Applications of remote sensing and gis in fisheries resource management.

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Introduction

The sustainable management of fisheries resources has become a critical global priority in the face of overfishing, climate change, habitat degradation, and increasing demand for seafood. Traditional fisheries management approaches, which often relied on manual data collection and local knowledge, are no longer sufficient to address the complex, large-scale, and rapidly changing nature of modern marine and freshwater ecosystems. In this context, the integration of advanced technologies such as remote sensing and Geographic Information Systems (GIS) has revolutionized fisheries resource management by enabling more precise, timely, and comprehensive monitoring and decision-making [1, 2].

Remote sensing refers to the acquisition of information about an object or phenomenon without making physical contact with it. In the context of fisheries, remote sensing is typically carried out using satellite sensors or airborne instruments that capture data on various oceanographic and environmental parameters. These include sea surface temperature (SST), chlorophyll concentration, ocean color, turbidity, salinity, and phytoplankton abundance. Such parameters are essential indicators of fish habitats, distribution, and migration patterns. By regularly monitoring these variables over large areas, remote sensing technologies allow fisheries scientists and managers to identify productive fishing zones, forecast fish movements, and assess changes in marine ecosystems with unprecedented accuracy [3, 4].

Geographic Information Systems, on the other hand, provide a powerful platform for integrating, analyzing, and visualizing spatial data. GIS tools allow users to overlay multiple layers of information—including biological, environmental, socioeconomic, and regulatory data—to create detailed maps and models that support resource management. In fisheries, GIS can be used to delineate fishing zones, evaluate habitat suitability, track fishing vessel movements, assess the impact of human activities, and plan marine protected areas (MPAs). The spatial analysis capabilities of GIS also facilitate risk assessments, conflict resolution, and the optimization of fishing efforts, thereby promoting both ecological sustainability and economic efficiency [5, 6].

One of the most important applications of remote sensing in fisheries is the monitoring of sea surface temperature. SST is a key factor influencing the distribution and abundance of many commercially valuable fish species. Changes in temperature can alter the location of feeding grounds, spawning areas, and migratory routes. Satellite-derived SST data, available from platforms such as NOAA's AVHRR (Advanced Very High Resolution Radiometer) or NASA's MODIS (Moderate Resolution Imaging Spectroradiometer), enable real-time tracking of thermal fronts—zones where warm and cold water masses meet—which are often associated with high biological productivity and fish aggregation. By analyzing SST trends over time, fisheries managers can predict the impacts of climate variability, such as El Niño and La Niña events, on fish stocks and plan adaptive strategies accordingly [7].

Chlorophyll concentration is another crucial parameter obtained through remote sensing. Chlorophyll-a is a pigment found in phytoplankton, which forms the base of the aquatic food web. Areas with high chlorophyll concentrations generally support higher levels of primary production and, consequently, attract larger populations of fish. Satellite sensors like SeaWiFS, MODIS, and Sentinel-3's OLCI (Ocean and Land Colour Instrument) provide global chlorophyll data that can be used to identify potential fishing grounds, monitor ecosystem health, and detect harmful algal blooms (HABs). Coupling chlorophyll data with SST and other oceanographic parameters enhances the ability to model habitat suitability and forecast fish distribution with high spatial and temporal resolution [8].

In addition to oceanographic parameters, remote sensing can be employed to assess coastal and inland fish habitats. High-resolution satellite imagery and aerial photography allow for the mapping of critical habitats such as mangroves, coral reefs, seagrass beds, estuaries, and wetlands. These habitats serve as nurseries, feeding areas, and shelter for numerous fish species, especially during their juvenile stages. Monitoring the extent, health, and degradation of these habitats is vital for effective fisheries management and conservation. For instance, loss of mangrove cover due to urbanization or aquaculture can lead to declines in nearshore fish populations. Using remote sensing, managers can detect habitat changes over time and implement targeted restoration or protection measures [9].

GIS complements remote sensing by integrating spatially explicit datasets and facilitating complex analyses that inform fisheries planning and policy. One of the core functions of GIS in fisheries is habitat mapping. By combining remote sensing data with field observations and biological surveys, GIS can be used to generate detailed maps of fish habitats

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and distribution patterns. These maps help managers identify essential fish habitats (EFHs), assess their vulnerability to human activities, and prioritize areas for conservation. GIS also enables the modeling of habitat suitability based on environmental variables and species preferences, allowing for dynamic predictions of fish movements under different scenarios.

Another valuable application of GIS in fisheries is the management of fishing effort and enforcement of regulations. Vessel Monitoring Systems (VMS) and Automatic Identification Systems (AIS) provide real-time tracking data on the location and activities of fishing vessels. This data can be visualized and analyzed in GIS to monitor compliance with fishing zones, quotas, and seasonal closures. By identifying patterns of illegal, unreported, and unregulated (IUU) fishing, authorities can target enforcement efforts more effectively and reduce the pressure on vulnerable stocks. Additionally, GIS-based analyses of catch data, effort distribution, and economic performance can inform the design of more equitable and sustainable fisheries management plans [10].

Conclusion

Inland fisheries, which are often underrepresented in global assessments, can also benefit from remote sensing and GIS technologies. Rivers, lakes, and floodplains are dynamic systems where fish abundance is closely linked to hydrological patterns, land use, and habitat connectivity. Satellite imagery can monitor water levels, sedimentation, land cover changes, and pollution sources, while GIS can be used to model fish migration corridors, identify critical spawning areas, and evaluate the impacts of infrastructure such as dams and irrigation schemes. These insights are particularly valuable in developing countries where inland fisheries provide essential food and income but face increasing pressure from population growth and environmental degradation.

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