GIS techniques become of great help and enable detailed mapping and monitoring of mangrove ecosystems-providing critical data for decision-making (Maurya, K., Mahajan, S. & Chaube, N.)
With the integration of GIS in mangrove management, there is an understanding of the changes in ecosystems and initiation of sustainable development activities. This is an approach that would help in detecting at-risk areas, which saves enough time for conservation efforts to be directed towards the preservation of these ecosystems for future generations.
The researcher's objective is to analyze and quantify the changes of Panabo Mangrove Forest overtime using the Geographic Information System (GIS) technology, to provide a comprehensive understanding of the extent of degradation or reforestation. This study poses the following questions:

1. How does the lack of current spatial data on mangrove forest cover and its changes over time in Panabo City impede effective management and conservation efforts?
2. In what ways do current approaches to monitoring mangrove changes fall short in utilizing advanced technologies?
3. Why is it essential to evaluate the impacts of urbanization and environmental changes on mangrove ecosystems to effectively inform policy and management strategies?

According to the ITTO study in 2012, the mangrove forest is one of the most productive, biologically rich ecosystems that developed to survive and grow under such difficult circumstances found between the sea and the shore. The term "mangrove" refers to trees, their plant family, and ecosystem associated with oceans zones (Tomlinson, 1986). According to FAO (2007), "mangrove forests are defined as salt-tolerance evergreen forests found at sheltered coastlines, shallow-water lagoons, estuaries, rivers, or deltas." These peculiar forests are primarily intertidal by being present in almost every part of the earth but particularly in tropical and subtropical areas (Woodroffe and Grindrod, 1991).
Over a few decades, anthropogenic activities have been creating an alarming scenario of mangrove forests lost due to rapid local and global changes in land use and habitat conversion. The leading causes of damage include aquaculture development, expansion of agriculture, overexplosion of upland forests, industrial buildings, and urbanization, which are said to have led to an estimated loss of one-third of all mangroves in the world over the last 50 years (Alongi, 2002). In the Philippines, by 1994, the area of mangrove forest had shrunk to nearly 120,000 hectares from an estimated coverage of between 400,000 and 500,000 hectares as at 1920 (Primavera, 2002). The remaining mangrove would mostly be degraded or in recovery, and his condition would reduce their ability to render some essential ecosystem services (Walters, 2003).
Primavera (2006) noted that the most common cause of loss of mangroves is conversion for aquaculture. Mangrove forests are important for food security and play a role in economic enhancement and pollution control, but aquaculture bears a number of adverse effects such as local water pollution through effluents discharged by aquaculture farms, disease dissemination, and over-extraction of freshwater that may lead to intrusions of seawater into coastal aquifers and damage local water supplies. Most of the cases, these aquaculture sites cease operation after about ten years due to problems associated with disease and pollution (De la Torre and Barnhizer, 2003). Ironically, this is the industry that heavily depends on the ecosystem services provided by healthy mangrove forests.
The major area reductions for mangrove forests include a severe change in the size of mangrove resources from about 400,000 hectares in 1943, which was reduced to 157,500 hectares by 2005 (McNally et al., 201).
Indeed, GIS, according to Goodchild (2007), has been one of the most significant tools for environmental research. It helps the researcher to visualize the data spatially as well as analyzes changes concerning a specified area and a much larger region. Particularly within GIS applications involving the study of changes in the mangrove forest, spatial patterns, and trends become clear.

METHODOLOGY

This study employs a quantitative research design using GIS and remote sensing techniques to analyze changes in mangrove cover. The analysis included land cover classification and estimates of mangrove loss or gain over various time periods. Field surveys were also conducted in order to ground-validate the remote sensing data and collect qualitative information regarding the health and implications of the mangrove from urbanization at the local level. This integrated approach allowed an integral examination of the various factors affecting the mangrove forests' dynamics in light of urban development.

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Data collection. was carried out using a combination of remote sensing, field surveys, and interviews with various stakeholders. The prominent source of data was satellite imagery from different time periods which were further processed on GIS software to analyze the changes in mangrove forest cover. Hence, the quantitative basis for assessment of spatial change over time was thus made possible through this remote sensing data. Validation of these findings from remote sensing involved carrying out field surveys. In particular, there were on-site assessments conducted on the health and biodiversity of mangroves, with soil and water samples gathered to quantify the conditions of the environment. At the same time, interviews were conducted with local stakeholders-the community people and environmental experts-for qualitative data on perceptions of mangrove changes in the impacts of urbanization. It is through this mixed-method approach that a more holistic understanding of the dynamics driving the changes of mangrove forests along Panabo City can be achieved.
Ethical Considerations. This study will adhere to ethical standards, including obtaining necessary permits for data collection and ensuring the confidentiality of local communities involved.

RECOMMENDATION

For the effective and efficient management and protection of the mangrove forest in Panabo City, it is more important to scale up the use of geographic information systems (GIS) to monitoring into the future. With regular updates to the GIS database, precise tracking of changes in mangrove cover will be gained such as in deforestation processes, coastal erosion and restoration efforts for evidence-based decision making.
It is important, therefore, to engage local communities in data gathering activities as these will not only improve the accuracy of data but also get communities involved in the effort of conserving mangroves to build a stronger constituency for its conservation. Collaboration with local government units, non-governmental organizations (NGOs), and other environmental groups is equally indispensable. Such partnerships will increase effectiveness in coordination in the
Integrating GIS data into local land use planning and environmental policies should hence protect the mangrove areas from urban development and other unsustainably greedy developments. Finally, raise public awareness through educational campaigns that employ GIS-generated maps and visualizations. Raise awareness in the public, most especially those involved with coastal management and planners who make policies.

CONCLUSION

Implementing the Geographic Information System application for monitoring mangrove forest changes in Panabo City as an excellent tool for studying one of the vital ecosystems. GIS provides accurate, reliable, and real-time data that improve ways to manage and protect mangrove forests, which are very important for biodiversity, climate change adaptation and mitigation, and coastal protection.
However, as much as GIS technologies would contribute to the successful use of mangrove conservation, it will also depend on the continued technological improvements, people's involvement, and collaboration of the various stakeholders. For Panabo to learn how to integrate GIS data into local planning, public awareness campaigns, and sustainable practices, doing so would direct the efforts for the effective protection of its mangrove forests for generations yet to come.
Indeed, the use of GIS in mangrove forest management is much more than a technological effort; it opens the way toward a more integrated and community-driven as well as ecological management approach. This study has emphasized the significance of continuing innovation and cooperation in achieving effective conservation objectives in places such as Panabo City, which is very much like many coastal regions.

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