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Review

Application of Remote Sensing and GIS in Indian Aquaculture: A Review

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Abstract: The GIS is a computer-built system that input, stock, regain, examine and show geographically referenced information which is useful for taking designs which are related to aquaculture. The data about water, land mapping, disease monitoring, species ecology, pollution management, inland capture fisheries management, mapping of aquatic species, management of water resources, collection of data like suspended sediment, algal bloom of slick, etc is important in aquaculture to get optimum outcome. This data can be obtained easily through the geographical information system (GIS) and remote sensing. Application of remote sensing in aquaculture has a vast scope in India as it helps in efficient decision making based on various scenarios. GIS and remote sensing technology provide high quality output. In aquaculture, site selection plays important role to achieve great outcome. The final data can be achieved by combining all the factors of the site selection. Obtaining data from GIS and remote sensing is also less expensive. Therefore, it will be more beneficial for farmers to achieve great outcome by using such kind of techniques. By using such techniques, farmers can secure their financial status. The study examines the significance, necessity, and applications of Remote Sensing and Geographical Information System in the Indian aquaculture. The gap and the potential of remote sensing and GIS for the sustainable development of aquaculture in India has been studied.

Keywords: Remote sensing, GIS, aquaculture, fisheries, water quality monitoring, satellite imagery

Introduction:

Aquaculture is one of the pillars of food security in the world and especially in India where it has a significant role in fish production and livelihood of the rural communities. Combination of remote sensing (RS) and geographic information system (GIS) are transforming aquaculture management since it allows effective tracking of water quality, surface habitat suitability, disease outbreaks and other environmental factors vital to production optimization (Sri Bala et al., 2025). These technologies offer spatially explicit information that ground surveys in the traditional sense cannot offer in terms of the magnitude, the timeliness as well as the affordability enabling informed decision-making in site selection, resource allocation, as well as sustainability (Klemas, 2013). Remote-sensing (RS) and geographic information system (GIS) are important tools to be used in the Indian scenario, where aquaculture is practiced in various general ecosystems such as coastal ponds, inland lakes, and rivers, and where the main goal is to solve problems such as environmental pollution, algae growth, fish ecology, and the final outcome is a better productivity and income of farmers (Nayak et al., 2014).

Remote-sensing (RS) and geographic information systems (GIS) applications in aquaculture date back to the 1990s, when the first coastal mapping was conducted, and their application was later expanded to inland systems in the 2000s. Multi-layered analyses of suspended solids, water resources, and habitat suitability with satellite files such as Landsat and Sentinel-2, paired with GIS analysis, enable the elimination of the utilization of field methods due to the extensive workload (Declaro and Kanae, 2024). In India, this development is coinciding with the increase of the sector to more than 14 million tons in 2023, made possible by states such as Andhra Pradesh and West Bengal, where technology has helped to map the area under aquaculture and to track the fish industry capture fishing in the country (FAO, 2022). Those developments signal the transition of the concept of sustainable management between the practices grounded on empirical observations and data-informed policies and make RS-GIS indispensable in scaling to sustainable aquaculture in the face of climate variability and population pressures.

Despite these advantages, the Indian aquaculture is still faced with serious challenges such as ineffective site selection which causes low yields, disease susceptibility as well as hotspots of pollution which pose a threat of unsustainability. The conventional techniques are still expensive and laborious, making them unavailable to smallholder farmers who control the industry (Wall, 2007). The research gap is geographically divided adoption with low integration of multi-sensor RS data to real time monitoring and predictive modelling unique to any of the many agro-climatic areas in India, which prevents nationwide adoption.

The case study of the Himalayan areas in Uttarakhand gives evidence of GIS based site suitability modelling, which was able to quantify aquaculture potential, but gaps are evident in the high-perched uses when uncovered by cloud cover as well as terrain complicate the precision of RS-based estimates (Nayak et al., 2014). In the same manner, coastal researchers boast of successes in mapping studies, but casts doubt on the lack of resolution of investigations into eco-environment impact assessment including entropy due to intensive cultivation (Wu and Wan, 2024). These results reveal a long-term disparity between the potential and actual realization of technology in India.

Additional examples found in analogues of Southeast Asia, such as case studies within India, reveal that RS allows the delineation of aquaculture areas with above 85% accuracy with the use of machine learning, but longitudinal studies that monitor land-use trends and the impact of biodiversity remain lacking (Ratan et al., 2025). The Mahanadi Delta experienced mangrove encroachment of aquaculture revealed by RS-GIS, which requires improved regulating frameworks (Pattanaik and Prasad, 2011).

On the state level, states such as Assam, Andhra Pradesh, West Bengal, Gujarat, and Kerala have taken advantage of these technologies to generate profit, using GIS to support resource management of water and disease-surveillance in shrimp farming in saline lakes (Vijayan and Alavandi, 2021; Paroda, 2018). Nonetheless, the

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question of uneven penetration is that it results in large areas of inland prioritization and increases the susceptibility of rainfed systems.

The objective of this review is to integrate the significance, usage, and shortcomings in RS and GIS to Indian aquaculture in terms of site selection, monitoring and sustainability. The objective of this paper is to examine the applications, significance, deficiencies, and future potential of remote sensing and GIS in improving site selection, monitoring, and the sustainable development of aquaculture across India.

Remote sensing and GIS

Unlike traditional field surveys which often get hampered due to accessibility problems in the coastal areas, remote sensing is frequently used for aquaculture mapping in the last few decades (Rajitha et al. 2007; IOCCG 2009; Chen et al. 2024). Various structures of ponds, cages and rafts along shore, clustered circular or square formations in the open water have been identified through object oriented extraction, correspondence analysis, ratio index analysis, visual interpretation and spatial structure analysis (Fig.1) (Cheng et al., 2012). GIS modelling is useful in generating maps that can be applied to locate marine aquaculture, taking into account several environmental, socio-economic and operational considerations (Buitrago et al., 2005; Radiarta et al., 2008; Micael et al., 2015).

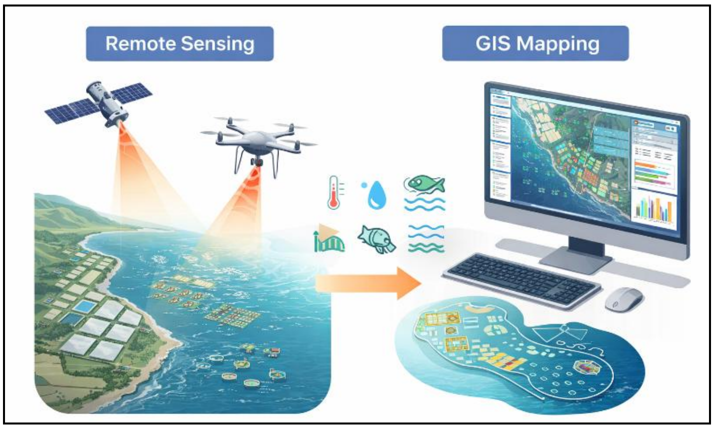

Figure: 1. Remote Sensing and GIS for collection and mapping of aquaculture data.

To help solve the complex problems related to aquaculture and coastal planning, Geographic Information Systems (GIS) are often used in the context of spatially explicit options for natural resource decision-making scenarios (Stelzenmüller et al., 2017). GIS is used to handle and analyze spatial and attribute information from multiple sources. Furthermore, it generates reports in the form of maps, databases, statistics, field calculations and texts for proper decision-making (Malakar et al., 2025). Different physical, biological and chemical parameters can be evaluated in GIS environment to identify suitable zones for aquaculture both onshore and offshore (Primavera et al., 2006).

India ranks as the second largest nation in the aquaculture sector, with shrimp farming being widespread in coastal lagoons, deltas, estuaries, and the transitional areas beyond mangrove forests (Jayanthi et al., 2022). The mainland of India boasts an extensive coastline measuring 5422 km, where shrimp farming is practiced across 102 districts in nine coastal states: Gujarat, Maharashtra,

Goa, Karnataka, Kerala, Tamil Nadu, Pondicherry, Andhra Pradesh, Odisha, and West Bengal, primarily by small-scale farmers (de Jong, 2017). In spite of the rapid transformations occurring in India's coastal environment, there exists a deficiency of current, spatially detailed, and continuous data regarding the distribution of coastal aquaculture (Prasad et al., 2019). This information is crucial for establishing baseline assessments, facilitating informed decision making, and ensuring effective monitoring of coastal zones. The possible advantages of utilizing remote sensing data for aquaculture mapping were thoroughly examined in Reference (Ottinger et al., 2016). Researchers utilized medium- to high-resolution optical satellite data to delineate and observe temporal changes in the spatial extent and distribution of aquaculture ponds across various regions of the world, including India (Sridhar et al., 2008; Disperati and Virdis, 2015; Tsai et al., 2006; Sudarshana et al., 1993; Jayanthi et al., 2006; Rajitha et al., 2010).
Geographic Information Systems (GIS) and Remote Sensing (RS) serve as effective tool for the planning of aquaculture and mariculture management, allowing for a flexible distribution of resource allocation (Kairo et al., 2002). Consequently, ArcGIS 10.2.1 and Erdas Imagine
2014 have been utilized as effective tools for spatial analysis (Pandey and Ghosh, 2018). Results indicate that 88% of the bay area is suitable for scallop culture, and that 56% of this area had a high score in suitability rating (Michele et al., 2013; Radiarta et al., 2008). This type of thematic mapping, employing data from a variety of remote sensors coupled with decision support through GIS spatial analysis, provides more rigour and insight in aquaculture planning (Wilkinson, 1996). Several research studies have been released regarding the use of GIS and remote sensing in aquaculture. This involves the selection of shrimp farming locations utilizing SPOT imagery (Rajitha et al., 2007), identifying oyster cultivation sites (Lima, 2025), developing cat farms through the mapping and analysis of soil physical characteristics (Kapetsky et al., 1988).

Remote sensing Technologies in Aquaculture

Remote sensing is a method for gathering data through a sensing device that does not physically interact with the object being observed, and it involves the analysis of the acquired data, which is then represented in the form of maps or statistics (Howard, 1985). Extended satellite missions, including the European Remote Sensing satellites (ERS-1/2), ENVISAT, the Landsat series, the Moderate Resolution Imaging Spectroradiometer (MODIS), and the newly launched Sentinel series, provide comprehensive monitoring (Ottinger et al., 2017; Bakker, 2013). Utilizing the freely accessible Sentinel-1 SAR data with a spatial resolution of 10 meters, we were able to identify a significant quantity of individual ponds and dikes (Ottinger et al., 2017). The integration of optical and SAR data, for instance, merging Sentinel-1 SAR data with high-resolution Sentinel-2 satellite data, is ideal to improve the accuracy of aquaculture mapping outcomes (Wang et al., 2025).

GIS Applications and Integration

There is a history of employing GIS technology for planning purposes in aquaculture. GIS was utilized in fisheries management during the mid-1990s (Wanchana & Sayan, 2018). Through an adequate database, Geographic Information System (GIS) can serve as an effective analytical and decision-making tool for aquaculture's development. Also, it can be applied for management purposes and impact assessment of development (Aguilar-Manjarrez and Ross, 1995). The

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GIS-based Multi-Criteria Decision Analysis (GIS-MCDA) is a type of SDSS. Spatial Decision Support Systems (SDSS) refer to a computer-assisted interactive system aimed at improving the effectiveness of decision makers in tackling spatial decision problems (Yalew et al., 2016). In the Thiruvarur District, a research study assessed the suitability of sites for conducting brackish water aquaculture using a multi-criteria decision analysis (MCDA) method. Ways to mitigate environmental impacts would ensure sustainable development of coastal aquaculture (Shunmugapriya et al., 2021).
According to Dolan (2008), the Analytic Hierarchy Process provides a transparent and structured method to decision analysis. This technique involves comparing a number of different alternatives against a variety of different criteria to choose the best one. The GIS-AHP model is employed to analyze the various thematic layers, which are assigned weights and ratings according to the level of groundwater potential (Chen et al., 2025).

Key Applications in Aquaculture

Remote sensing (RS) and geographic information systems (GIS) are crucial in improving aquaculture practices throughout India, especially in site selection, resource monitoring, and sustainability initiatives. Aquaculture has rapidly advanced over the past thirty years and has emerged as a significant economic endeavour globally (Bostock et al., 2010). The accessibility of contemporary technologies and the boundless opportunities for export have drawn substantial investment into this sector.

Site Suitability and Zoning

The selection of an appropriate site is a crucial element in determining the sustainability of an aquaculture farm (Abdullah et al., 2023). It is essential to consider the water retention capacity of the soil and its fertility, as these factors significantly affect the response to both organic and inorganic fertilization of the aquaculture site (Ihejirika et al., 2012; Das et al., 2005).
The site should have sufficient water supply throughout the year to fill the site with clean, unpolluted water. In terms of soil quality, the primary criteria utilized in the selection of aquaculture sites include pH, organic matter, and texture (Divu et al., 2021; Ghobadi et al., 2021, Esmaeilpour-Poodeh et al., 2019). Soils with a high clay content are particularly advantageous as they possess the ability to retain water for prolonged durations. Notably, Esmaeilpour-Poodeh et al. (2019) were the only researchers to incorporate sand percentage, fertility, and soil depth into their site selection criteria for sturgeon farming along the southern coasts of the Caspian Sea in their study. The topography of the area is to be noted, as in swampy and marshy areas, bunds should have a greater accumulation of soil. The location must be easily reachable by roadways or any alternative means of transportation to access the market for convenient fish disposal (Jayanthi and Ravichandran, 2009).

Water Quality and Environmental Monitoring

In ancient times, traditional methods were employed to evaluate water quality parameters. The sampling and monitoring of water samples are the age-old practices required in previous decades. Karthik et al. (2005) have identified alkalinity, ammonium, nitrites, nitrates, and phosphate as the primary factors for assessing water quality in their model designed for selecting an aquaculture site in brackish water.

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Table 1: comparative analysis methods for assessing water quality.

Parameters	Chemical Methods	Automation Techniques	Relevant Literature (Modern Technology)
Temperature	Lab testing	Temperature sensor LM35	Saukani & Triturani, 2022
pH	Titration method	pH electrode generates voltage and is connected to the sensor module	Zeta et al., 2025
Conductivity	Chemical method and equations (PSS-78)	Conductivity sensor	Wei et al., 2011
Dissolved oxygen	Titration method and lab testing	Dissolved oxygen probe interfaced with electronic control system	Ma & Ding, 2018
Ammonia	Titration method and lab testing	Ammonia sensor MQ135	Maulini et al., 2022
Water flow	Manual methods	Water flow sensor to measure flow rate	Okarma et al., 2022

Aquaculture Extent Mapping and Change Detection

The sophisticated remote sensing and GIS techniques are used to map aquaculture and determine changes by accurately delineating fish pond boundaries and monitoring changes over time throughout India. The use of multi-temporal satellite data including IRS-LISS III, Sentinel-1 SAR, and Landsat-series allows for the automated extraction of ponds using various spectral indices (NDWI, MNDWI) and machine learning classifiers with an accuracy exceeding 90% in the mapping of brackish water shrimp farms in Andhra Pradesh and inland carp systems in Uttar Pradesh (Malinowski et al., 2017; Venkateswarlu et al., 2019; Prasad et al., 2020). The table below presents a summary of the methodology used for GIS analysis, areas where GIS were practised and essential key parameters used in the studies done in India.

Advantages Over Traditional Methods

The linkage of RS and GIS is more advantageous than conventional approaches and is quite powerful in monitoring dynamic changes in land use and land cover (Hamud et al., 2019). For conventional recording techniques there are limitations about the speed and accuracy of collection and evaluation of actual state data. By RS, enormously useful multi-temporal data can be obtained for monitoring land-use patterns and processes, and GIS techniques can be used to analyze and map the patterns (Liu and Cai, 2012; Farshidi et al., 2023). The use of Geographic Information System (GIS) in forecasting cage effects has several advantages in spatial modelling. These advantages include rapid image generation and manipulation, the ability to explore alternative scenarios, statistical analysis of the imagery, and colour outputs that enhance the visual interpretation of results (Kapetsky, 2004; Ghadirian & Bishop, 2008). Where progress is being achieved concerning user-friendliness, the handling of substantial datasets (>100 MB), the compatibility of databases across various systems, as well as in the gathering and initial processing of datasets (Nath et al., 2000).

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Table 2: GIS based techniques and their applications in various States of India.

Author	GIS Technique	Application Area	Key Parameters	Region
Nayak et al. (2014)	AHP-MCDA Overlay	Site Suitability	Water quality, soil, infrastructure	Uttarakhand
Rajitha et al. (2010)	NDVI Approach	Pond Zoning	land-cover change detection	Andhra Pradesh
Pattanaik & Prasad (2011)	Post-classification Change	Extent Mapping	Dense mangrove, open mangrove, aquaculture, plantation, mudflat, sand, water body and agriculture	Mahanadi delta, Orissa
Jayanthi et al. (2011)	Arc GIS 9.0, GS5+ GPS	Aquaculture Development Monitoring	Aquaculture ponds, agricultural fields, creeks, reserve forest boundaries and fallow lands	Pichavaram , Tamil Nadu
Padmanaban & Sudalaimuthu (2012)	Thematic Map Technique, ENVI/ERDAS	Offshore and Onshore of Tuticorin Coastal area	Infrastructure facilities, salptan, water bodies, distance from land, waste land, area type of soil etc.	Tamil Nadu
Jayanthi et al. 2006	ERDAS IMAGINE, ARC GIS	Impact of Aquaculture on Lake	Land, water	Kolleru Lake, Andhra Pradesh
Shunmugapriya et al., 2021	GIS-AHP	Site selection	Geology, pH, salinity, soil media, slope, geomorphology, land use land cover, distance to water, settlement and road networks	Thiruvarur, Tamil Nadu
Jayanthi et al., 2021	MCDS	Site selection	Depth, turbidity, salinity, temperature, dissolved oxygen, pH, and total ammonia nitrogen using suitability scores and its comparative rank. pH, salinity, temperature, and TAN	Muttukadu Lagoon, Chennai

Limitations of RS-GIS

Remote sensing (RS) and geographic information systems (GIS) present significant opportunities for Indian aquaculture; however, they encounter various challenges that impede their broad

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implementation and precision. Cloud cover during the monsoon season, common in coastal regions such as West Bengal, hinders optical satellite imagery for instance, Landsat and Sentinel-2, thereby affecting the reliability of data for water quality assessment and pond mapping (Huda, 2022; Rajeevan et al., 2013). This requires expensive SAR alternatives such as RISAT; however, their reduced resolution restricts detailed aquaculture applications (Agarwal et al., 2025).

Spatial and temporal resolution limits slow progress, as moderate-resolution sensors are unable to identify smallholder ponds in inland systems. This results in an underestimation of the extent and changes in aquaculture, as evidenced by studies conducted in Kolleru Lake (Soti et al., 2009; Pattanaik et al, 2008). The high software costs, high-resolution imagery, and manpower hiring have made things difficult for small farmers in Indian aquaculture. According to Dhillon & Moncur (2023), and Subramani et al. (2017) the situation further contributes to ongoing digital divide within Maharashtra and Assam rural areas. Gladju et al. (2022) opinionated the same. The INCOIS PFZ advisories indicate that limitations in infrastructure, including inadequate internet connectivity for real-time GIS dashboards in remote coastal regions, limits the scalability for their use (Eluri et al., 2025; Owen, 2025). Capacity building remains inadequate at various levels as many extension workers and fisher folk are untrained in geospatial tools resulting in a failure to use them despite the initiatives of PMMSY (Kelkar & Arthur, 2022). Policy and Regulatory obstacles, including disjointed zoning at the state level, exacerbate the risks associated with unplanned growth, such as the loss of mangroves (Carter et al., 2015). Tackling these issues necessitates the use of open-source platforms, the integration of drone technology, and the establishment of national data hubs to improve fairness and accuracy in Indian aquaculture.

Future Perspectives

The advanced technology with Remote sensing and GIS provides opportunity for sustainable development of aquaculture in India (Rajitha et al., 2007). Up and coming satellite constellations, especially the Sentinel-1A/1B SAR sensors and hyperspectral platforms, will be deployed to overcome the cloud cover problems in monsoon season along the coasts and ensure consistent all-weather monitoring of water quality parameters such as chlorophyll-a, turbidity, and suspended sediments (Klemas 2013; Rodríguez-Veiga et al. 2017). The UAVs along with drone technology are going to enhance the satellite remote sensing which will help in obtaining sub-metre resolution for mapping of smallholder ponds along with managing on-farm operations (Bansod et al., 2017; Mabhaudhi et al., 2022).

The future of GIS analysis will be shaped by the incorporation of artificial intelligence and machine learning, enabling the automatic detection of ponds, species identification based on spectral signatures, and the creation of climate-resilient site selection models tailored to India’s agro-climatic zones (Ferriby et al., 2021; Hasan & Sojib, 2025). GIS cloud-based platforms will make access more equitable. This via mobile applications and open-source software such as QGIS will lower infrastructure obstacles for smallholder farmers, and participatory mapping for management of inland fisheries (Meaden & Aguilar-Manjarrez, 2013). Capacity building through digital literacy initiative for extension officers and farmers living in remote areas will aid in equitable adoption of technology in different states (Khatri et al., 2024).

The use of blockchain technology will facilitate traceability and sustainability certification in aquaculture supply chains (Rashid & Gani, 2025). Transferring this technology in Geographic Information Systems (GIS) already enables farmer-ready production. This assures compliance with market orientation and payment of market premiums. We will ensure that India's aquaculture sector produces millions of tonnes by 2030 while ensuring no harm to the environment and farmers' prosperity through management frameworks that are credible and science-backed.

References:

Sri Bala, G., Nagaraju, T.V., Krishnam Raju, G.L.V., Rambabu, T., Harish Kumar Varma, G. (2025) Advancing Estuarine Aquaculture with Remote Sensing for Water Management. In: Nagaraju, T.V., Das, B. (eds) Inland Aquaculture Sustainability and Effective Water Management Strategies. *Springer Water. Springer, Cham*. https://doi.org/10.1007/978-3-031-88384-2_6

Klemas, V. (2013) Fisheries applications of remote sensing: An overview. *Fisheries Research*, 148, 124-136. https://doi.org/10.1016/j.fishres.2012.02.027

Nayak, A. K., Pant, D., Kumar, P., Mahanta, P. C. and Pandey, N. N. (2014) GIS-based aquaculture site suitability study using multi-criteria evaluation approach. Indian Journal of Fisheries, 61(1), 108-112.

Declaro, A. and Kanae, S. (2024) Enhancing surface water monitoring through multi-satellite data-fusion of Landsat-8/9, Sentinel-2, and Sentinel-1 SAR. Remote Sensing, 16(17), 3329. https://doi.org/10.3390/rs16173329

FAO. (2022) The State of World Fisheries and Aquaculture. *Food and Agriculture Organization of the United Nations*.

Wall, P. C. (2007) Tailoring conservation agriculture to the needs of small farmers in developing countries: an analysis of issues. Journal of crop improvement, 19(1-2), 137-155. https://doi.org/10.1300/j411v19n01_07

Wu, W. and Wan, L. (2024) Coastal ecological and environmental management under multiple anthropogenic pressures: A review of theory and evaluation methods. *Current Trends in Estuarine and Coastal Dynamics*, 385-415. https://doi.org/10.1016/b978-0-443-21728-9.00013-2

Ratan, R., Ashwini, M. and Nagarajan, V. (2025) Artificial Intelligence in Aquaculture: Advancing Monitoring and Sustainability via Remote Sensing. In, Inland Aquaculture Sustainability and Effective Water Management Strategies: Optimizing Resources for Environmental Harmony. *Cham: Springer Nature Switzerland*, Pp. 69-85. https://doi.org/10.1007/978-3-031-88384-2_5

Pattanaik, C. and Prasad, S. N. (2011) Assessment of aquaculture impact on mangroves of Mahanadi delta (Orissa), East coast of India using remote sensing and GIS. Ocean & Coastal Management, 54 (11), 789-795.

Vijayan, K. K. and Alavandi, S. V. (2021) Brackishwater Aquaculture Health Management with Special Reference to Shrimp Farming in India: Status and the Way Forward. *Journal of the Indian Society of Coastal Agricultural Research*, 39(2), 15-29. https://doi.org/10.54894/jiscar.39.2.2021.110668

Paroda, R. S. (2018) Aquaculture development and the blue revolution. In Reorienting Indian agriculture: challenges and opportunities. *Wallingford UK: CAB International*, Pp. 50-63. https://doi.org/10.1079/9781786395177.0050

Rajitha, K., C. K. Mukherjee, and R. V. Chandran (2007) Applications of Remote Sensing and GIS for Sustainable Management of Shrimp Culture in India. Aquaculture Engineering, 36 (1), 1-17.

https://doi.org/10.1016/j.aquaeng.2006.05.003.

IOCCG (2009) Remote Sensing in Fisheries and Aquaculture. In Reports of the International Ocean-Colour Coordinating Group, Vol. 8. Dartmouth, Canada: IOCCG.

Chen, A., Z. Lv, J. Zhang, G. Yu, and R. Wan. (2024) "Review of the Accuracy of Satellite Remote Sensing Techniques in Identifying Coastal Aquaculture Facilities." *Fishes*, 9(2): 52. https://doi.org/10.3390/fishes9020052

Cheng, T., W. Zhou, and W. Fan. (2012) Progress in the Methods for Extracting Aquaculture Areas from Remote Sensing Data. Remote Sensing for Land Resources, 94, 1-5.

Buitrago, J., Rada, M., Hernández, H., & Buitrago, E. (2005) A single-use site selection technique, using GIS, for aquaculture planning: choosing locations for mangrove oyster raft culture in Margarita Island, Venezuela. Environmental Management, 35(5), 544-556. https://doi.org/10.1007/s00267-004-0087-9

Radiarta, I. N., Saitoh, S. I. and Miyazono, A. (2008) GIS-based multi-criteria evaluation models for identifying suitable sites for Japanese scallop (Mizuhopecten yessoensis) aquaculture in Funka Bay, southwestern Hokkaido, Japan. *Aquaculture*, *284*(1-4), 127-135. https://doi.org/10.1016/j.aquaculture.2008.07.048

Micael, J., Costa, A. C., Aguiar, P., Medeiros, A. and Calado, H. (2015) Geographic information system in a multi-criteria tool for mariculture site selection. Coastal Management, 43(1), 52-66. https://doi.org/10.1080/08920753.2014.985178

Stelzenmüller, V., Gimpel, A., Gopnik, M. and Gee, K. (2017) Aquaculture site-selection and marine spatial planning: the roles of GIS-based tools and models. In *Aquaculture perspective of multi-use sites in the open ocean: The Untapped Potential for Marine Resources in the Anthropocene*. *Cham: Springer International Publishing*, Pp. 131-148. https://doi.org/10.1007/978-3-319-51159-7_6

Malakar, K. D., Roy, S., & Kumar, M. (2025). Practical approaches to GIS data analysis. In *Geospatial Technologies in Coastal Ecologies Monitoring and Management Cham: Springer Nature Switzerland*, Pp. 159-190. https://doi.org/10.1007/978-3-031-92017-2_6

Primavera, J. H. (2006) Overcoming the impacts of aquaculture on the coastal zone. *Ocean & Coastal Management*, 49(9-10), 531-545. https://doi.org/10.1016/j.ocecoaman.2006.06.018

Jayanthi, M., Samynathan, M., Thirumurthy, S., Duraismay, M., Kabiraj, S., Vijayakumar, S., & Muralidhar, M. (2022) Is aquaculture development responsible for mangrove conversion in India? - a geospatial study to assess the influence of natural and anthropogenic factors on mangroves in the last three decades. *Aquaculture*, *561*, 738696. https://doi.org/10.1016/j.aquaculture.2022.738696

de Jong, J. (2017) Aquaculture: Opportunities and Challenges in Andhra Pradesh, India, *Rijksdienst voor Ondernemend Nederland (RVO.nl). Netherlands*.

Prasad, K. A., Ottinger, M., Wei, C., & Leinenkugel, P. (2019) Assessment of coastal aquaculture for India from Sentinel-1 SAR time series. *Remote sensing*, *11*(3), 357.

Ottinger, M.; Clauss, K.; Kuenzer, C. (2016) Aquaculture: Relevance, distribution, impacts and spatial assessments - A review. *Ocean & Coastal Managemen*, *119*, 244-266. https://doi.org/10.1016/j.ocecoaman.2015.10.015

Sridhar, P.N.; Surendran, A.; Ramana, I.V. (2008) Auto-extraction technique-based digital classification of saltpans and aquaculture plots using satellite data. *International Journal of Remote Sensing*, *29*, 313–323. https://doi.org/10.1080/01431160701250374

Disperati, L. and Virdis, S.G.P. (2015) Assessment of land-use and land-cover changes from 1965 to 2014 in Tam Giang-Cau Hai Lagoon, central Vietnam. *Applied Geography*, *58*, 48-64. https://doi.org/10.1016/j.apgeog.2014.12.012

Tsai, B.W.; Chang, K.T.; Chang, C.Y.; Chu, C.M. (2006) Analyzing Spatial and Temporal Changes of Aquaculture in Yunlin County, Taiwan. *The Professional Geographer*, *58*, 161-171. https://doi.org/10.1111/j.1467-9272.2006.00523.x

Sudarshana, R.; Bhan, S.K.; Siddiqui, M.S.; Vohra, T.P.S.; Prasad, P.N.; Bhat, U.G.; Neelakantan, B. (1993) Experiments in site selection for coastal aquaculture using Indian remote sensing satellite: IRS-1A. *International Journal of Remote Sensing*, *14*, 2275-2284. https://doi.org/10.1080/01431169308954036

Jayanthi, M.; Rekha, P.N.; Kavitha, N.; Ravichandran, P. (2006) Assessment of impact of aquaculture on Kolleru Lake (India) using remote sensing and Geographical Information System. *Aquaculture Research*, *37*, 1617-1626.

Rajitha, K.; Mukherjee, C.K.; Chandran, R.V.; Mohan, M.M.P. (2010) Land-cover change dynamics and coastal aquaculture development: A case study in the East Godavari delta, Andhra Pradesh, India using multi-temporal satellite data. International Journal of Remote Sensing, 31, 4423-4442. https://doi.org/10.1080/01431160903277456

Kairo, J. G., Kivyatu, B., & Koedam, N. (2002) Application of remote sensing and GIS in the management of mangrove forests within and adjacent to Kiunga Marine Protected Area, Lamu, Kenya. *Environment, Development and Sustainability*, 4(2), 153-166. https://doi.org/10.1023/a:1020890711588

Pandey, K., & Ghosh, S. K. (2018) Modeling of parameters for forest fire risk zone mapping. *The international archives of the photogrammetry, remote sensing and spatial information sciences*, *42*, 299-304. https://doi.org/10.5194/isprs-archives-xlii-5-299-2018

Michele, M., Thuoc, P., Canh, N. T., Khanh, P. T., & Fausto, M. (2013) Site suitability analysis for Bay scallop aquaculture and implications for sustainable fisheries management in the Ha Long Bay archipelago, northern Vietnam. *JNRD-Journal of Natural Resources and Development*, *3*, 01-13. https://doi.org/10.5027/jnrd.v3i0.01

Wilkinson, G. G. (1996) A review of current issues in the integration of GIS and remote sensing data. *International Journal of Geographical Information Science*, *10*(1), 85-101. https://doi.org/10.1080/02693799608902068

Lima, A. R. (2025).Exploring Nationwide Oyster Aquaculture Data: An Index to Compare Regulatory, Production, and Economic Attributes of Oyster Aquaculture Among US States and Regions. *Fishes*, *10*(4), 138. https://doi.org/10.3390/fishes10040138

Kapetsky, J. M., Hill, J. M., & Worthy, L. D. (1988) A geographical information system for catfish farming development. *Aquaculture*, *68*(4), 311-320. https://doi.org/10.1016/0044-8486(88)90245-1

Howard, J. A. (1985) “Overview of Remote Sensing”. In, Report of the ninth International training Course on application of remote sensing to aquaculture and inland fisheries. RSC

Series 27, *FAO Rome*. 51-21. https://doi.org/10.1016/j.ocecoaman.2011.07.013

Ottinger, M., Clauss, K., & Kuenzer, C. (2017) Large-scale assessment of coastal aquaculture ponds with Sentinel-1 time series data. *Remote Sensing*, *9*(5), 440. https://doi.org/10.3390/rs9050440

Bakker, W. H. (2013) Satellites & sensors. *EARSeL Newsletter*, (93), 50-53. https://doi.org/10.1117/12.2531621

Wang, J., Wang, S., Wang, X., & Liu, J. (2025) High-precision mapping of aquaculture ponds based on multi-feature fusion, using Sentinel-1 and Sentinel-2 time series images. *International Journal of Remote Sensing*, 1-22. https://doi.org/10.1080/01431161.2025.2586472

Wanchana, W., & Sayan, S. (2018) Application of GIS and remote sensing for advancing sustainable fisheries management in Southeast Asia. *Fish for the People*, *16*(1), 21-28.

Aguilar-Manjarrez, J., & Ross, L. G. (1995) Geographical information system (GIS) environmental models for aquaculture development in Sinaloa State, Mexico. *Aquaculture International*, *3*(2), 103-115. https://doi.org/10.1007/bf00117877

Yalew, S. G., Van Griensven, A., & van der Zaag, P. (2016) AgriSuit: A web-based GIS-MCDA framework for agricultural land suitability assessment. *Computers and Electronics in Agriculture*, *128*, 1-8. https://doi.org/10.1016/j.compag.2016.08.008

Shunmugapriya, K., Panneerselvam, B., Muniraj, K., Ravichandran, N., Prasath, P., Thomas, M., & Duraisamy, K. (2021) Integration of multi criteria decision analysis and GIS for evaluating the site suitability for aquaculture in southern coastal region, India. *Marine Pollution Bulletin*, *172*, 112907. https://doi.org/10.1016/j.marpolbul.2021.112907

Dolan, J. G. (2008) Shared decision-making-transferring research into practice: the Analytic Hierarchy Process (AHP). *Patient Education and Counseling*, *73*(3), 418-425. https://doi.org/10.1016/j.pec.2008.07.032

Chen, M., Zhang, S., Liu, S., Li, M., Zhang, T., Wu, T., & Bu, X. (2025) Mapping the groundwater potential zones in mountainous areas of Southern China using GIS, AHP, and fuzzy AHP. *Scientific Reports*, *15*(1), 17159. https://doi.org/10.1038/s41598-025-01837-y

Bostock, J., McAndrew, B., Richards, R., Jauncey, K., Telfer, T., Lorenzen, K., ... & Corner, R. (2010) Aquaculture: global status and trends. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 365 (1554), 2897-2912. https://doi.org/10.1098/rstb.2010.0170

Abdullah, L., Awang, N. A., Liow, P. T., & Mohd, W. R. W. (2023) Optimal site for aquaculture farming: an elimination decision approach. Journal of Computational and Cognitive Engineering, 2 (2), 116-123. https://doi.org/10.47852/bonviewjcce2202295

Ihejirika, C. E., Onwudike, S. U., Nwaogu, L. A., Emereibeole, E. I., Ebe, T. E., & Ejiogu, C. C. (2012) Assessment of aquaculture sediment for agricultural fertilizer supplement and soil conditioner in Owerri Urban, Nigeria. Journal of Research in Agriculture, 1(1), 34-38.

Das, P. C., Ayyappan, S., & Jena, J. (2005) Comparative changes in water quality and role of pond soil after application of different levels of organic and inorganic inputs. *Aquaculture Research*, 36(8), 785-798. https://doi.org/10.1111/j.1365-2109.2005.01288.x

Divu, D.N., Mojjada, S.K., Pokkathappada, A.A., Sukhdhane, K., Menon, M., Mojjada, R.K., Tade, M.S., Bhint, H.M., Gopalakrishnan, A. (2021) Decision-making framework for identifying best suitable mariculture sites along north east coast of Arabian Sea, India: A preliminary GIS-MCE based modelling approach. *Journal of Cleaner Production*, 284, 124760. https://doi.org/10.1016/j.jclepro.2020.124760

Ghobadi, M.; Nasri, M.; Ahmadipari (2021) M. Land suitability assessment (LSA) for aquaculture site selection via an integrated GIS-DANP multi-criteria method; a case study of Lorestan province, Iran. *Aquaculture*, 530, 735776. https://doi.org/10.1016/j.aquaculture.2020.735776

Esmaeilpour-Poodeh, S.; Ghorbani, R.; Hosseini, S.A.; Salmanmahiny, A.; Rezaei, H.; Kamyab, H. (2019) A multi-criteria evaluation method for sturgeon farming site selection in the southern coasts of the Caspian Sea. *Aquaculture*, 513, 734416. https://doi.org/10.1016/j.aquaculture.2019.734416

Jayanthi, M. and Ravichandran, P. (2009) Optimizing site selection for the development of sustainable aquaculture. In: Training Manual on Better Management Practices in Shrimp Farming, CIBA Special Publication No. 44 : 12-20.

Karthik, M.; Suri, J., Saharan, N., Biradar, R.S. (2005) Brackish water aquaculture site selection in Palghar Taluk, Thane district of Maharashtra, India, using the techniques of remote sensing and geographical information system. *Aquaculture Engineering*, 32, 285-302. https://doi.org/10.1016/j.aquaeng.2004.05.009

Saukani, I., & Triturani, R. (2022) Application of Lm 35 Temperature Sensor for Seawater Distillation. *Jurnal Neutrino: Jurnal Fisika dan Aplikasinya*, *14*(2), 35-43. https://doi.org/10.18860/neu.v14i2.13924

Zeta, B. M. A., Alam, S. U., Rahman, G. M. E. U., & Ahmed, K. I. U. (2025) A Low-Cost pH Sensor for Real-Time Monitoring of Aquaculture Systems in a Multi-Layer Wireless Sensor Network. *Sensors*, *25*(9), 2824. https://doi.org/10.3390/s25092824

Wei, Y., Ding, Q., Li, D., Tai, H., & Wang, J. (2011) Design of an intelligent electrical conductivity sensor for aquaculture. *Sensor Letters*, *9*(3), 1044-1048. https://doi.org/10.1166/sl.2011.1395

Ma, Y., & Ding, W. (2018, October). Design of intelligent monitoring system for aquaculture water dissolved oxygen. In *2018 IEEE 3rd Advanced Information Technology, Electronic and Automation Control Conference (IAEAC)*. IEEE. 414-418 https://doi.org/10.1109/iaeac.2018.8577649

Maulini, R., Sahlinal, D., & Arifin, O. (2022) Monitoring of pH, amonia (NH3) and temperature parameters aquaponic water in the 4.0 revolution era. In *IOP Conference Series: Earth and Environmental Science*. *IOP Publishing*, 1012 (1), p. 012087. https://doi.org/10.1088/1755-1315/1012/1/012087

Okarma, K., Lech, P., Andriukaitis, D., Navikas, D., Korzelecka-Orkisz, A., Tański, A., & Formicki, K. (2022) A visual feedback for water-flow monitoring in recirculating aquaculture systems. *Applied Sciences*, *12*(20), 10598. https://doi.org/10.3390/app122010598

Malinowski, R., Groom, G. B., Heckrath, G., & Schwanghart, W. (2017) Do remote sensing mapping practices adequately address localized flooding? A critical overview. *Springer Science Reviews*, *5*(1), 1-17. https://doi.org/10.1007/s40362-017-0043-8

Venkateswarlu, V., Seshaiah, P. V., Arun, P., & Behra, P. C. (2019) A study on water quality parameters in shrimp L. vannamei semi-intensive grow out culture farms in coastal districts of Andhra Pradesh, India. International Journal of Fisheries and Aquatic Studies, 7(4), 394-399.

Prasad, L., Kumar, R., Singh, S., Kumar, D., Maurya, A., Pal, J., ... & Kumar, S. (2020) Adoption of carps-based polyculture system and status of fish productivity in eastern Uttar Pradesh, India. Journal of Entomology and Zoology Studies, 8(3), 157-161.

Jayanthi, M. (2011) Monitoring brackishwater aquaculture development using multi-spectral satellite data and GIS-a case study near Pichavaram mangroves south-east coast of India. Indian Journal of Fisheries, 58(1), 85-90.

Padmanaban, R., & Sudalaimuthu, K. (2012) Marine fishery information system and aquaculture site selection using remote sensing and GIS. International Journal of Advanced Remote Sensing and GIS, 1, 20-33.

Jayanthi, M., Samynathan, M., Thirumurthy, S., Kumararaja, P., Muralidhar, M., & Vijayan, K. K. (2021) Mapping coastal lagoon characteristics for the aquaculture suitability using multi-criteria decision support (MCDS) spatial analysis: A case study from south-east coast of India. Journal of Earth System Science, 130(1), 56. https://doi.org/10.1007/s12040-02101560-y

Hamud, A. M., Prince, H. M., & Shafri, H. Z. (2019, November). Landuse/Landcover mapping and monitoring using Remote sensing and GIS with environmental integration. In *IOP Conference Series: Earth and Environmental Science*. *IOP Publishing*., 357 (1), p. 012038. https://doi.org/10.1088/1755-1315/357/1/012038

Liu, D., & Cai, S. (2012) A spatial-temporal modeling approach to reconstructing land-cover change trajectories from multi-temporal satellite imagery. Annals of the Association of American Geographers, 102(6), 1329-1347. https://doi.org/10.1080/00045608.2011.596357

Farshidi, S., Farnood Ahmadi, F., & Sadeghi, V. (2023) Modeling and prediction of land use land cover change dynamics based on spatio-temporal analysis of optical and radar time series of remotely sensed images. *Earth Science Informatics*, *16*(3), 2781-2793. https://doi.org/10.1007/s12145-023-01072-x

Kapetsky, J. M. (2004) Geographic information systems applications in aquaculture. *Geographic Information Systems in fisheries*, 13-48. https://doi.org/10.47886/9781888569575.ch6

Ghadirian, P., & Bishop, I. D. (2008) Integration of augmented reality and GIS: A new approach to realistic landscape visualisation. *Landscape and Urban Planning*, *86*(3-4), 226-232. https://doi.org/10.1016/j.landurbplan.2008.03.004

Nath, S. S., Bolte, J. P., Ross, L. G., & Aguilar-Manjarrez, J. (2000) Applications of geographical information systems (GIS) for spatial decision support in aquaculture. Aquacultural Engineering, 23(1-3), 233-278. https://doi.org/10.1016/s0144-8609(00)00051-0

Huda, N. (2022) Changing surface water in the Bengal Delta, observed by satellite remote sensing analysis and people's perception. https://doi.org/10.3390/su13179798

Rajeevan, M., Rohini, P., Niranjan Kumar, K., Srinivasan, J., & Unnikrishnan, C. K. (2013) A study of vertical cloud structure of the Indian summer monsoon using CloudSat data. *Climate dynamics*, *40*(3), 637-650. https://doi.org/10.1007/s00382-012-1374-4

Agarwal, N., Sahay, A., Shah, S. M., Babu, K. N., Thapliyal, P. K., Dube, N., ... & Desai, N. M. (2025) Remote sensing, geospatial and AI/ML techniques: catalysing growth in India's blue economy. *CSI Transactions on ICT*, *13*(1), 27-42. https://doi.org/10.1007/s40012-025-00408-w

Soti, V., Tran, A., Bailly, J. S., Puech, C., Seen, D. L., & Bégué, A. (2009) Assessing optical earth observation systems for mapping and monitoring temporary ponds in arid areas. International Journal of Applied Earth Observation and Geoinformation, 11(5), 344-351. https://doi.org/10.1016/j.jag.2009.05.005

Pattanaik, C., Nagabhatla, N., Sellamuttu, S. S., Prasad, S. N., & Finlayson, C. M. (2008) Remote sensing application to study the aquaculture dynamics in Kolleru lake, India. In *Proceedings of the 29th Asian Conference on Remote Sensing (ACRS)*, 10-14. https://doi.org/10.3390/rs11030357

Dhillon, R., & Moncur, Q. (2023) Small-scale farming: A review of challenges and potential opportunities offered by technological advancements. *Sustainability*, *15*(21), 15478. https://doi.org/10.3390/su152115478

Subramani, T., Moorthy, K. V., & Priyanka, S. (2017) Assessment of impact on aquaculture using remote sensing data and GIS in Tiruchendur. *International Journal of Emerging Trends & Technology in Computer Science (IJETTCS)*, *6*(3), 157-166.

Gladju, J., Kamalam, B. S., & Kanagaraj, A. (2022) Applications of data mining and machine learning framework in aquaculture and fisheries: A review. *Smart Agricultural Technology*, *2*, 100061. https://doi.org/10.1016/j.atech.2022.100061

Eluri, P. R. R., Annapurnaiah, K., Uday Bhaskar, T. V. S., Kiran Kumar, N., Padmanabham, J., Karthik, T. N. C., ... & Srinivasa Kumar, T. (2025) Empowering the Blue Economy: the role of ICT in ocean observations, data, information and advisory services. CSI Transactions on ICT, 13(1), 3-25. https://doi.org/10.1007/s40012-025-00407-x

Owen, J. (2025) Broadband Performance Monitoring through GIS and IoT Integration.

Kelkar, N., & Arthur, R. I. (2022) A review of governance and tenure in inland capture fisheries and aquaculture systems of India. https://doi.org/10.4060/cb8615en

Carter, H. N., Schmidt, S. W., & Hirons, A. C. (2015) An international assessment of mangrove management: incorporation in integrated coastal zone management. *Diversity*, *7*(2), 74-104. https://doi.org/10.3390/d7020074

Rodríguez-Veiga, P., Wheeler, J., Louis, V., Tansey, K., & Balzter, H. (2017) Quantifying forest biomass carbon stocks from space. *Current Forestry Reports*, *3*(1), 1-18. https://doi.org/10.1007/s40725-017-0052-5

Bansod, B., Singh, R., Thakur, R., & Singhal, G. (2017) A comparision between satellite based and drone based remote sensing technology to achieve sustainable development: A review. *Journal of Agriculture and Environment for International Development (JAEID)*, *111*(2), 383-407.

Mabhaudhi, T., Bangira, T., Sibanda, M., & Cofie, O. (2022) Use of drones to monitor water availability and quality in irrigation canals and reservoirs for improving water productivity and enhancing precision agriculture in smallholder farms. IWMI.

Ferriby, H., Nejadhashemi, A. P., Hernandez-Suarez, J. S., Moore, N., Kpodo, J., Kropp, I., ... & Haque, M. M. (2021) Harnessing machine learning techniques for mapping aquaculture waterbodies in Bangladesh. *Remote sensing*, *13*(23), 4890. https://doi.org/10.3390/rs13234890

Hasan, M. F., & Sojib, M. R. (2025) Climate Change Resilience. *Intelligent Solutions to Evaluate Climate Change Impacts*, 347. https://doi.org/10.4018/979-8-3693-5898-6.ch015

Meaden, G. J., & Aguilar-Manjarrez, J. (2013) Advances in geographic information systems and remote sensing for fisheries and aquaculture. FAO fisheries and aquaculture technical paper, (552), I. https://doi.org/10.47886/9781888569575.ch2

Khatri, A., Lallawmkimi, M. C., Rana, P., Panigrahi, C. K., Minj, A., Koushal, S., & Ali, M. U. (2024) Integration of ICT in agricultural extension services: A review. Journal of Experimental Agriculture International, 46(12), 394-410. https://doi.org/10.9734/jeai/2024/v46i123146

Rashid, M. and Gani, G. (2025) Reimagining the Future of Sustainable Agriculture in South Asia: Integrating Ecological Resilience, Technological Innovation, and Inclusive Policy Reform for Transformative Agri-Systems. *Precision Agriculture and Climate-Resilient Farming: Artificial Intelligence, IoT, and Blockchain for Sustainable Agriculture*, 118.