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CHAPTER 3

Digitization of Aquatic Sector Towards Fulfilment of Important Sustainable Development Goals of United Nations

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Abstract

The aquaculture is one of the fastest growing industries globally owing to its contribution to support basic livelihood that includes daily staple food, providing nutrition, promoting employability and raising economy. Measures are in full swing for the conservation of various aquatic habitats and the natural resources. The United Nations Sustainable Development Goals have pinpointed around 17 areas of work. They stand as a framework for better world by working to end poverty and ensuring the planet's overall well-being. The SDG14 emphasizes on "life below water" aiming at managing and protecting the aquatic ecosystem along with the regulated harvesting of fishes. The fourth industrial revolution has witnessed remarkable "smart" automation in various sectors. The digitization of aquatic sector is equally

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influenced by communication and technological advancements. Evaluation of water quality parameters, employing automated feed supply, marketing the different products obtained from aquaculture, data science for innovative strategies for aquaculture, location determination using Geographical Information System are the areas chiefly regulated by digitization. This review is an attempt to provide an overall aspect of how aquatic ecosystem is governed by digitization at its various levels. The article aims to address emerging trends, changing developments, other challenges and budding opportunities like increasing employability surrounding digitalization of fisheries and aquaculture. Different parameters like localization of sites of cultivation, automated feeding system, water quality assessments and digital marketing are some of the key aspects being covered. These paradigms are the essential requisites aiming towards fulfilment of UN's Sustainable Goals towards wellbeing of aquatic organisms in their habitat.

Keywords: Aquaculture, Fisheries, Digitization, Production, Sustainable, Ecosystem

Introduction

Aquaculture is a process attempted towards breeding, rearing, followed by harvesting of fish, algae, shellfish and several other organisms in varied types of water habitats. With the growing population, there has been increasing demand for the food and related products. In the process of aquaculture, there lies the method not only restricted to produce food and other commercial products but to restore habitats, replenish wild stocks and rebuild populations of affected, threatened and endangered aquatic species (Xia *et al*., 2020). There are two main types of aquaculture - marine and freshwater. Marine aquaculture is the production of varied species including clams, oysters, shrimps, mussels, seaweeds and numerous fish species - black sea bass, sablefish, yellowtail, pompano are to name a few. Freshwater aquaculture primarily takes place in ponds or other manmade systems (Naylor *et al.,* 2021).

The United Nations have estimated that the human population will become around 9.7 billion by 2050 and approximately 4 billion by 2100. Population growth and consequent climate change have generated concerns about food security and its sustainability). Aquaculture serves as the primary means of obtaining food with excellent protein, vitamin, and mineral values (Garlock et al., 2019). The United Nations members meet in 2015 framed the 2030 Agenda for Sustainable Development conceived 17 world SDGs (Sustainable Development Goals). These were framed with the motto to bridge preservation of natural resources & restoring biodiversity loss in the aspect of changing climatic conditions. The SDGs were an attempt to highlight the interconnectedness of global health with social, environmental and economic aspects of sustainability & hence enforcing "Sustainable Development". The statement of the mission says "A shared blueprint for peace and prosperity for people and the planet, now and into the future". The Goal 14 emphasizes on "Life Below Water" and emphasizes on effective measures to protect and restore ecosystems; reduce marine pollution & ocean acidification; conserve coastal and marine areas; establishing sustainable fishing; ending subsidies contributing to overfishing and increase the economic benefits from sustainable use of marine resources (Arora & Mishra, 2019).

Geospatial Technology in reference to "Life Below Water" is integral to collection, analysis, management, understanding and visualization of the ecosystem. The SDG14 is an intricate plan of action aimed for the protection and sustainable use of marine and oceanic resources and this technology has emerged as a firm ally in achieving this. It provides important insights, valuable data and strengthened tools that enables stakeholders of different strata ranging from scientists, policy makers, communities to make important decisions and design effective strategies for the preservation of life below water (Ficarelli & Ribeiro, 2021).

Sustainable Development Goal 14 (SDG-14)

The Goal 14 of United Nations SDGs aims at conserving and sustainably using marine & oceanic resource. These natural resources are integral to existence & maintenance of life and various life forms. They are the sources of chief natural resources including biofuels, medicines, food and are involved in key processes like breakdown, removal or transformation of waste materials and various pollutants. They serve as the greatest sink to planet's carbon content. The acidification (pH) of the oceans is nearly around 8.1 which is around 30 percent more than that of pre-industrial times. This serves as a severe threat and have raised important concerns like disruption of food web, cut down in the yields of essential services obtained from it and interruptions in the food manufacturing process (Virto, 2018).

Hence for the sustainable future, it is important that careful management of natural resources takes place and oceans serves as an important natural resources. Besides being the largest ecosystem, oceans acts as the source of staple food (fishing), serves as home to various life forms, hub of unexplored potential, supports economy amongst others. Howsoever literature suggest decades of irresponsible exploitation and degradation of oceans and marine resources leading to intense problems like degradation of coral reefs (one of the richest ecosystems), increased level of debris, marine heatwaves etc causing important environmental and economic concerns (Hoof *et al*., 2019).

To counter various such concerns, immediate, co-ordinated and swift action at the global level is imperative. Monitoring the protected areas, establishing equitable management of the vulnerable sites, combating unregulated and illegal fishing, are integral for the safety and conservation of Earth's largest ecosystem (Cormier *et al.*, 2014). The brief overview of targets of SDG14 are:

- Target 14.A – Increase scientific knowledge, research, technology for ocean health
- Targetv14.B – Support small scale fishers
- Target 14.C – Implement and enforce international sea law
- Target 14.1 – Reduce marine pollution
- Target 14.2 – Protect and restore ecosystems
- Targets 14.3 – Reduce ocean acidification
- Target 14.4 – Sustainable fishing
- Target 14.5 – Conserve coastal and marine areas
- Target 14.6 – End subsidies contributing to overfishing
- Target 14.7 – Increase the economic benefits from sustainable use of marine resources

Implications of Digitization in Oceanic and Marine Ecosystem

Satellite remote sensing is an integral component of marine biodiversity studies. Marine and coastal ecosystems are vastly changing owing to anthropogenic factors. Changes in marine biological composition and altered productivity are on rise due to fluctuating circulation patterns, acidification, loss in sea ice & elevating sea levels. Furthermore, growing population and resulting changed economy are creating localized regional pressures, hence transformed infrastructures *viz*., changed sea-escapes, increased uses originating from uncontrollable fishing, eutrophication and degradation of natural resources. Hence, understanding biodiversity is comprehensive and integral for the assessment and management of coastal, marine and related ecosystems. Remote sensing and GIS Technologies are fundamental in providing broad and compact data important in assessing biophysical interactions at diverse scales (temporal & spatial). These monitoring are useful for the invigilation of biodiversity in critical zones, benthic sea-escapes, complex coastal regions, identifying species assemblages, observing physiological shifts, retrieving distributions etc (Pratiwy *et al*., 2022).

Aquatic Digitization – The Overview

The aquatic sector comprises of land bound water bodies like ponds & lakes, rivers and various other water habitats such as cages, coasts, longlines and stakes in brackish and marine bodies. This accounts for major portion of global fisheries production that meets the increasing demand for staple seafood in rapidly escalating world. Digitization of aquaculture sector have impacted profound changes encompassing localizing the site of collection, yield of fishes, curtailing down the labour charges, monitoring of vulnerable sites etc. Automated processes like using the electronic tools, satellite based navigation system, information based technologies, global positioning system are integral to sustainable capturing and cultivation of fishes and allied organisms. Furthermore GIS, GPS & remote sensing technology plays important role in management, assessment and hence utilization of natural resources influencing several parameters of fish production (Anjarsari *et al*., 2024).

There is increase in fish and seafood consumption and eventually the pressure that originated in the aquatic sector encompassed the oceans. The status of many fishes have reached critical level and continue deteriorating. Almost half of the global fish population are depleted or are classified to be at the risk of depletion. According to the data of UN-FAO, there is significant increment in the exploitation of marine fish stocks from 10 % to 35 % from 1974 till 2021. Modern approaches to Fisheries Management have become integral to strengthen fisheries regulatory system.

Agriculture including fisheries & aquaculture is one such field where digitization has always been at a lower level. Gradually the strategies were framed for the digitization of aquatic sector and Ecosystem-Based Fishery Management (EBFM) or Ecosystem Approach to Fisheries (EAF) landmarked one of the earliest such measures. This Russian technology was a holistic approach to manage fisheries for it's characteristic approach to cover various aspect of the fisheries (Mnatsakanyan & Kharin, 2021).

The possible arenas for implementing digitization in aquaculture are:

- **Data collection** - Data capturing devices like sensors lay the base of modern information system. They are economic, versatile, compact, easy to install and universal. This facilitates data collection over a wider radius and across various aquatic ecosystem. Specialized radial and optical sensors enables satellite system to view the environment with more improved spatial and temporal resolution. Optical sensors analyzing the light reflected by the surface of water provides valuable information on the various physical parameters of the aquatic ecosystem. Radar sensors function on microwave radiation provide valuable inputs on topography and unlike optical sensors can operate even in bad weather and dim light conditions as well.
- **Improved technologies for data transfer** - Digitization of data aims at transferring the physically collected inputs into a computer-based language. This in turn leads to integrated technologies merged into Internet of Things (IoT) environment. This converged framework are the outcome of physical objects bound through the dedicated sensors, softwares and various technologies facilitating exchange and gathering of data.
- **Advancements in data analysis** - The improved techniques and technologies in fisheries involving real time analysis, AI and other different machine learning manages enormous quantity of data. This is a sincere attempt towards exploring accelerated opportunities for efficient activities across related sectors of fisheries; hence a noble attempt towards sustainable practices.
- **Noble aquaculture improvement strategies** – Some notable areas for applications are

    1. Using Robotics to address complicated tasks and laborious work, such as cleaning ponds and repair damaged nets, monitoring behaviours, removing diseased fish, feeding, injecting vaccines, underwater inspections of nets, evaluating fish health and escapes.
    2. Involving Drones to monitor fish farms above and below water, checking of holes in damaged cages, collecting data and employing AI and cloud computing to improve aquaculture operations.
    3. Remote sensing to monitor the collection of water parameters in real time, underwater sensors to record hunger levels of fish in ponds and cages, monitoring fish metabolism and heart rates, reducing wastage and improved feed rates.
    4. Involving AI to conclude better and faster decisions, improving efficacy of feeders, water quality monitoring and control, harvesting and processing, reducing labour involvement.
    5. Augmented Reality for Teaching, training and imparting education for improved production efficiencies, decreased costs, engineer improved facilities for under water drones and robots, monitoring fish behaviour, net holes and fish mortality, risk mitigation, measuring and analyzing different water parameters.
    6. Employing the technology of Virtual Reality for real time simulation of environmental situations using digital interface (head sets), assessing high risk environments using human computer and multimedia platforms.

7. 3D Printing for reduced equipment and production costs.
8. Internet of Things for connecting big data across aquaculture industry and combining the use of social media.

- Transparent and traceable services for monitoring the threats like illegal, unreported and unregulated fishing & thereby increasing accuracy in fish detection.
- Block chain technology for cybersecurity, safe data sharing, industry protection, payment processing, reducing food wastage, improving food safety and ensuring full traceability across value chain.
- Digital marketing have revolutionized aquaculture businesses paradigm and conquered potential customers beyond their local markets. Different social media platforms have further provided a global stage for showcasing products, popularize success stories, build in stronger customer relationship. The integration of digital marketing in aquaculture have promoted the aquaculture and placed it into the modern global business landscape because of engaging content, search engine optimization & marketing, influencer collaborations, social media campaigns amongst others.

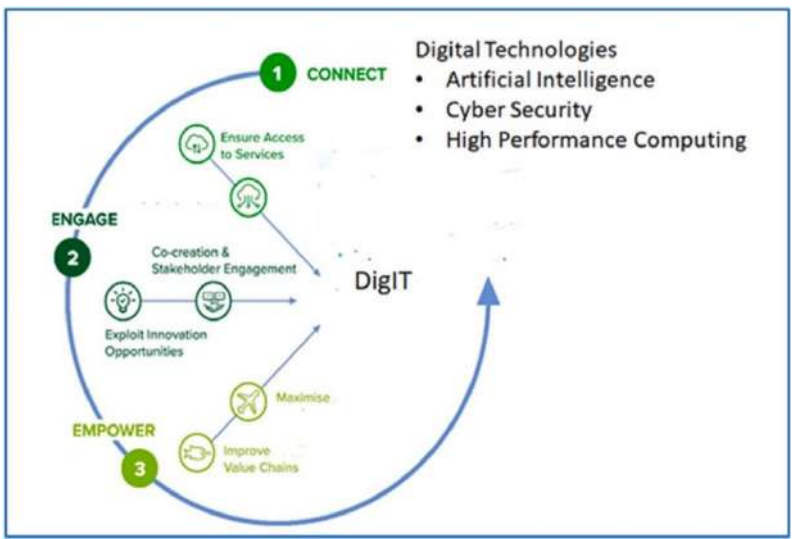

Fig. 1. As proposed by European Digital Innovation Hub. A blueprint of how digital Innovation at different strata are shaping fisheries and aquaculture (Rowan, 2023)

Digitization of Aquatic Sector: The Indian Perspective

Digitization in aquatic sector is creating impacts and have benefitted through various ways. The efficiency and sustainability of fisheries and aquaculture has been increased with the help of artificial intelligence, ensuring a consistent supply of fish for food and other uses. Below are the list of commercially available Intelligent Solutions for Aquaculture and Fish Processing in India (Verma *et al.*,2024).

Table 1: Development of Commercially Available Digitized Intelligent Solutions for Aquaculture & Fish Processing in India

S. No	Application	Developer/Products	Weblinks
1.	Monitoring and control of feeding rate	Eruvaka Pond Mother	https://eruvaka.comReal
2.	Monitoring & Control of Water Quality	Eruvaka Pond Mother	https://eruvaka.com
3.	Monitoring & Forecasting Disease Outbreak	Aquaconnect-Farm MOJO	https://aquaconnect.blue

The presence of vast coastline and abundant freshwater resources in India have bestowed the country with remarkable growth following digitization. The Indian government launched several initiatives to encourage the use of digital technologies in fisheries and aquaculture. India Government has made tremendous progress in establishing sustainable fishing methods and increasing the livelihoods of fish-farmers by assisting and enhancing the production and efficiency of fisheries and aquaculture. Key arenas include handling data privacy, security concerning sector and developing all stakeholders, especially small-scale fishers and the associated women farmers. Few notable initiatives are as follows:

- **e-PashuHaat portal** (initiative of the Department of Animal Husbandry, Dairy and Fisheries (DAHDF) in collaboration with the National Dairy Development Board (NDDB).
- **Matsya setu** (initiated by the NFDB, Fisheries Information System, GOI).
- Building **fish seed banks** and **fish feed factories**.
- Launch of **Report Fish Disease' App.** Developed by ICAR - National Bureau of Fish Genetic Resources (ICAR-NBFGR) under the National Surveillance Programme for Aquatic Animal Disease.

These noble initiatives are attempts towards providing information to fish farmers on different aspects of fish farming, increasing the access of related learning materials, platforms to exchange knowledge & information, increasing skill to manage inventories, obtain real-time price information and keep track of sales.

Conclusion

As per the National Fisheries Development Board (NFDB) and the Marine Products Export Development Authority (MPEDA), there is a significant upsurge in Indian Blue Economy. The reports from Confederation of Indian Industry (CII) suggests that over 60% of aquaculture farmers have adopted technology-driven practices, leading to an average increase in yield of 25-30% and a reduction in feed conversion ratios of 10-15%. Hence data analytics in alliance with artificial intelligence (AI) and machine learning (ML) have transformed aquaculture practices in India. Innovative farming technologies like Recirculating aquaculture systems (RAS), AI-powered systems coupled with extensive data analysis, genetics and breeding technologies have enriched aquaculture portfolio and improved the country's positioning globally. Digital applications in the aquatic sector have improved the global scenario of aquaculture. Hence the process of digitization in aquaculture has been observed in various aspects and can be categorized as

- Pre-production aspect like determination of locations necessary for fish cultivation employing GIS
- Production aspect involving automation in feeder and water quality testing tools
- Post-production aspect like using digital marketing.

Achievement to a greater extent has been attained in the aquatic sector following digital application. The coordinated work of different stakeholders is in full bloom, though a long way remains to be covered involving sustainable agriculture practices owing to increasing population, decreasing habitat and restoring earth's environmental health.

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