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The Roles of Remote Sensing in Aquaculture Site-Selection

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Abstract

Site selection for aquaculture production is a challenging task that entails identifying areas that are socially, economically, and environmentally suitable as well as areas that are appropriate for aquaculture. Remote sensing uses electromagnetic or acoustic waves released by the targets of interest to acquire data/ information about objects/ substances that are not in direct contact with the sensor. Geographic information systems and remote sensing technologies, which allow for the integration and analysis of spatial and attribute data from a variety of sources, have been commonly used to find suitable locations for aquaculture. This article described a summary of the roles of remote sensing in aquaculture site selection.

Introduction

Aquaculture's success is described by the existence of good water availability, suitable soil quality, and infrastructure facilities. Aquaculture, particularly fisheries, is practiced across a vast section of the Earth's surface, making data collection a significant issue for GIS work. Satellite remote sensing, on the other hand, is increasingly able to fulfill these data needs, because of its unique ability to conduct regular, repeated observations of the entire globe or specific regions at various spatial scales. Remote sensing and provides useful guidance for planning and employing the use of this technology, including image processing, selection and acquisition, data sourcing, and the integration of imagery with GIS.

Geographic information systems have been used in aquaculture since the mid-1980. The FAO used GIS and remote sensing to locate aquaculture and inland fisheries in 1985, which was one of the first applications of these techniques. The FAO used GIS and remote sensing to locate aquaculture and inland fisheries in 1985, which was one of the first applications of these techniques. However, most GIS-based site selection efforts are still focused on shrimp aquaculture in Asian coastal areas, with studies in offshore habitats remaining scarce. The use of GIS to help aquaculture development and planning has a long history and one of the most common applications of GIS has been the identification of potential aquaculture sites. The use of Geographical Information Systems (GIS) in regional progress is now becoming renowned as an important research tool in recognizing potential aquaculture development sites intended for culture and promoting better use of aquatic resources especially fisheries on a regional basis. Effective spatial management is existence recognized as one avenue for evolving sustainable aquaculture improvement worldwide. Meaden and Kapetsky (1991) combined numerous of the earliest case studies in an FAO technical paper besides comprehensive information on the use of GIS and remote sensing in aquaculture and inland fisheries. Recently, the combination of GIS and dynamic models to recognize suitable sites, as done by Silva *et al.* (2011) for the culture of shellfish is pleasant more popular. Essential parameters such as water source, accessibility to the site, soil types, topography, marketing, *etc*. are enough to identify suitable regions for sustainable aquaculture. GIS and RS are effective tools for planning aquaculture and mariculture management, allowing for flexible resource allocation. In a GIS environment, numerous physical, biological, and chemical factors can be analyzed, assisting in the identification of areas ideal for aquaculture, both onshore and offshore. The Remote Sensing data provides appropriate evidence about the area with their natural physical characteristics, these properties help to analyze several features in the ground and aid to accomplish the resources accessible in the earth. To reduce environmental consequences and social conflicts, optimize economic return, and ensure sustainable development, it is necessary to predict viable sites, potential production, economic outputs, and environmental implications. Remote sensing can help with spatial detection of different species as well as locating target species by detecting hydrographic features like fronts. Furthermore, ocean colour remote sensing can be used in aquaculture to provide information on nutrient transport, water quality, sea surface temperature, and harmful algal bloom identification (HABs).

An Overview of Aquaculture

For hundreds of millions of people around the world, the aquaculture sector provides a significant source of income and livelihood, and it is still a significant source of food and nutrition. Aquaculture commands increasing attention worldwide. "Aquaculture has become the world's fastest-growing food sector in recent years, with annual development of 10% compared to 2-3% for other major food sectors". Aquaculture has developed promptly over the last two decades and has become a significant economic activity worldwide. According to the state world fisheries and aquaculture, the total world fish production was 178.5 MMT in 2018 among the total production aquaculture contributing 82.1 MMT (46%). The total world aquaculture production inland contributing 51.3 MMT and marine 30.8 MMT. Aquaculture contributed around 52% towards worldwide food fish consumption and is anticipated to reach 59% by 2030. Aquaculture production is significantly skewed amongst continental areas with Asia accounting for 91%. Total fish production in India is 14.2 MMT, with 3.72 MMT of marine fish production and 10.48 MMT of inland fish production (Handbook on Fisheries Statistics, 2020). Aquaculture is a rapidly developing fisheries sector in India with a yearly growth rate of over 7 percent. Freshwater aquaculture represents over 95% of the total annual aquaculture yield. Aquaculture is mainly the farming of fish and shellfish, forms the main enterprise in the primary production sector in the inland freshwater, brackish water regions of India. India's support for world aquaculture production was 6.2%. Nearly 1.45 million hectares of brackish-water area exist in India, with about 5% being utilized for organized aquaculture. "Inland fisheries resources in our country are supported by long Riverine system with 29,000 km length; Canals and Streams network of 0.17 million km; Reservoir area of 2.67 million ha water spread and Lagoons Swamps; Brackish water resource to the extent of 2.66 million ha". While aquaculture's long-term sustainability is essential for global food security, it faces significant threats and challenges, including increased opposition for land, water, and energy resources, as well as vulnerability to global warming, water pollution, sea-level rise, harmful algal blooms (HABs), increased frequency of extreme events, and sometimes disease outbreaks. Aquaculture in the coastal and open waters has enormous growth potential compared to land-based aquaculture, which is constrained by spatial limits.

Site Suitability for Aquaculture

Assessing the suitability of a site is one of the most critical steps in the development of aquaculture. It also is one of the most frequent applications of GIS in aquaculture site selection. Aquaculture activity must be located in a way that represents conservation and economic return in a long-term manner. The social, economic, and environmental elements must all be carefully considered before a site's suitability can be determined. Planning exercises and management interventions are based on environmental suitability. It is now feasible to identify environmentally acceptable sites rapidly and methodically mainly to the development of the geographic information system (GIS) and the availability of remote sensing data. Site suitability determination, zoning, environmental implications, planning, monitoring and inventory of aquaculture and the environment, and competitive exploitation of shared areas are all areas where GIS has been used extensively in aquaculture development. Generally, satellite images have been used as input data for GIS investigation for the preparation of appropriate maps for regional planning or intended for aquaculture facilities design. Through use of multispectral images from very high spatial-resolution sensors has been widely used to select near-shore aquaculture sites (*e.g.*, Landsat, Spot). Remotely sensed imaging has only recently been used to identify aquaculture sites in the open sea (for example, mollusk rafts, fish cages, or long-line systems). "In divergence to land-based aquaculture planning where a few great spatial-resolution images are used, site selection in open seas involves broad use of medium-resolution images (*e.g.*, AVHRR, MODIS, SeaWiFS, and QuikSCAT) for the analysis of the seasonal and inter-annual unpredictability of the highly-dynamic appearances of the marine environment, and also for the investigation of environmental patterns and trends of likely aquaculture sites, or for the preparation of aquaculture suitability maps".

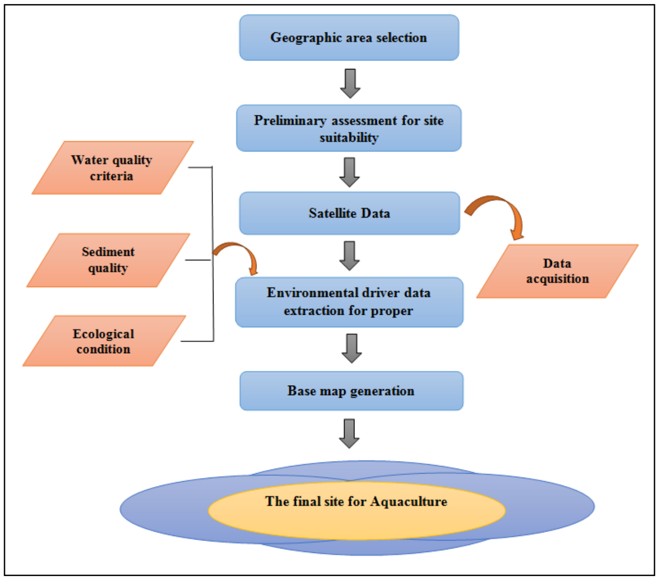

Figure 1: The site selection approach for aquaculture is depicted in a methodological flow diagram

There are three types of remote sensing based on satellite/ sensor altitude.

1. Space Born Remote Sensing

Sensors are mounted aboard a spacecraft (space shuttle or satellite) encircling the planet in space-borne remote sensing. The space shuttle or, more typically, satellites are used to do remote sensing.

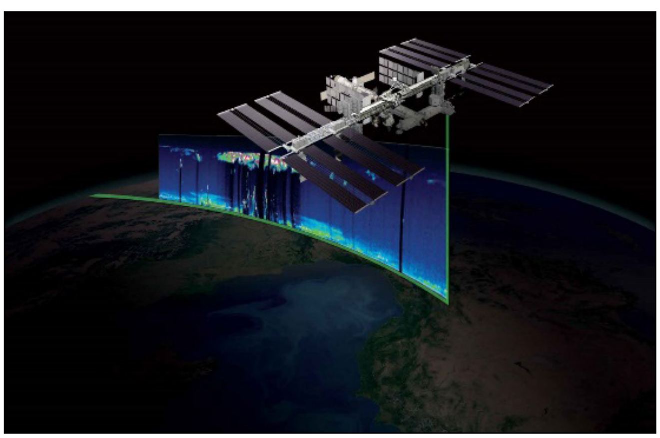

Figure 2: Satellites in space (Source: NASA image gallery)

2. Air Born Remote Sensing

Downward or sideward observing sensors are mounted on an aeroplane to collect images of the earth's surface in airborne remote sensing.

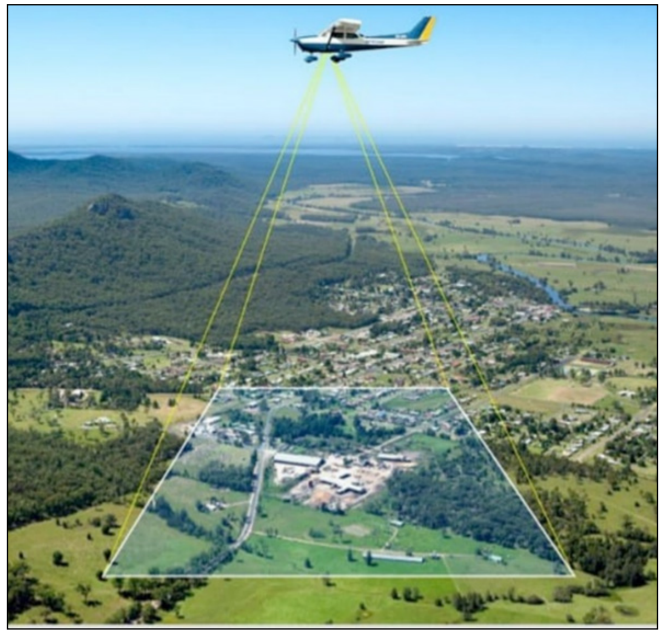

Figure 3: Sensor mounted on an aircraft

3. Ground-Based Remote Sensing

Ground-based sensors are frequently employed to capture detailed surface data, which is then compared to data collected by aircraft or satellite sensors.

Figure 4: Ground-based remote sensing

Strategic Planning for Aquaculture Development

Examples of long-range, large-area planning for aquaculture that use GIS are numerous. These investigations show the potential for aquaculture development at various levels of suitability in areal quantities, sometimes in terms of expected production, and usually according to administrative boundaries rather than by ecosystems. Often, more than one species is the focus and more than one kind of culture system is included.

Anticipating Aquaculture's Consequences

Planning for aquaculture development usually is seen as consisting mainly of determining the suitability of a site, or of a larger areal expanse, for the organism to be cultured and the culture system to be used. However, more and more, part of the predevelopment planning process has to include anticipating the social, economic, and political consequences of aquaculture. It is necessary to anticipate the environment for aquaculture before site selection. After aquaculture is employed, it is necessary to cope with environmental change to ensure sustainability. Anticipating and mitigating environmental change can be facilitated if planning for aquaculture is integrated with planning in other sectors.

Criteria for Aquaculture Site Selection

• Waste dispersal is another set of criteria for selecting ideal sites for aquaculture species farming in offshore waters, due to severe water and sediment quality problems connected with fish cage, mussel, or pearl farming.

• It's crucial to understand that aquaculture site selection employing remote sensing images as input data is based on before established water quality and culture requirements.

• Site selection for culture systems must be done with care, taking into account the needs of the species to be cultured as well as the structures to be constructed.

• Other factors to consider while considering an aquaculture sites selection include ground elevation, soil, water quality and supply, land vegetation, *etc*.

Advantages and Disadvantages of Remote Sensing for Aquaculture Site Selection

Advantages

• Finding an appropriate location for freshwater and brackish water aquaculture.

• Data for large areas is available.

• Provides data on locations that are extremely remote and inaccessible.

• Obtaining imagery of any region over a long period allows for the analysis of any manmade or natural changes in the environment.

• It is rather inexpensive when compared to establishing a team of surveyors.

• Data collecting is simple and quick.

• Maps for interpretation are made immediately.

Disadvantages

• Accessing, manipulating, and processing satellite data can be difficult, especially for those who have never done it before.

• The effort necessary to get appropriate parameters can be time-consuming.

• People are too preoccupied with their normal workloads to devote time to learning new analyses.

• In comparison to many fisheries datasets, satellite data time series are quite short.

Future Directions of GIS Applications in Aquaculture

It seems certain that aquaculture will continue its current upward development trend for some time to come; however, future development, like current practice, is likely to be patchy. Numbers and kinds of GIS applications in aquaculture are on an increasing trend but, considering the role that GIS might play in the improvement and management of aquaculture, they are remarkably few.

Conclusion

Among the various categories of applications, the use of GIS for site selection, for strategic assessments of inland aquaculture potential, and the inventory and management of some kinds of cultures is relatively well developed. One exception is that there are few examples of incorporating growth and production models in site selection and strategic assessments of potential. In contrast, there are unrealized opportunities for the use of GIS in several kinds of applications in monitoring within culture systems, offshore environments, anticipating the significances of aquaculture, estimating the environmental impacts of aquaculture, culture-based fisheries and sea ranching, socioeconomics, the distribution and marketing of aquaculture products, and multi administration, multidisciplinary planning, and management.

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