INFORMATICS INSTITUTE OF TECHNOLOGY

In Collaboration with

ROBERT GORDON UNIVERSITY ABERDEEN

# Shrimp Breeding Grounds Detector


Group 27 Project Proposal Document by

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Submitted in partial fulfilment of the requirements for the BSc (Hons) in Artificial Intelligence and Data Science degree at the Robert Gordon University.

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# Declaration

We hereby certify that this project proposal and all the artifacts associated with it is our own work, and it has not been submitted before nor is currently being submitted for any degree program.

| Student Name | Student ID | Signature |
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I have read the project proposal, and it is in accordance with the approved university project proposal outline.

(Kelum de Silva) 27th October 2024

Signature of the supervisor: Date:

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# 1. Introduction

The shrimp aquaculture industry is extremely dependent on maintaining good environmental conditions to achieve optimal results from shrimp breeding and rearing. Locating the appropriate areas for breeding would help in the highest production of shrimps and would keep the balance of the ecosystem intact. This project, Shrimp Breeding Ground Detector, involves a system that predicts potential shrimp breeding sites by analyzing environmental data such as water quality, chlorophyll levels, and geospatial factors combined with historical breeding information.

# 2. Problem Domain

An estimated 6,000 hectares of land are considered appropriate for prawn farming, which is a crucial sector in Sri Lanka, especially in the northwest and northeastern coastal regions. Most semi-extensive prawn farms existing in the Puttalam District in the North Western Province adopt advanced methods like supplemental feeding and aeration. Even with ample scope for expansion, land selection for shrimp aquaculture remains an extremely challenging task with respect to resource optimization and environmental sustainability.

The development of a software that will be able to appraise how suitable a piece of land is for shrimp breeding. This proposed software would yield a correct evaluation if a given land area is suitable for shrimp breeding. The system will take into consideration factors such as Water Quality Analysis: Salinity, pH, Dissolved Oxygen, Temperature; Geospatial Analysis: Satellite Imagery and Terrain Data; Historical Shrimp Breeding Patterns; and following sustainable farming protocols.

This software will, therefore, support the scale-up of sustainable shrimp farming practices of Sri Lanka in line with the National Coastal Zone Management Plans that upscale the shrimp production capabilities of the country by providing an easy-to-use decision-making tool for shrimp farmers and aquaculture developers.

# 3. Problem Definition

Aquaculture or shrimp farming encompasses some of the most complex and sophisticated processes, which largely depend upon various factors concerning the environment, such as water quality, geography, and historical breeding data. Most of the farmers today are finding it difficult to overcome these difficulties at hand due to a lack of advanced tools which can presuppose the suitable breeding areas, hence leading to inefficiency and huge economic losses. The fact that the environmental conditions cannot be predicted, and lack of data-driven insights turn it all the more complicated for farmers while taking crucial decisions.

The project shall, therefore, focus on overcoming these challenges by providing an AI-driven shrimp breeding area detection system that integrates real-time data of critical water conditions such as pH, salinity, and temperature. Employing geospatial analysis techniques together with historical breeding trends, the system shall provide exact predictions with actionable insights at specific locations.

This will be beneficial to farmers because this technology will enable them to easily choose the best breeding sites for the shrimps based on the environmental conditions. Also, the system will reduce chances of diseases among the shrimps and poor rates of growth; hence, it gives high yields and profit through shrimp farming. The project will empower farmers through reliable data-driven insights toward more sustainable and efficient ways of conducting shrimp farming; hence, there is an assurance of better resource management and economic viability within the sector.

### 3.1 Problem Statement

The location of ideal areas of shrimp breeding is difficult because traditional monitoring methods take a lot of time and are not very accurate; this results in poor farming outcomes and yields.

## 4. Research Motivation

Although shrimp is among the most famous products in the global aquaculture industry, few resources exist to assist farmers in determining ideal breeding environments. This project will attempt to address that much needed gap by offering a feasible tool that can help shrimp farmers and various government and non-government organizations involved therein. Besides, the data we gather can also be beneficial to students conducting research on shrimp farming or even analysts with special interest in data analytics.

The main factor that really motivates me in this project is the idea to implement technologies which may really help where needed. What we're doing now can end up helping the farming practices, the environment or indeed the future of the shrimp industry.

## 5. Existing Work

The literature related to shrimp aquaculture involves knowledge about environmental factors that affect shrimp breeding and farming. Most of the studies use various technologies and methodologies in the for of water quality, geospatial mapping, and historical breeding data to identify the optimal grounds for breeding. These will be instrumental in developing a holistic system to meet the challenges of shrimp farmers, especially on sustainability and resource management. The following table shows some of the key contributions from related research, summarizing their respective technologies, advantages, and limitations.

*Table 1: Existing Work*

| **Citation** | **Technology/Algorithm** | **Advantages** | **Limitations** |
|---|---|---|---|
| Athukorala & Perera (2016) | Focus on controlled breeding environments and water quality management. | Provides insights into successful captive breeding techniques tailored to local conditions. | Limited applicability to broader shrimp species; findings may not generalize to all aquaculture practices. |
| Wickramasinghe et al. (2023) | Utilizes remote sensing and GIS for spatial analysis. | Effective in visualizing and identifying conservation zones, aiding in ecological preservation. | Dependence on the quality of satellite imagery; may not account for dynamic environmental changes. |
| Jayakody (2015) | Emphasizes breeding techniques and environmental assessments. | Highlights the importance of research in enhancing shrimp production efficiency. | May overlook technological advancements in data analytics for predictive modelling. |
| Gunawardena &Rowan (2014) | Economic modelling combined with environmental assessments. | Provides a comprehensive view of the sustainability challenges faced by small-scale aquaculture. | Focuses primarily on economic aspects, potentially neglecting technological solutions. |
| Weerasinghe et al. (2015) | Land-use analysis using ecological modelling techniques. | Addresses environmental impacts, contributing to sustainable land management practices. | Findings may be region-specific and not applicable to other areas with different ecological contexts. |
| Ranasuriya (2009) | Ecological impact assessments through field studies and data collection. | Provides empirical evidence on the ecological consequences of | Limited scope due to specific geographical focus; |

| | | | |
|---|---|---|---|
| | | shrimp farming practices. | may not reflect broader trends. |
| Peng et al. (2022) | Utilizes Sentinel-2 satellite imagery for mapping aquaculture ponds. | High accuracy in pond mapping enhances management practices in aquaculture. | Requires access to advanced satellite data processing tools; may involve high operational costs. |
| Wang et al. (2020) | Satellite-based Chlorophyll monitoring algorithms for assessing water productivity. | Facilitates large-scale monitoring of aquatic ecosystems, crucial for shrimp breeding environments. | Algorithms may need refinement for specific regional applications; data interpretation can be complex. |
| Hu et al. (2019) | Focuses on enhancing satellite data algorithms for better chlorophyll product accuracy. | Improves the reliability of Chlorophyll data essential for assessing aquatic health. | Algorithm improvements may require significant computational resources and expertise. |

# 6. Research Gap

## 6.1 Theoretical Gap

The existing shrimp farming systems rely on single factors, such as either water quality or soil suitability, without the integration of relevant variables such as chlorophyll levels and historical breeding patterns. An integrative data-driven approach toward environmental variables, inclusive of stated mismatches, must be formulated to arrive at better predictions of shrimp breeding success.

## 6.2 Performance Gap

Current systems apply effective utilization of GIS and remote sensing, but real-time integration of chlorophyll monitoring and breeding history data has not been pursued explicitly by these systems, thus limiting utility for ongoing prediction and proactive management.

## 6.3 Empirical Gap

Most of the existing systems hardly utilize a comprehensive analysis of real-time and historic data of shrimp breeding. Conversely, our solution will bridge that gap because it will put together water quality data, geospatial insights, and chlorophyll analysis in an effort to offer a more accurate prediction model.

# 7. Contribution to the Body of Knowledge

## 7.1 Technological Contribution

This project uses Water Quality Analysis, Geospatial Analysis, Chlorophyll-a Concentration and Historical Shrimp Breeding patterns to predict whether a certain area is suitable for shrimp breeding.

It allows shrimp fishermen the ability to accurately judge whether a certain locale is suitable for the breeding of shrimp, this reduces the time and resources spent on manually deciding whether the conditions are suitable or not. This model can factor in features and data than a fisherman, so its predictions will be more accurate, therefore also reducing time and resources spent in a locale where shrimp breeding cannot happen or happens at a low rate.

## 7.2 Domain Contribution

This project uses salinity, pH, dissolved oxygen level, temperature, Chlorophyll-A Concentration (Phytoplankton Levels) along with geospatial analysis and historical shrimp breeding patterns to find out whether a certain location is suitable for shrimps to breed. This is possible because the aforementioned factors influence whether shrimps can live, grow and breed in a certain area.

Through training a model using this data, it makes it possible to determine whether a certain locale is suitable for shrimp breeding with just a coordinate or possibly a picture.

# 8. Research Challenge

Detecting shrimp breeding grounds has several challenges.

- Due to the unavailability of direct research papers for the project, the researchers have to make their own datasets which will take some time and effort.
- Another challenge is in the variability of environmental factors that influence shrimp breeding, such as chlorophyll-a concentration and water salinity. These

factors differ significantly across regions which will make it difficult to create a model that works globally.
- The quality of satellite images can also vary which will make our project quiet and make it hard to decide.
- On top of these things acquiring and processing satellite data at a large scale may be highly expensive, especially when working with high-resolution images. Still we can get details from (U.S. Geological Survey (USGS), 2024) this website.
- More than anything, since our project's main target users are shrimp farmers it is necessary to develop a simple and clear interface which will be more beneficial.
- Last of all, since our focus is on assisting shrimp farmers, it is necessary to develop a simple and clear interface, which will allow them to obtain benefits from using the developed technology without complex actions.

# 9. Research Questions

**RQ1:** Which algorithm will give the best result while developing a predictive model for shrimp breeding areas using environmental and geospatial data?

**RQ2:** How can satellite imagery and geospatial data be incorporated to accurately map shrimp breeding areas?

**RQ3:** How does the historical pattern of shrimp breeding combine with environmental data to improve prediction accuracy?

# 10. Research Aim

The goal of the study is to design a complete land suitability evaluation software covering water quality analysis, chlorophyll levels, geospatial data, and past records of shrimp breeding.

It will also provide shrimp farmers and aquaculture stakeholders with an innovative, data-driven decision-making tool to improve precision in site selection while strengthening sustainability gaps within contemporary aquaculture methods by including variables that are currently underutilized like chlorophyll productivity as well as breeder historic trends.

# 11. Research Objectives

*Table 2 : Research Objectives*

| Research Objectives | Explanation | Learning Outcome |
|---|---|---|
| Problem Identification | RO1: Some aspects of the external environment, such as water quality, chlorophyll-A can be determined to influence shrimp breeding (Heenatigala and Fernando 2016)<br>RO2: Test machine learning models for which prediction analysis is suitable. | LO1 |
| Literature Review | Analyse prior research and technologies (e.g., GIS, water quality sensors) for shrimp breeding<br>- RO1: Review on shrimp breeding habitat factors<br>- RO2: Analysis of current monitoring tools and techniques<br>- RO3: Evaluation of decision-support systems for aquaculture | LO1 |
| Data Gathering and Analysis | -Download satellite imagery of chlorophyll-a, salinity, and temperature from Google Earth Engine and USGS (Google Earth Engine, n.d.; Zenodo, 2020).<br>- Use prior historical data in shrimp breeding.<br>- Conduct literature review from research databases. | LO1, LO3 |
| Research Design | Propose the Environmental Predictive Modeling Framework to estimate potential new shrimp breeding areas in the light of environmental indicators and prior data trends. | LO3, LO4 |

| | | |
|---|---|---|
| | | |
| Implementation | Implementation includes:<br>- Satellite data processing to analyze environmental factors.<br>- Machine learning model to predict breeding grounds.<br><br>- User dashboard for real-time predictions. | LO2, LO3, LO4 |
| Testing and Evaluation | Evaluation involves administering questionnaires to the shrimp farmers to get their perception on the accuracy for their predictions. Metrics of model performance will also be computed including accuracy (Wu et al., 2020). | LO2, LO4 |

# 12. Project Scope

## 12.1 In-scope

*Table 3 : In-scope*

| No | Description |
|---|---|
| 1 | Using satellite imagery and other environmental variables such as chlorophyll-a, and salinity to identify shrimp breeding waters. |
| 2 | Using ML techniques to analyse the environmental factors which helps to identify the exact shrimp breeding grounds. |
| 3 | Real time monitoring and constant changes based on the physical environment. |
| 4 | Testing and validating the model using historical breeding patterns which accurate the predictions. |

## 12.2 Out-scope

*Table 4 : Out-scope*

| No | Description |
|---|---|

| | |
|---|---|
| 1 | Manual detection or physical monitoring of shrimp breeding grounds. |
| 2 | Application of this model to species other than shrimp (e.g., fish, other aquaculture species). |
| 3 | Providing detailed business recommendations for shrimp farmers (focusing on environmental factors). |
| 4 | Development of infrastructure by having IoT sensors for in-field monitoring. |

## 12.3 Feature Prototype

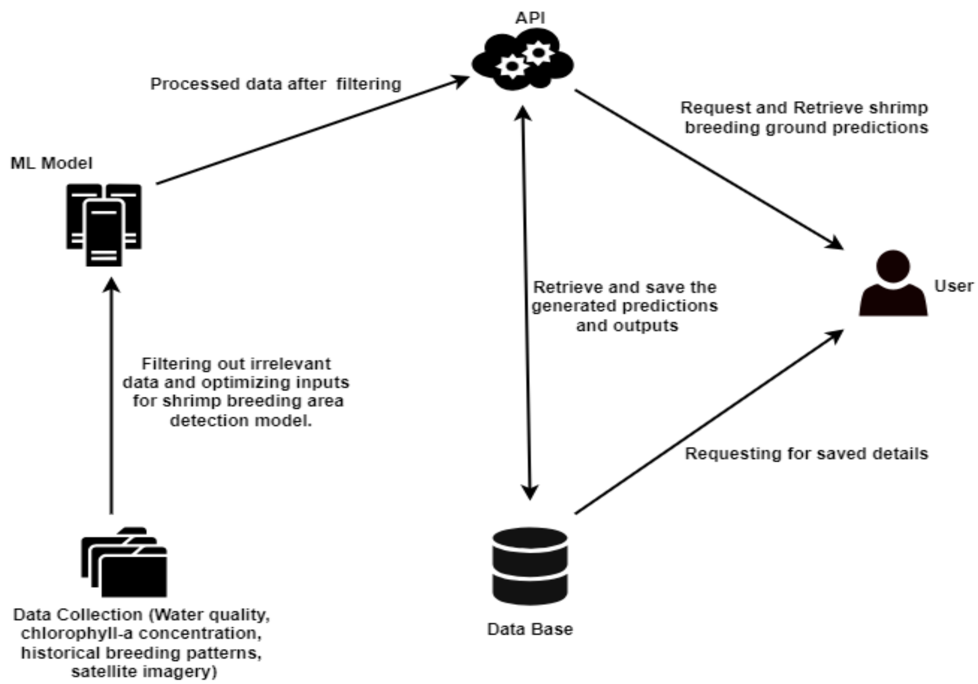


*Figure 1: Feature Prototype*

## Process: -

1. Data Collection: Water quality, chlorophyll-a concentration, historical breeding patterns, and satellite imagery taken from various sources.
2. Data Pre-processing: Now, the raw data is filtered and pre-processed to discard irrelevant information, and the input becomes optimized for the shrimp breeding area detection ML model.
3. Model Input: The cleaned and filtered data are fed to the ML Model, which, based on the environmental pattern and correlating with historic breeding data, detects probable shrimp breeding sites.

4. Prediction of ML Model: The ML Model processes the data and gives out predictions concerning the shrimp breeding areas in terms of aspects such as chlorophyll-a levels and water quality.

5. API Interaction: The cleaned data and predictions obtained from the ML model are then sent to the API, which saves them in a repository for processing.
6. Data Storage: Generated predictions, including related environmental data, are stored in the Database for possible future use.
7. User Requests: The User requests and receives shrimp breeding ground predictions through the API. A user can request previously saved details or reports from the database as well.
8. Prediction Delivery: It obtains generated predictions and outputs from the API and relays them back to the user.

# 13. Methodologies

## 13.1 Research Methodology

*Table 5 : Research Methodology*

| | |
|---|---|
| Research Philosophy | In the context of this project, data is used that is factual and measurable (for example water quality; chlorophyll levels; and geospatial) so researchers have chosen positivism as their research philosophy. The researchers are objective and make conclusions based on what happens to the data. |
| Research Approach | Deductive research is followed in the study. Kicking off with the existing scientific theories, proven factors, and knowledge needed for shrimp breeding (like water quality… chlorophyll levels), then they will test these criteria by matching that set of few parameters to geospatial data + historical data in terms of land capability. |
| Research Strategy | First, the research strategy employed is experimental and archival with a focus on plant responses to soil disturbances. It incorporates the collection of environmental data and experimentation on different conditions (i.e.: water quality, concentration levels) paired with historical shrimp production patterns for comparison to validate results. |
| Research Choice | This research will employ a multi-method approach with several quantitative methods. Suitability evaluation for shrimp breeding sites Land suitability assessment for commercial aquaculture will combine different tools such as sensors, GIS (Geographical Information System) and historical data analysis. |

| | |
|---|---|
| | |
| Time Zone | As the project is looking at land suitability for shrimp breeding a cross-sectional time horizon was selected, but only so far as to assess water quality with nutrient build-up (nitrogen and phosphorus) leading to poor chlorophyll production levels doctoral determined that historical data are indicating good potential shrimping. |

## 13.2 Development Methodology

The Agile development methodology will be applied for this project to make the development process adaptive and iterative. Since we will be using Agile, we will organize the development of the whole project in sprints, broken down into user stories, and the key requirements, namely the features and functionalities that the end users will require. Such a structure facilitates an interesting scope of work because different parts of the software will be tested and delivered, which adds a component of control to the project and makes it possible to accommodate user requests quickly.

Due to the specific and changing nature of requirements concerning areas for shrimp breeding detection like environmental and user factors, it makes sense to adopt the Agile approach since it is the most responsive to changes while the product is being developed. The Agile methodology is based on the iterative model; this means we can adjust and enhance the software considering what users tell us and what testing shows.

The set of applications will be developed in an OOAD manner, which in addition integrates with our Agile approach. This method enables the design of modular and reusable components so that the system design can be improved and grown in an incremental rather than a top-down manner. In the process of software development, OOAD will allow predicting the structure of the system in such a way that the incoming changes and the new functionality can be accommodated whereby the end product is effective and occupies the user's needs.
Bringing it all together, one could conclude that the interaction of Agile development with the Scrum framework and OOAD will be beneficial for achieving the set goal of the shrimp breeding area detection project. This will enable software engineers to be able to produce high-quality software that is required by the shrimp farmers and the stakeholders in the aquaculture business.

# 13.3 Project Management Methodology

## a) Gantt Chart

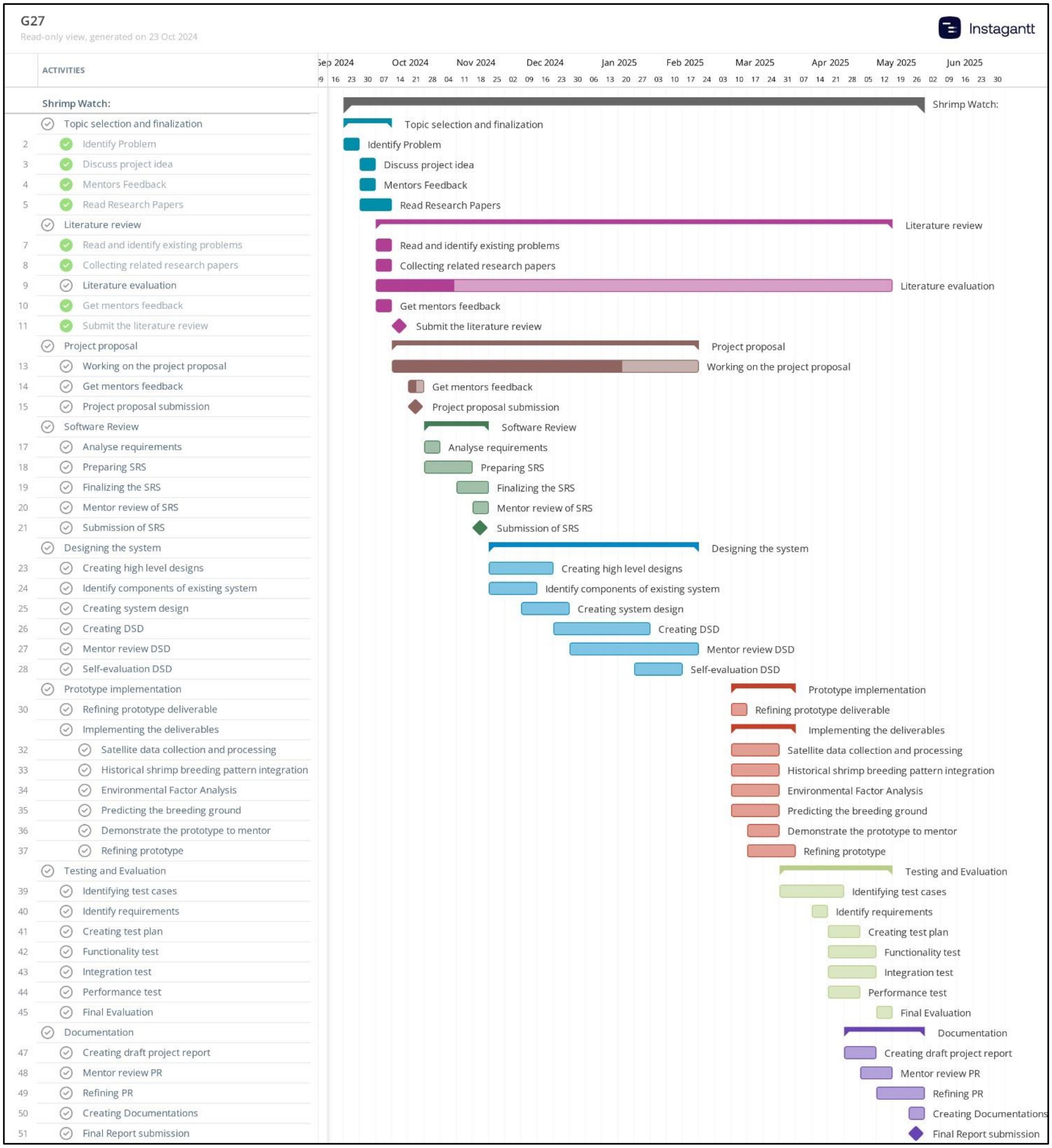


*Figure 2 : Gantt Chart*

## b) Deliverables

*Table 6 : Deliverables*

| Deliverable | Date |
|---|---|
| **Semester 01** | |
| Submission of literature review | Week 3 |
| Submission of the Project Proposal to the supervisor | Week 4 |
| Submission of the Project Proposal (Final PP) | Week 5 |
| Submission of the SRS to the supervisor | Week 8 |
| Submission of the SRS (Final SRS) | Week 9 |
| **Semester 02** | |
| Prototype Implementation | Week 14 |
| Testing and Evaluation | Week 19 |
| Documentation and final report submission | Week 23 |

## c) Resource Requirements

### I. Hardware Requirements

- CPU: Intel Core i7 (8th gen or higher) or equivalent - To process environmental data and satellite imagery.
- 16GB RAM or higher - To manage large datasets and complex models.
- Storage (minimum 512GB SSD) - For fast access to data.
- GPU (NVIDIA GTX 1650 or better) - To accelerate deep learning tasks (e.g.: - Image processing for satellite images)

### II. Software Requirements

- Python (Python 3.10 or later) - For data analysis, machine learning, and model building.
- QGIS (QGIS 3.28 or later) or ArcGIS (ArcGIS Pro 3.1or Later) - For geospatial analysis of environmental data.
- OpenCV (OpenCV 4.8.0) - To process satellite images for chlorophyll-a concentration

- TensorFlow (TensorFlow 2.16.1)/Keras - For building and training deep learning models.
- Flask - For backend server integration if the project will have a web interface.
- HTML/CSS/JavaScript - For the fronted development of the user interface.
- MS Word (Microsoft 365)- To write documents
- SQLite (SQLite 3.40.0 or later) - To manage databases and servers
- Windows OS (Windows 11 Pro 24H2 (64bit)) - To handle huge computational functionalities
- Google Colab - To collaborate with teammates while developing the model

## III. Skill Requirements

- Project Management
- Web Development
- Time Management
- Problem Solving
- Report Writing
- Critical Thinking
- Searching for information
- Planning and Scheduling
- Data Science & AI Skills

## IV. Data Requirements

- Chlorophyll-a concentration data (environmental indicators).
- Historical shrimp breeding data (from authorities).
- Water quality data (Salinity, pH, temperature).
- Satellite imagery (For geospatial analysis of the lagoon areas).
- Soil and lagoon data (Related to the shrimp habitats.

Since there are no suitable datasets found for our project, our team need to request data from local environmental and aquaculture authorities and conduct field data collection to create the dataset.

## d) Risk associated with project and mitigation plan

*Table 7 : Risk associated with project and mitigation plan*

| Risk Item | Severity | Frequency | Mitigation Plan |
|---|---|---|---|
| Availability of Data | 5 | 4 | Request datasets from relevant authorities and create our own dataset. |
| Accuracy related to predictions | 3 | 3 | Train models continuously and fine-tune parameters. |
| Sensor Malfunction | 4 | 3 | Implement backup sensors and routine maintenance checks. |
| Changes in Environmental Factors | 3 | 4 | Update system models according to the changes of environmental data. |
| Regulatory Issues | 4 | 2 | Ensure compliance with local regulations early in planning. |

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