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Exploring Drone Technology towards Unmanned and Autonomous Fisheries Operations: ICAR-CIFRI's Initiatives

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Abstract

Advanced technologies cast an impact on fisheries with increasing demand as well as concerns about sustainability, which undergo a transformation. Drones, also known as Unmanned Aerial Vehicles (UAVs), have evolved into a ground-breaking device in fisheries, catering for resource optimisation as well as advanced monitoring. ICAR-CIFRI, Barrackpore has an intense engagement with drone application for water quality monitoring, water sampling, fish transportation, farm input application along with underwater inspection. These technologies accredit real-time data collection, lower labour costs and time, and improve decision-making towards sustainable resource management.

Keywords: Drone technology, Fish health management, Fish transportation, Inland fisheries

Introduction

Inland aquatic resources are subject to many challenges like increased pollution, climate change *etc*., that hamper effective and sustainable planning for the management and conservation of the resources. Inland open waters, being vast and diverse in nature, often pose difficulties in capturing the dynamic environments, which is crucial for understanding the aquatic system and its hidden characteristics. Therefore, spatio-temporal monitoring of water quality parameters is crucial in managing key aquatic habitats. In a conventional system, waterbody monitoring, input application, fish transportation *etc*. involve high operating costs related to deploying vessels, hiring manpower and limited budget. Additionally, the logistical complexities of accessing remote or hazardous areas can impede data collection efforts. At the same time, the expanding population has caused increased focus on emphasising rapid growth of fisheries industry and satisfying diverse food needs. These collective issues highlight the urgent need for efficient alternative solution which can address these challenges for sustainable fisheries management.

Through modern technology, agriculture is being transformed to increase food production in a sustainable way where drone technology plays a pivotal part by utilising its monitoring and management abilities. Technological advancements in drones has given it the ability to perform many functions concurrently (Mohsan *et al*., 2023); thereby increasing production along with providing time- and labor-efficient solutions.

Unmanned Aircraft Systems (UAS) or Drone Technology

The drones are categorised based on payload as nano (less than 250 g), micro (between 250 g and 25 kg), medium (between 25 kg and 150 kg) & large (more than 150 kg). Classification of it is done by the maximum take-off weight including payload.

Drone Flying Zone Classifications

DGCA (Directorate General of Civil Aviation) has classified drone flying zone as:

- *Red Zone*: Flying is prohibited.
- *Yellow Zone*: Requires special permissions from air traffic control.
- *Green Zone*: Requires no permission upto 400 feet.

Article History

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Drone Technology in Inland Open Water Fisheries

Drone technology can be efficiently used for monitoring resources, applying farm inputs, transport *etc*. with minimum time and labour (Figure 1).

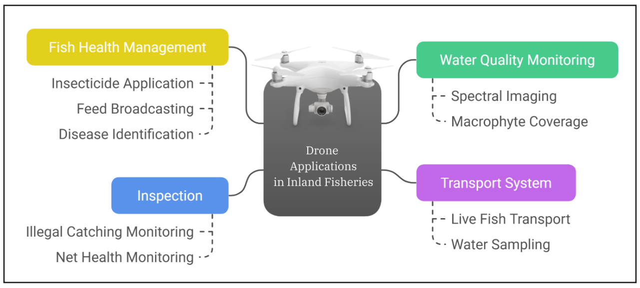

Figure 1: Applications of drone in inland fisheries

1. Mapping and Monitoring of Water Quality

Water parameters should be maintained at optimal levels for healthy fisheries. The existing evaluation process is time taking, labour intensive and costly. Drones offer high resolution spatio-temporal data that can be used to capture in-depth information of large water bodies like reservoirs, lakes, or river systems using multispectral or hyperspectral imaging (Bangira *et al*., 2024). The recent technologies have advanced variety of sensors with greater resolution like light detection and ranging (LIDAR), thermal imaging and multispectral imaging. The timely assessment of water health status may help to take proper remedial measures to manage unfavourable conditions, aiming for sustainable fisheries management.

2. Underwater Cage Net Inspection

Intensive fish farming demands all necessary measures to ensure a strong fish rearing process for high production rates. Floating underwater fish cages, pens with sufficient oxygen supply with fresh water are required to be maintained. Inspections by divers are essential to restrain faults such as fish escaping through net holes, reduced growth or low oxygen levels caused by excessive fouling *etc*. Employing a ROV (Remotely Operated Vehicle) with high-resolution video cameras may help to minimise the reliance on divers, leading to a more autonomous and safer inspection procedure. The technology facilitates ongoing data collection for cage or pen net monitoring, allows for more accurate species identifications and enables the calculation of true densities.

3. Fish Health Management

Fish maintained under optimal circumstances reduces disease susceptibility, resulting enhanced growth, hence yielding superior quality. The traditional methods with ineffective feeding control and spraying technology, leads to significant waste of feed and chemicals, consequently compromising water quality. The drone technology has enabled the precise and optimal application of feed and chemicals in the fish farm focusing on particular regions, minimising chemical waste. The drones for the chemicals and feed application in for high valued fishes, difficult terrains and contaminated areas present a safer and more efficient solution for practitioners.

4. Fish Transport System

The growing demand for logistics can only be achieved through efficient, convenient and automated logistics operations. The rapid delivery speed in comparison with conventional logistics (Thiels *et al*., 2015) and the absence of requisite physical infrastructure render the drone-based logistics system beneficial. Along with the logistics sector, Cargo drones are also being used in the fishing industry for transporting live fish from remote catch sites to nearby market area, ensuring freshness and reducing transportation time and cost.

5. Fisheries Surveillance

Drones offer a cost-effective alternative option for surveillance of waterbodies for illegal fishing compared to conventional methods. It can supply sufficient evidence to determine the occurrence of a crime (Girard and Du Payrat, 2017). Due to its ability to combat illicit, unreported and unregulated fishing activities, drones have drawn the attention of researchers, farm owners and environmentalists for fisheries management.

6. Fish Disease Detection and Behavioural Studies

For effective management of fish growth, monitoring fish behaviour is crucial which indicates the fish health status, thereby enhancing productivity by mitigating the risk of losses due to disease and stress incidents. ROV poses the ability to capture underwater images and videos which helps to detect unusual changes in the fish behaviour.

7. Life Jacket Delivery

In offshore (cage based) and inland water systems, safety of the workers remains a concern especially during emergency scenarios such as equipment malfunctions *etc*. Under such circumstances, delay in rescue may happen due to terrain challenges, remote locations or water conditions. Drone technology can be used to quickly supply life jackets using GPS-tools for guaranteed precise targeting.

8. Water Sampling

Traditional methods of water sampling as well as in-situ physicochemical measurements is labour intensive, time taking and potentially hazardous for workers especially in challenging environments. The use of these techniques is also hampered by the study areas' restricted accessibility (Delgado *et al*., 2022). Here, drone is proved to be a useful technology that can address the problems of reaching to the inaccessible areas and help to collect water sample from waterbodies for water resource monitoring. Its advantages include ease handling, affordability and the ability to relocate to inaccessible locations.

ICAR-CIFRI's Research on Drone Technology

The ICAR-CIFRI is leading efforts to integrate different drone technologies (Table 1) into fish farming practices. The institute is conducting research as well as demonstrations to devise ways for effective integration of drones in enhancing operations and productivity.

Table 1: Types of drones available in ICAR-CIFRI, Barrackpore			
Type	Class	Payload	Use
Broadcaster	Small	10 litre	Automated feed distribution
Sprayer	Small	10 litre	Medicine & pesticides spaying
Water sampler	Small	1 litre	Collect samples from waterbodies
Fish transport	Medium	70 kg	Transport live fish
Mapping	Micro	RGB sensor	high-resolution aerial imaging
Multispectral	Small	Multispectral sensor	Multispectral data for advanced monitoring
Underwater ROV	Light weight	Normal camera	Underwater inspection

Water Quality Monitoring

1. Spectral Imaging for Water Quality Assessment

ICAR-CIFRI has initiated the research to assess the water quality parameters like turbidity, Chl-a, algal bloom *etc*. using drone mounted multi-spectral images under ICAR-Network program on Precision Agriculture (NePPA) project. Multispectral sensors like parrot sequoia, MicaSense RedEdge *etc*. are being used to do the imaging.

2. Macrophyte Coverage Area Assessment

Machrophtes prove beneficial to aquatic ecosystems as they stabilize sediments and shorelines but excessive growth of it causes severe negative effects like reduced water flow and oxygen depletion thereby reducing the overall productivity. In this direction, ICAR-CIFRI has made an effort to estimate the macrophyte coverage area of large water bodies using drone mounted RGB sensors.

Various wetlands in West Bengal (WB) named *Akaipur, Chamta, Chamardaha, Beledanga* and *Khalsi* were studied using RGB drone. The macrophytes area was analysed in GIS environment (Figure 2). High-resolution RGB imaging can be an affordable and effective solution to monitor real-time macrophytes area in large waterbodies. This approach provides a significant advantage over traditional labour-intensive field methods and offers higher spatial resolution than satellite imagery.

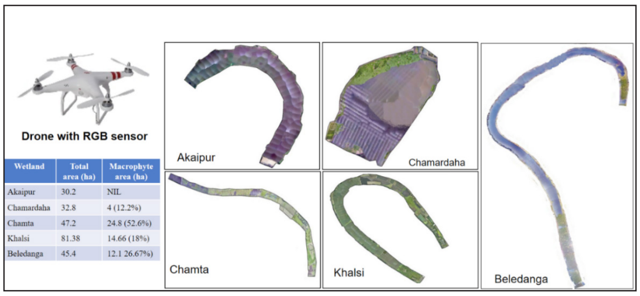

Figure 2: RGB sensor estimated macrophyte area of five wetlands

Underwater Monitoring System

1. Underwater Fish Behaviour Study

ICAR-CIFRI is also employing ROVs for analysing fish behaviour at cage and pen culture sites located in Maithon (Figure 3), Kolaghat, Hirakud Dam and Sindrani wetlands.

2. Cage and Pen Net Monitoring

The ROV system is also used to monitor the cage net in

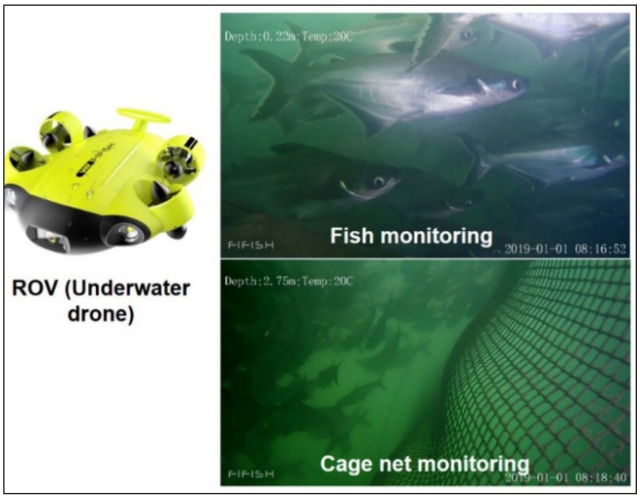

Figure 3: ROV for underwater monitoring

Maithon reservoir (Figure 3), Hirakud Dam *etc*. ROVs can autonomously navigate along the nets; enable operators to focus on cage nets and any unusual changes, thus improving efficiency in fish farming operations.

Figure 4: Drone demonstration program

Fish Health Management

1. Application of Chemical and Feed Materials in Large Waterbody

It is safer and more convenient for farmers to use drones to apply chemicals and feed in large water bodies, challenging terrains, inaccessible areas, polluted areas *etc.* with less time, input material and human resources. ICAR-CIFRI is actively organising awareness cum demonstration program under ICAR-ATARI drone demonstration program to popularise the drone technology among fish farmers (Figure 4). The application includes spraying of insecticides, disinfectants ($KMNO_4$, cifax, salt *etc.*), medicine (Kumbhakarna, Danav, Tandav *etc.*) and feed (CIFRI CAGEGROW) distributions over large water areas. More than 30 awareness and demonstration program (Table 2) have been organised covering more than 4000 fish farmers, state department officials, students and other stake holders.

Table 2: Awareness programs conducted by ICAR-CIFRI

Date	Organised at	Participant (Nos)	Organised for	Type of Program
11th-13th Apr, 2023	Chamta, Khalsi and Sindrani wetland, North 24 Parganas, WB	270	Fish farmers	Demonstration and fish feed Application
6th Jan, 2024	Moyna Aqua Expo, Purba Medinipur, WB	300	Farmers from different parts of WB	Demonstration
16th-17th Apr, 2024	East Kolkata Wetlands, WB	150	Fish farmers	Demonstration and Chemical spraying
3rd Jun, 2024	Minakha, Sundarbans, WB	90	Fish farmers	Chemical and Feed Application
3rd Oct, 2024	East Kolkata Wetlands, WB	75	Fish farmers	Demonstration and Chemical Application
10th Oct, 2024	ICAR-CIFRI	40	Fish farmers	Demonstration
19th Oct, 2024	Gyan Bhavan, Patna, Bihar	500	Fish farmers	Demonstration
11th Dec, 2024	ICAR-CIFRI	30	Officials	Workshop
18th Dec, 2024	Akaipur, WB	80	Fish farmers	Demonstration and Application
20th Dec, 2024	ICAR-CIFRI	90	Farmers of Bhagalpur, Bihar & Malda, WB	Demonstration
26th Dec, 2024	Kultali, Sundarbans, WB	3000	Women Fishers of Sundarbans	Demonstration

Transport System

1. Live Fish Transportation

In remote catch areas, such as diverse delta zones and large waterbodies like reservoirs where, transporting fish harvest from the catch site to the bank or main collection hub is a very challenging task. In this situation, drone technology may be an easy and efficient solution for transporting fish harvest from one location to another, reducing transit time, human involvement and stress on the fish. In this direction, ICAR-CIFRI is carrying out a pilot project aiming to develop a heavy payload transport drone funded by NFDB, Hyderabad, MoF, Govt. of India. The proposed drone will transport 70 kg payload and travel upto 7 km in a single fly.

2. Water Sampling from Inaccessible Area

ICAR-CIFRI has developed a drone-based vertical water sampler that can collect one litre of water samples from inaccessible areas utilising a remote-controlled water sampling mechanism. This system will reduce risks, manpower costs, vessel expenses and time requirements.

Conclusion

The revolutionary potential of drone technology in fisheries management practices is considered to be one of the alternative and efficient approaches which lead to precision farming and sustainable management. With the increasing inclination of drone applications in various industries, fisheries are also gradually accepting the technology aiming to empower fishers with innovative and latest technologies with an increased efficiency, reduced costs and improved productions.

This drone technology navigates a revolution in the Indian farming system which provides unusual opportunities to enhance productivity, intensify efficiency and stimulate sustainability. This change is essential for meeting the accelerated global food demand and addressing challenges including resource constraints along with climate change. Although this technology is more complex and costly in the initial days, it will capitulate remarkable consequences in no time once it is established. However, drones have transformed the data-acquisition strategy in almost every sector and will become more successful in transforming farming systems in bigger and better ways in the coming years. To address the current and upcoming demands on fisheries, it is also essential to educate next generations about the technologies to carry forward and promote precision farming.

Acknowledgement

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