NIR DHWANI TECHNOLOGIES

DIGITAL TRANSFORMATION AND APY TOOL FIELD VALIDATION REPORT

Findings of the field survey conducted by our team at seaweed sites in Ratnagiri, Maharashtra and Veraval, Gujarat

www.nirdhwani.com

Table of Contents

Overview of the Fisheries and Aquaculture Sector

The global fisheries and aquaculture sector serves as a vital economic pillar, supporting approximately 61.8 million livelihoods, with Asia accounting for 85% of this workforce, according to 2022 FAO data. In India, this sector has emerged as a sunrise industry, directly sustaining 28 million livelihoods while contributing significantly to the nation's food security and export earnings. The Government of India, through the Pradhan Mantri Matsya Sampada Yojana (PMMSY), envisions creating an additional 5.5 million employment opportunities by 2024-25, underscoring the sector's strategic importance in India's development trajectory.

Despite possessing an 11,098-kilometer coastline rich in marine resources, Indian coastal communities face persistent challenges, including climate change impacts, declining fish stocks, and fragmented market access. These systemic constraints demand innovative solutions that combine technological advancement with sustainable practices - a challenge that we have embraced through our comprehensive approach to coastal development.

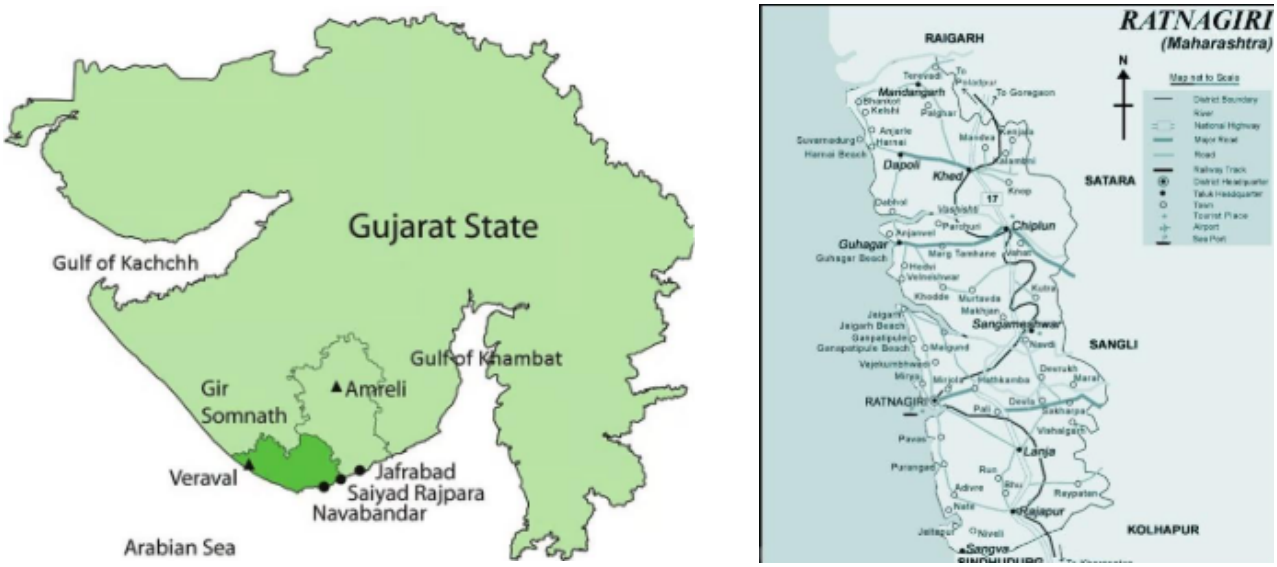


Figure 1: Seaweed sites of Veraval (Gujarat) and Ratnagiri (Maharashtra) which have been surveyed and studied by Our Engineering team

Highlighting our Initiative

Our strategy represents a thoughtful convergence of digital innovation and grassroots empowerment, aligning with national priorities under Digital India, Skill India, and the Blue Economy Policy. This report details our multifaceted interventions, beginning with an examination of technology's transformative role in modern aquaculture (The Role of Technology), followed by an in-depth analysis of our field engagement in Veraval that demonstrates how theoretical solutions are adapted to local realities (NDT's Strategic Field Engagement). The narrative then explores our pioneering work in digital transformation through the development and deployment of the Area Production Yield (APY) tool, including its technical architecture (Development of the APY Tool Android Application). Crucially, the report highlights our community-centric philosophy, documenting how training programs and skill development initiatives are bridging the digital divide while preserving traditional knowledge systems (Empowerment of Fisherman Communities). Through these interconnected initiatives, we are establishing a replicable model for sustainable coastal development - one that balances technological innovation with social inclusion, and economic growth with environmental stewardship. This report not only chronicles these achievements but also outlines the pathway for scaling such interventions across India's diverse coastal ecosystems.

Digital Transformation as an enabler for sustainable fisheries

The global aquaculture landscape presents notable disparities in technological adoption between nations. While leading producers like Norway, Japan, and Vietnam have harnessed advanced solutions such as AI-driven analytics and automated systems to achieve remarkable productivity gains, Indian aquafarmers continue to face persistent challenges including climatic variability, disease management, and market volatility. This technological gap manifests clearly in comparative yield metrics - Norwegian operations utilizing intelligent feeding systems (notably the Dual-Stream Recurrent Network achieving 80% behavioural prediction accuracy) demonstrate 3-4 times greater productivity than conventional Indian shrimp farms, translating to significantly higher income levels for international producers.

India currently stands at a pivotal moment to address this divide through strategic technological integration. The development of indigenous innovations like the Area Production Yield (APY) system, demonstrating 95% predictive accuracy for shrimp and seaweed yields, represents a significant step forward. Such advancements align seamlessly with national initiatives including the Pradhan Mantri Matsya Sampada Yojana (PMMSY) and its ambitious target of doubling sector exports to ₹1,00,000 crore, as well as the Pradhan Mantri Matsya Kisan Samridhi-Saha Yojana (2023-2027) which specifically facilitates technological adoption. Recent sector investments, including a notable $4.5 million infusion in aquaculture biotech research in March 2025, further underscore this positive trajectory.

The successful democratization of these technologies depends fundamentally on grassroots capacity building. Current efforts have trained over 63,290 stakeholders through Blue Revolution initiatives, while Digital India's rural connectivity expansion enables even small-scale farmers to access critical real-time data. This technological empowerment is yielding measurable impacts: CII reports indicate 25-30% yield improvements among adopting farmers, while ICAR research documents 40% reduction in disease-related losses, translating to annual savings of approximately ₹500 crore.

The September 2024 launch of the National Fisheries Digital Platform, already registering over 2 million stakeholders, provides an institutional framework to accelerate this transformation. By combining precision aquaculture techniques with inclusive policy measures, India is positioned to emerge as a global aquaculture leader - provided these innovations penetrate effectively to the smallholder level. The potential triple dividend of enhanced farmer incomes, national food security objectives, and environmental sustainability makes this technological transition not just an economic imperative, but a cornerstone of holistic development. Continued investment and collaborative implementation will be essential to fully realize this potential while ensuring equitable benefits across the fisheries value chain.

Field Engagements: Advancing Sustainable Coastal Development

Purpose of the Visit

The Veraval field visit was undertaken as a strategic initiative to bridge the gap between theoretical research and on-ground realities in India's coastal communities. Supported by ClimaCrew's expertise in seaweed farming, this engagement allowed us to demonstrate the APY tool's functionality to local farmers and collect critical feedback about its integration with their existing practices. Through interactions with fishing communities and seaweed cultivators, we assessed socio-economic challenges including market price manipulation by commercial companies and the lack of government subsidies beyond diesel support. The visit also facilitated important knowledge exchange, with locals demonstrating innovative cultivation techniques like the tubenet method while expressing strong interest in adopting predictive technologies. These ground-level interactions revealed both the potential for technology adoption and the need for solutions that account for local conditions such as monsoon weather patterns and security concerns about sensor deployment. By documenting these realities, the visit served its core purpose of ensuring our research initiatives remain aligned with the actual needs of coastal communities while supporting national programs like Digital India and the Blue Economy Policy through evidence-based interventions.

Table 1: Demography and Gender-wise participation in fisheries activities based on the responses of the respondents in the ground survey

Category	Shreyansh Sikotariya	Ravi Kotiya	Kaushik Nanjibhai Solanki	Jignesh	Visjha Haribhari
Age	25	32	25	25	26
Level of Education	Graduate	12th Pass	Graduate	12th Pass	12th Pass
Access to Credit	1 Lakh to 5 Lakh	50,000 to 1 Lakh	50,000 to 1 lakh	More than 5 Lakh	More than 5 Lakh
Women Participation	High	Medium	Low	Medium	Low
Women's Primary Activity	Processing of Seafood	Marketing of seafood	Others	Processing of Seafood	Others
Women's Challenges	Social Barrier	Limited access to financial Resource	Time Burden	Lack of Training	Limited access to financial Resource
Barrier to Tech (if yes, give reason)	Due to High Cost	Due to High Cost	Due to High Cost	Lack of Technical Skills	Due to High Cost

Table 2: Fisheries production and other business-related details of the fishermen involved in the ground survey

Category	Shreyansh Sikotariya	Ravi Kotiya	Kaushik Nanjibhai Solanki	Jignesh	Visjha Haribhari
Farm Area owned	Between 1 to 5 Acres	Less than 1 Acre	1 to 5 Acres	1 to 5 Acres	Less than 1 Acres
Species grown with No. of cycles	Fish, with 3 or more	Seaweed, with 3 or more	Fish, 1 cycle per year	Fish, 1 cycle per Year	Fish, with more than 3 cycle
Farm Production per year	Less than 2000 Kg	5000 Kg to 10,000 Kg	2000 to 5000 Kg	2000 to 5000 Kg	Between 2000-3000 Kg
Minimum Support Price for selling	No	No	No	No	No
Access to Insurance	Yes, via Private Company	No	Yes, Private Company	Yes, Private company	Yes, Private Company
Access to Internet & Recharge Cost	Yes, more than 1000 Rs.	more than 1000 Rs.	more than 1000 Rs.	Around 2000 Rs.	Yes, more than 1000

Access to Smart Phone (If yes, then use for what)	Communication Only	News & Communication	Communication	Entertainment & Communication	Communication & News
Change in Weather Pattern	Unpredictable weather pattern	Unpredictable weather pattern	Unpredictable weather pattern	Unpredictable weather pattern	Unpredictable weather pattern
Storage	No, Self Manged	Unpredictable weather pattern	Unpredictable weather pattern	Unpredictable weather pattern	Unpredictable weather pattern

Field Validation of the innovative Area, Production and Yield (APY) Analysis Tool

The NDT field visit to Veraval exemplified a thoughtful, solutions-oriented approach to addressing the complex challenges facing India's coastal communities. Through this carefully structured engagement, NDT demonstrated its commitment to ground-truthing technological innovations while fostering meaningful partnerships with local stakeholders.

During the visit, our team undertook a comprehensive validation process for its Area Production Yield (APY) tool, conducting live demonstrations that enabled direct feedback from seaweed farmers and fishing communities. This interactive approach not only showcased the tool's predictive capabilities but also allowed for immediate refinement based on practical considerations unique to the region. The team's willingness to adapt solutions to local conditions - such as accounting for monsoon weather patterns and integrating indigenous cultivation techniques like the tubenet method - reflected our respect for traditional knowledge systems.

Beyond technology validation, NDT facilitated a valuable two-way exchange of expertise. The organization's researchers immersed themselves in the daily realities of coastal livelihoods, gaining first-hand understanding of operational challenges ranging from market access limitations to environmental vulnerabilities.

Concurrently, through presentations and discussions, NDT shared its specialized knowledge on digital transformation and sustainable aquaculture practices, empowering local stakeholders with new perspectives on optimizing their operations.

A particularly noteworthy aspect of NDT's engagement was its emphasis on institutional collaboration. By working closely with ClimaCrew, they ensured its interventions were culturally appropriate and built upon existing community initiatives. This partnership model amplified the visit's impact while demonstrating our commitment to sustainable, locally rooted solutions.

The visit also served as an important fact-finding mission, with us documenting critical policy gaps and market inefficiencies that require systemic intervention. By elevating these grassroots insights to the policy level, we are positioned to advocate more effectively for reforms that support coastal communities.

Through this multi-dimensional engagement, we not only advanced its research objectives but also strengthened its role as a trusted partner in India's blue economy transition - one that values community participation as much as technological innovation in driving sustainable development.

Perspective of the Community: Fishermen's Feedback on Our Engagement

The fishing community in Veraval responded with notable enthusiasm to NDT's initiatives during the field visit, demonstrating particular interest in the practical applications of the APY tool. Fishermen appreciated the tool's ability to predict yields based on environmental parameters like salinity and temperature, which aligned with their existing manual monitoring practices using refractometers and pH meters.

During interactions, community members actively engaged with our team, offering valuable suggestions to enhance the tool's implementation. They proposed practical solutions for securing sensors in the marine environment, including collaboration with local marine police and using floating mechanisms alongside seaweed cultivation. This demonstrated their thoughtful consideration of the technology's real-world application.

The community's positive reception was evident in their participation across multiple days of activities, including boat-based demonstrations and structured discussion sessions. Fishermen expressed interest in how such digital tools could complement their traditional knowledge, particularly in addressing challenges like unpredictable weather patterns and market fluctuations.

However, they also raised important considerations about equitable implementation, questioning how the technology would be made accessible to small-scale fishermen and expressing concerns about potential misuse by larger commercial operators. These constructive discussions revealed the community's balanced perspective - welcoming innovation while thoughtfully considering its broader implications for their livelihoods.

The fishermen's engagement throughout the visit, from demonstrating their tubenet cultivation methods to participating in tool demonstrations, reflected a meaningful exchange of knowledge and a foundation for continued collaboration between NDT and coastal communities.

How APY Tool can transform India’s Fisheries Landscape?

The NDT has emerged as a pivotal force in driving digital transformation within India’s fisheries sector, particularly through the development of the Area Production Yield (APY) tool. This innovation represents a strategic leap toward modernizing traditional aquaculture practices, aligning with India’s broader ambitions under the Digital India and Blue Economy initiatives. Unlike conventional methods that rely on anecdotal experience, the APY tool leverages data-driven insights to optimize shrimp and seaweed farming, ensuring precision, scalability, and sustainability. By integrating environmental parameters such as temperature, salinity, pH, and stocking density, the tool generates predictive analytics with 95% accuracy—empowering farmers to make informed decisions on feeding schedules, harvest timing, and risk mitigation.

Our approach distinguishes India in the global aquaculture landscape, particularly when compared to technologically advanced nations like China. While China has heavily invested in large-scale automation and AI-driven aquaculture systems, its focus has often been on industrial-scale operations, leaving small-scale farmers underserved.

In contrast, the APY tool democratizes access to advanced analytics, catering specifically to India's vast network of small and marginal aquafarmers. This inclusive model not only bridges the technology gap but also fosters equitable growth, ensuring that the benefits of digital transformation reach grassroots stakeholders. Furthermore, the tool's iterative learning mechanism—where farmers can input ground-truth data to refine predictions—creates a feedback loop that continuously improves accuracy, a feature lacking in many static, top-down systems employed elsewhere.

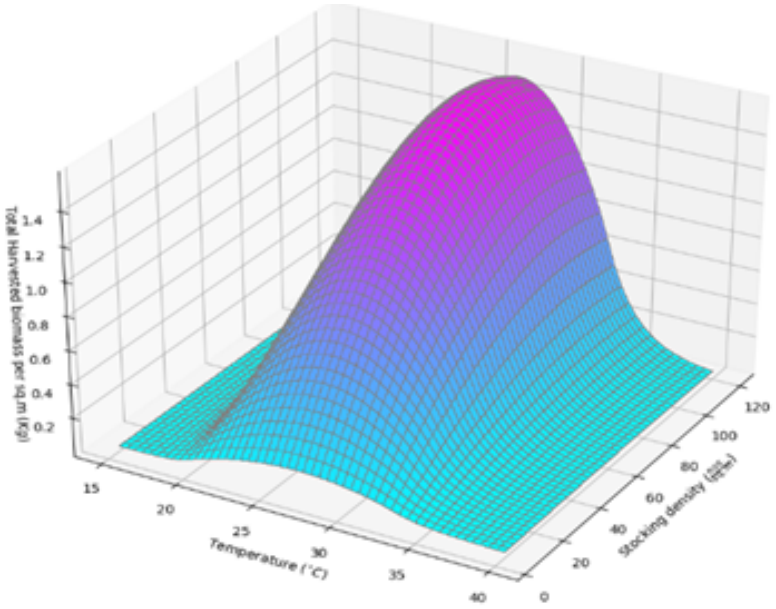


Fig.2: Gist of our Research, presented in various conferences and publications. The graph shows the variation in shrimp biomass as influenced by temperature and stocking density, incorporating the impact of varying survival rates. (Image part of MRC publication and not to be reproduced)

The geopolitical implications of such innovations are significant. By reducing dependency on imported technologies and fostering indigenous solutions like the APY tool, India positions itself as a self-reliant leader in sustainable aquaculture. The tool's open architecture and compatibility with mobile platforms further enhance its accessibility, setting a precedent for other developing nations seeking to balance technological adoption with socio-economic inclusivity. As global competition intensifies in the blue economy, our work underscores India's potential to chart a distinct path—one that harmonizes technological advancement with community-centric development.

Technical details behind development of the APY Tool Android Application

The APY Tool is an Android application designed to assist in aquaculture management by enabling users to input key environmental parameters that influence the growth of shrimp and seaweed. Based on these inputs, the tool estimates survival rates, biomass yield, and other relevant performance indicators for farm evaluation.

While the underlying predictive models were developed using the Python programming language, efforts were made to ensure accessibility and user-friendliness. To achieve this, the models were deployed through **Flask**, a lightweight Python web framework, and hosted on **PythonAnywhere**, a cloud-based platform for running Python applications. This deployment approach allows both users and external applications to interact with the model via **API** (Application Programming Interface) calls—providing a streamlined mechanism for exchanging data and receiving predictions over the internet.

- The model is integrated into a Flask application with a designated API endpoint.
- When a POST request containing the required input data in JSON format is received, Flask handles the request processing.
- The model then interprets the input, executes the regression algorithm, and returns the predicted growth rate in a structured JSON response.

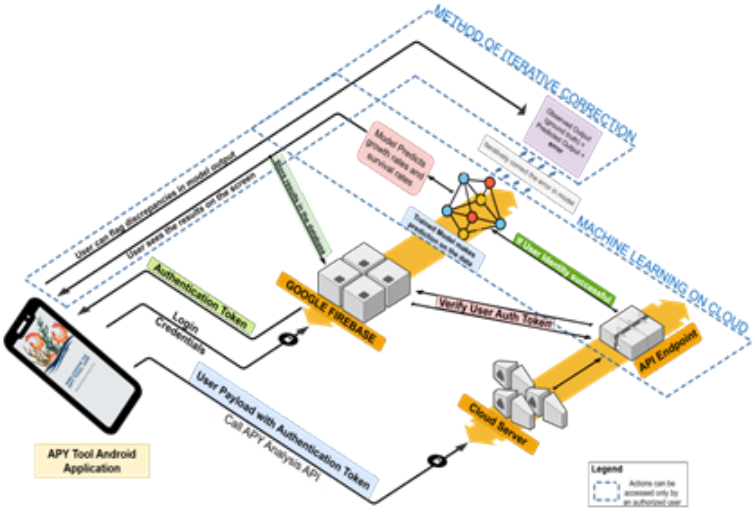
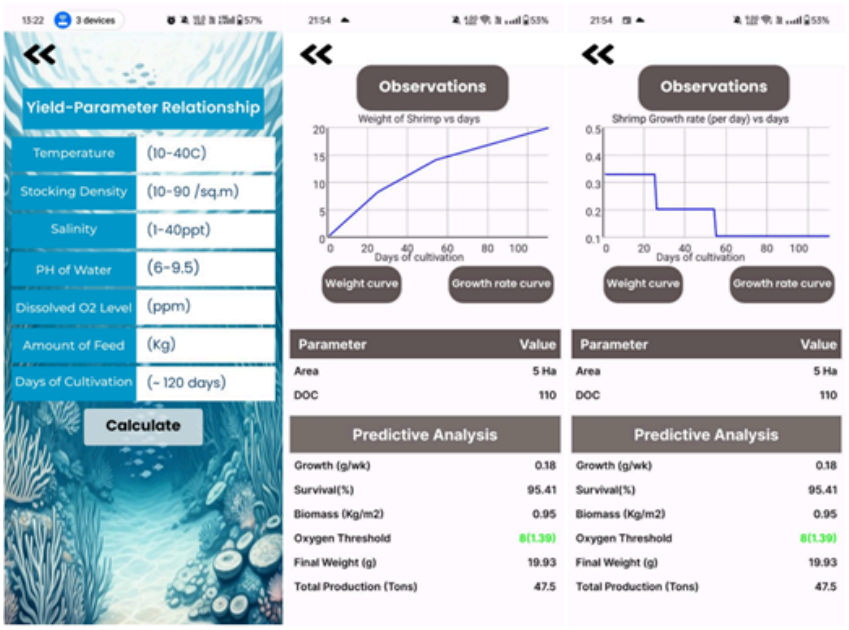


Fig.3: Comprehensive System Architecture of the APY Analysis Tool (Image part of MRC Publication and not to be reproduced)

Attribute	Specification
Compile SDK Version	34
Target SDK Version	33
Java Compatibility	Java 8
Main Dependencies	Volley, Firebase Auth/Database, GraphView, Lottie
Test Device Model	OnePlus Nord CE 4
OS Version	Android 14
Processor	Qualcomm Snapdragon 7 Gen 3
RAM	8 GB
Storage	128 GB
Testing Tools	JUnit, Espresso

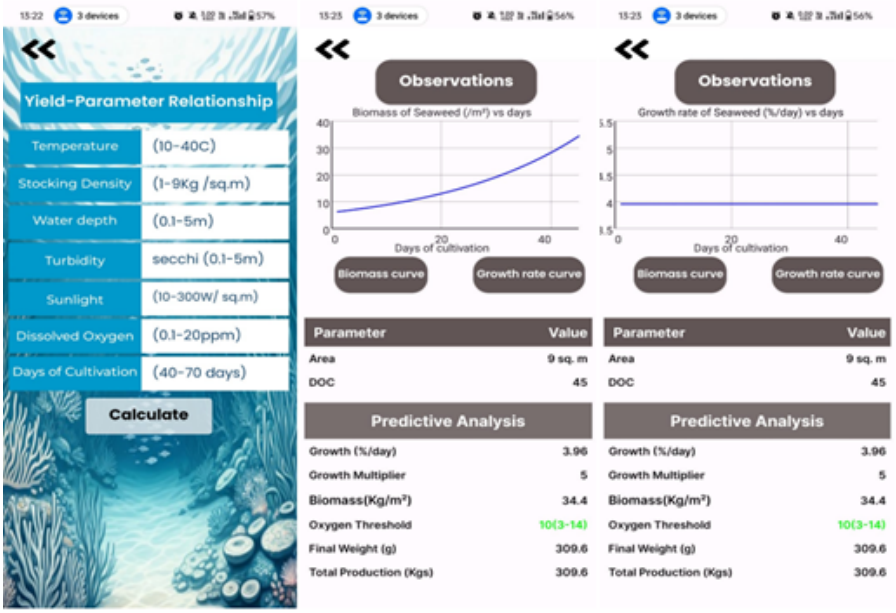
Table.1: Device specifications for the development of the APY Tool

The predictive model was deployed as a POST API endpoint using PythonAnywhere, a cloud-based service for hosting Python applications. The backend was implemented with the Flask framework, which enabled the application to process HTTP POST requests and return well-structured JSON responses.



(a) (b) (c)

Fig.4: Screenshots of the Shrimp APY Tool: (a) Main screen for inputting farm environmental parameters (e.g., temperature, stocking density, salinity, pH, dissolved oxygen, and cultivation days). (b) Predictions along with a graph of shrimp weight vs. cultivation days. (c) "Growth Rate Curve" feature to track weekly growth rate (g/week) variations over time.



(a) (b) (c)

Fig.5: (a) Main screen for inputting farm environmental parameters (e.g., water temperature, seed stocking density, water depth, turbidity, sunlight, dissolved oxygen, and cultivation days) (b) Predictions with a graph of seaweed biomass vs. cultivation days (c) "Growth Rate Curve" feature to track daily growth rate (%/day) variations throughout the cultivation period.

Iterative correction based on manual inputs from user

Within the **Registry** section of the APY Application, users are presented with their previously entered inputs and the associated model predictions, all securely retrieved from the database and linked to their unique session and cultivation record. This information includes key aquaculture parameters such as **pH**, **temperature**, **stocking density**, **salinity**, **dissolved oxygen**, **feed quantity**, and other relevant production metrics. To support iterative model improvement, users are provided with two editable fields—**True Biomass** and **True Final Weight**—where they can enter observed outcomes from their cultivation. Upon clicking the **Save** button, the application validates the entries and updates the user-specific database path with this ground-truth data. This mechanism enables a comparison between predicted and actual outcomes, allowing the system to assess model accuracy.

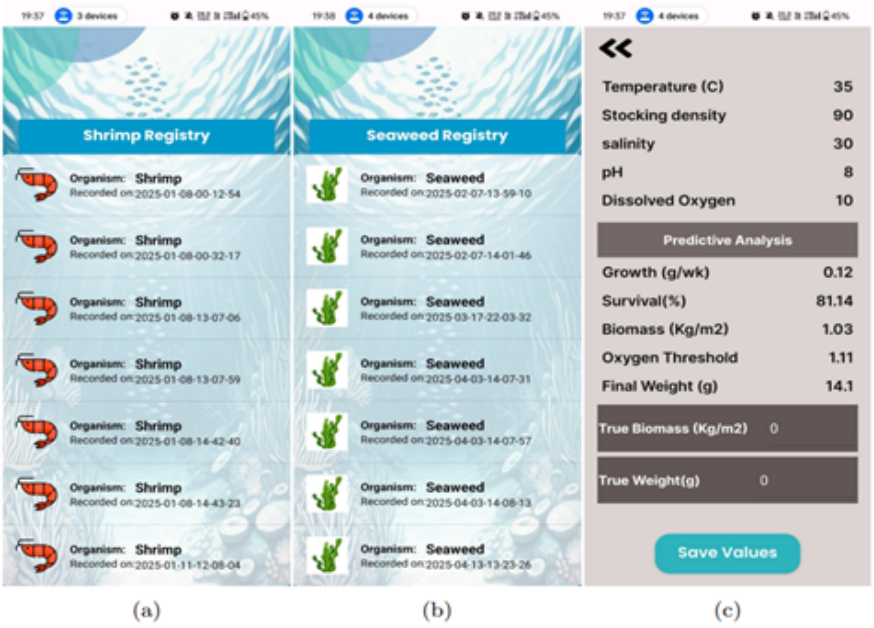


Fig.6: Registry Section of the APY Tool: (a) Shrimp registry tracking the user's history with the shrimp APY Tool. (b) Seaweed registry tracking the user's history with the seaweed APY Tool.
(c) Option for users to report observed biomass and final weight to update and retrain the model with new data.

Conclusion

The field validation exercise conducted in Ratnagiri, Maharashtra, and Veraval, Gujarat, marks a significant milestone in the ongoing journey of digital transformation in India's coastal economy. The APY tool, developed as part of NDT's broader technological initiative, was met with a highly encouraging response from the local fishing communities. Fishermen not only expressed a strong appreciation for the tool's ease of use and practical value but also confirmed the accuracy of its predictions based on their own observational and experiential knowledge. This ground-level endorsement of the APY tool reinforces its relevance, usability, and potential as a transformative technology for marine farmers. Beyond technical validation, the exercise served a broader strategic purpose. It facilitated meaningful dialogue between NDT and the coastal communities, building mutual trust and opening avenues for continued collaboration.

With the APY tool receiving both technical validation and user approval, NDT has achieved a critical milestone in its mission to promote data-driven decision-making in the marine sector. This success not only validates our technological approach but also underscores its commitment to scalable, replicable models of innovation that address the real needs of coastal communities.

Looking ahead, NDT is poised to take this innovation to the next level—both within India and globally—through strategic partnerships, policy support, and further field-level engagement. The field validation has reaffirmed that when technology is thoughtfully integrated with local knowledge systems, it can drive meaningful transformation, empower communities, and contribute substantially to national and global sustainability goals. We remain dedicated to advancing this vision, ensuring that digital transformation serves as a catalyst for economic resilience, ecological stewardship, and social inclusion in the marine and fisheries sector.

NIR TECHNOLOGIES DHWANI

SCAN ME

www.nirdhwani.com

Dr. (Cdr) Arnab Das
Founder and Director, MRC and NDT

+91-96650-33463

UDA Framework Page

director@maritimeresearchcenter.com

Address: Maritime Research Center, Koregaon Bhima, Pune, Maharashtra – 412216