Fish Welfare Initiative

Innovation Challenge:
Satellite-Based Remote Sensing for Aquaculture Farms

Summary

Purpose

Fish Welfare Initiative (FWI) would like to study the potential of satellite-based remote sensing for monitoring water quality in aquaculture farms in India to help us scale and increase the impact of our work. FWI is interested in entering into a partnership with an entity that can successfully show us that they have models that match our needs, leveraging the technology to help scale our programming to improve the welfare of many millions of fishes.

The Challenge

FWI is seeking interested parties to either (i) develop new models that would allow us to remotely monitor key water quality parameters at aquaculture farms in India through satellite data analysis, or (ii) share existing models that can be utilized for our purposes. FWI will provide a financial reward—up to USD 10,000—based on the outcomes of a validation process.

Submission & Timeline

Interested parties are invited to notify FWI that they have a model or models ready for validation by **March 14th, 2025** (18:00 Indian Standard Time). The submission process does not require submitting any code, merely a brief description of the model(s). FWI plans to conduct a validation exercise for submitted models in March-April 2025.

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1. Introduction

Who We Are

Fish Welfare Initiative (FWI) is a nonprofit organization that works to improve the welfare of farmed fishes in India, a country that farms several billion fishes annually. FWI has primarily focused on improving the welfare of these animals by addressing issues like water quality and stocking density. More information on our work can be found on our website.

Our Core Program and its Limitations

FWI's current core program is the Alliance for Responsible Aquaculture (ARA). This program centers on FWI field teams collecting water quality data—including dissolved oxygen, pH, and ammonia—from member farms and providing the farmers with recommendations for corrective actions in the event of key water quality parameters indicating that fish may be exposed to unhealthy conditions.

The ARA currently supports over 150 fish farms in Andhra Pradesh. The current ARA model requires FWI personnel to physically visit fish farms, with the current strategy being to conduct visits approximately once a month[1] to each farm. This dependency on field teams, and the limitation on the number of farms that FWI personnel can visit each day, means this methodology is not considered scalable. The limited scalability, coupled with the low frequency of visits per farm, limits how impactful the program can be. Given these concerns, there is a desire to make improvements to the ARA such that it is more scalable and impactful.

The Proposed Solution: Satellite-Based Remote Sensing

Monitoring water quality using satellite-based remote sensing technology offers a potential way to improve the scalability and impact—and overall cost-effectiveness—of the ARA. Utilizing satellite imagery as a means for remotely monitoring water quality would allow the ARA to collect water quality data from each farm more regularly—thereby allowing the identification of more events that suggest welfare infringements—while simultaneously limiting the requirement for personnel to actually visit farms. This technology also offers a potential mechanism to support many more farms, helping to cost-effectively scale up the program.

[1] The frequency of visits to each farm varies depending on various factors, with some farms being visited once a month, some every three weeks, and a select few every two weeks or weekly.

FWI would like to study the potential of satellite-based remote sensing for monitoring water quality in aquaculture farms in India to inform decisions around viable strategies for cost-effective scale-up of the ARA. FWI has limited experience using satellite-based remote sensing technology and is interested in a partnership with an entity that can successfully show us that they have models that match our needs.

2. Targeted Water Bodies

The ARA focuses its support on farmers of Indian major carps (IMC) in two districts—Eluru and Nellore—in Andhra Pradesh. IMCs are farmed in earthen ponds, ranging in size from 1 acre to over 100 acres, with the average size of ARA-member farms being 12.4 acres. The depth of the ponds is typically 1.5 to 2 meters. Ponds are typically found close to each other—often side-by-side, separated by earthen banks (Figure 1). It is water bodies like this for which FWI is striving to develop capabilities for satellite-based remote sensing to detect water quality.

Figure 1. Satellite image showing a patchwork of fish farms in the Eluru region of Andhra Pradesh, India.

3. The Challenge

What We Seek from Interested Parties

- FWI is seeking interested parties to either (i) develop new models that would allow us to remotely monitor key water quality parameters at IMC farms via analysis of satellite data, or (ii) share existing models that can be utilized for our purposes.
- The most critical water quality parameters of interest to FWI are **dissolved oxygen** and **ammonia**. Others of interest are **pH** and **chlorophyll-a**.
    - At a minimum, we are seeking a model that can remotely monitor dissolved oxygen or ammonia (Figure 2).
    - Ideally, we seek a package of models that can remotely monitor dissolved oxygen along with one or more other parameters.
- We recognize that dissolved oxygen, pH, and ammonia are optically inactive parameters which present challenges for their direct measurement through analysis of satellite imagery. We are open to models that indirectly determine dissolved oxygen, pH and/or ammonia by directly measuring proxies.
- The models should be able to determine water quality at a frequency of at least every 5 days.

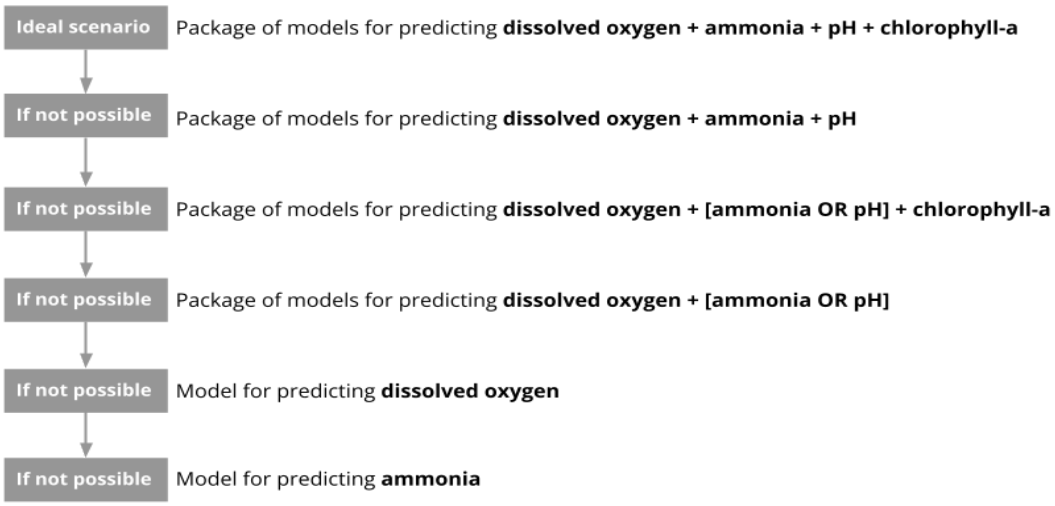

Figure 2. Models sought by FWI for remote monitoring of water quality. At a minimum, FWI seeks to remotely monitor dissolved oxygen or ammonia. Ideally, dissolved oxygen could be remotely monitored in association with one or more other water quality parameters, with the ideal scenario being a capability to remotely monitor dissolved oxygen, ammonia, pH, and chlorophyll-a.

Criteria for Validating Models

- FWI will validate any model submitted to us by collecting "ground-truthed" data at a number of ARA-member fish farms and comparing these data to the "predicted" values determined through the models.
    - FWI will require parties to use their models to remotely determine the relevant water quality parameter(s) at 20 ARA member farms from Eluru district in Andhra Pradesh. FWI will provide GPS coordinates of each farm and the dates for which parameters should be determined via the satellite-fed model.
    - For models that predict a water quality parameter indirectly by measuring a proxy, FWI will only collect ground-truthed data for the ultimate water quality parameter of interest.
        - For example, the validation of a model intended to predict dissolved oxygen by directly measuring a different parameter will be based on comparing ground-truthed dissolved oxygen data with the predicted dissolved oxygen values.

- To be useful for FWI's intended purpose, models for each water quality parameter must meet minimum criteria, based on the validation exercise (Table 1).

Table 1. Minimum criteria models for each water quality parameter must meet, determined by FWI's validation exercise.

Statistical parameter	Minimum criteria for each model			
	Dissolved oxygen	pH	Ammonia	Chlorophyll-a
Coefficient of determination (R^2)	≥ 0.73	≥ 0.79	≥ 0.73	≥ 0.81
Root mean square error (RMSE)	≤ 1.47 mg/L	≤ 0.12	≤ 0.07 mg/L	≤ 54 µg/L
Mean absolute error (MAE)	≤ 0.97 mg/L	≤ 0.1	≤ 0.05 mg/L	≤ 38 µg/L

What We Will Offer Interested Parties

- FWI will provide a financial reward based on the outcomes of the validation process (Table 2).
- Rewards will be allocated as follows:
    - **Reward A** will be awarded to the party that has submitted a package validated to remotely sense all four of FWI's key water quality parameters. If packages from two or more parties meet this requirement, the best package will be rewarded.[2]
    - If no package meets the criteria for Reward A, **Reward B** will be awarded to the party that has submitted a package validated to remotely sense the indicated water quality parameters. If packages from two or more parties meet this requirement, the best package will be rewarded.
    - If no packages meet the criteria for Reward A or Reward B, **Reward C** will be awarded to the party that has submitted a package validated to remotely sense the indicated water quality parameters. If packages from two or more parties meet this requirement, the best package will be rewarded.
    - If no packages meet the criteria for Reward A, Reward B, or Reward C, **Reward D** will be awarded to the party that has submitted a package validated to remotely sense the indicated water quality parameter. If packages from two or more parties meet this requirement, the best package will be rewarded.
    - If no packages meet the criteria for Reward A, Reward B, Reward C or Reward D, **Reward E** and/or **Reward F** will be awarded to the party(ies) that has submitted models validated to remotely sense dissolved oxygen and/or ammonia. If models from two or more parties meet this requirement, the best model will be rewarded.
- For any submitted package, if the package as a whole does not meet the minimum requirements but one or more of the individual models does, those models will be considered for the relevant financial rewards.

[2] The "best package" will be based on the R^2, RMSE and MAE values for each individual water quality parameter within the package. The order of importance of models from FWI's perspective is as follows: dissolved oxygen > ammonia > pH > chlorophyll-a.

- For example, in the case of a package of three models intended to remotely sense dissolved oxygen, pH, and ammonia (competing for Reward B), if the models for pH and ammonia do not pass the validation process but the model for dissolved oxygen does, this model will be eligible for consideration for Reward E.

Table 2. Financial rewards provided by FWI. Models for each water quality parameter must be validated by FWI and meet the minimum criteria. If no package meets the criteria for Reward A, Reward B will be awarded; if no packages meet the criteria for Reward A or B, Reward C will be awarded; if no packages meet the criteria for Reward A, B, or C, Reward D will be awarded; if no packages meet the criteria for Reward A, B, C, or D, Reward E and/or Reward F will be awarded. If two or more parties meet the minimum requirements for a reward, the best package will be determined by comparing the R^2, RMSE and MAE values for each of the individual water quality parameters. The order of importance of models is as follows: dissolved oxygen > ammonia > pH > chlorophyll-a.

Reward	Water quality parameters for which the package has been validated	Financial reward
A	Best package for predicting **dissolved oxygen + ammonia + pH + chlorophyll-a**	**USD 10,000**
B	Best package for predicting **dissolved oxygen + ammonia + pH**	**USD 8,000**
C	Best package for predicting **dissolved oxygen + [ammonia OR pH] + chlorophyll-a**	**USD 7,000**
D	Best package for predicting **dissolved oxygen + [ammonia OR pH]**	**USD 5,000**
E	Best model for predicting **dissolved oxygen**	**USD 3,000**
F	Best model for predicting **ammonia**	**USD 1,500**

Requirements For Claiming Rewards

- To claim the rewards, the party must be willing to allow FWI access to the models to incorporate into their programming. FWI recognizes that there may be proprietary restrictions that prevent full and unrestricted access to the algorithms and that there may be costs involved in utilizing a service. FWI seeks to partner with the successful party to leverage the technology to help scale our programming to improve the welfare of millions of fishes. The reward will be provided upon mutually agreeing on a path forward for how FWI can leverage the technology.

4. Eligibility

This innovation challenge is open to any interested parties.

5. Submission Requirements

- Interested parties are invited to notify FWI that they have a model or models ready for validation by completing **THIS ONLINE FORM.** This form provides an opportunity to describe your model(s); there is no need to submit any code/data, etc.
- The notification must be received before **March 14th, 2025**, **18:00 Indian Standard Time (IST)**.
- If additional information is required, submit enquiries to **paul@fwi.fish** with the subject heading ***"FWI Satellite Innovation Challenge–Enquiry"***

6. Timeline

- FWI will accept submissions until **March 14th, 2025** (18:00 IST).
- FWI plans to conduct the validation exercise for all submitted models in **March-April 2025**.
    - Approximately 1 week after the submission deadline, FWI will share GPS coordinates for approximately 20 farms—all in the Eluru district of Andhra Pradesh—with all parties who have submitted a notification. Interested parties will be expected to determine the water quality parameters relevant to their models, and upload them to a spreadsheet that will be shared by FWI in late early April. FWI will collect ground-truthed data, and compare these data with values predicted by the models.
- FWI will inform applicants of the outcome of the validation exercise shortly thereafter.
- A reward, where applicable, will be paid to the winning party upon the party complying with the "*Requirements for claiming rewards"* criteria.