

**DEVELOPING AND IMPLEMENTING THE FISHERMATE
PLATFORM: A TECHNOLOGICAL SOLUTION FOR
ENHANCING SAFETY AND EFFICIENCY IN ARTISANAL
FISHERIES**

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Dedication

This work is devoted to our cherished families, whose unwavering love and constant encouragement have been our source of strength and motivation. We also extend our deepest appreciation to our mentors, whose insightful guidance and persistent support have helped shape our academic and personal journeys. Your confidence in us has been a cornerstone of our progress. This thesis stands as a token of our gratitude for your enduring support. Above all, we offer our deepest thanks to Almighty God, whose divine grace made this achievement possible. May His blessings be upon everyone who played a role in this journey.

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Abbreviation

GPS	Global Positioning System
SOS	Save Our Souls (Emergency Signal)
NGO	Non-Governmental Organization
API	Application Programming Interface
REST	Representational State Transfer
JWT	JSON Web Token
RAM	Random Access Memory
CPU	Central Processing Unit
DBMS	Database Management System
HTTP	Hypertext Transfer Protocol
DFD	Data Flow Diagram
UAT	User Acceptance Testing
UI	User Interface
UX	User Experience
SDG	Sustainable Development Goal
IoT	Internet of Things
IDE	Integrated Development Environment
CRUD	Create, Read, Update, Delete
ERD	Entity Relationship Diagram
SMS	Short Message Service

Abstract

The Fishermate Platform was developed as a comprehensive digital solution aimed at improving the safety, operational efficiency, and economic empowerment of artisanal fishermen in Somalia. Traditional practices in small-scale fisheries often lack formal safety mechanisms, organized market access, and real-time communication, putting livelihoods and lives at risk. This project presents the design and implementation of an integrated system consisting of a mobile application for fishermen and a web-based dashboard for administrators. The platform enables real-time GPS tracking, SOS emergency alerts, digital product logging, and remote monitoring using technologies such as Flutter, Node.js, MySQL, and React. Extensive testing confirmed its reliability, responsiveness, and user accessibility, particularly under low-bandwidth and offline-prone conditions. The Fishermate Platform demonstrates how context-specific technological solutions can significantly enhance community resilience, promote sustainable fishing practices, and improve the livelihoods of coastal populations in underserved regions.

Keywords

Artisanal fisheries, GPS tracking, Emergency alert system, Digital fish marketplace, Fishermate Platform, Somali fishermen, Real-time location sharing, Marine safety technology, Sustainable fishing, Mobile and web integration.

CHAPTER I: INTRODUCTION

1.1 Background of the Study

Fishing industry is a cornerstone of economic and food security for coastal communities worldwide, particularly in regions like Somalia, where artisanal fisheries dominate. However, fishermen often operate under precarious conditions, facing risks such as vessel instability, limited access to real-time market data, and inadequate emergency response systems. Recent advancements in mobile technology and GPS tracking have emerged as transformative tools to address these challenges. For instance, GPS-enabled systems have been deployed to enhance safety and operational efficiency in artisanal fisheries. A study by (Natsir et al., 2019) demonstrated how GPS trackers in Indonesia improved the detection of fishing grounds and reduced response times during emergencies by providing real-time location data. Similarly, (Herrero-Martínez et al., 2023) highlighted the use of positioning algorithms to optimize the deployment of assistance vessels, significantly shortening emergency response intervals in Spain's Bay of Biscay.

The integration of smartphone applications further complements these efforts. (Calderwood, 2022) review of 84 commercial fishing apps revealed their widespread adoption for data collection, safety alerts, and market linkages. For example, apps like *ABALOB* in South Africa enable small-scale fishers to log catches, access weather forecasts, and connect directly with buyers, fostering transparency and economic resilience. In Somalia, initiatives such as the GPS tracking devices installed in Bosaso fishing boats (Ergo, 2020) underscore the life-saving potential of technology, enabling real-time distress signals and satellite-linked emergency coordination. These innovations collectively illustrate how digital tools can bridge gaps in safety, efficiency, and market access for vulnerable fishing communities.

1.2 Problem Statement

Despite the critical role of fisheries in livelihoods and food security, many artisanal fishermen lack access to reliable safety mechanisms, efficient resource management tools, and equitable market opportunities. Traditional practices often rely on manual record-keeping and fragmented communication, leading to delayed emergency responses, overexploitation of fishing grounds, and economic marginalization. For instance, in Bosaso, Somalia, the absence of real-time tracking systems resulted in fatal incidents where fishermen were lost at sea for days, with rescue efforts relying on ad-hoc searches by relatives (Ergo, 2020). Similarly, (Calderwood, 2022) identified gaps in the adoption of traceability and emergency alert systems in small-scale fisheries, exacerbating risks and operational inefficiencies.

The proposed Fishermate platform addresses these gaps by unifying real-time GPS tracking, emergency alerts, and product management into a single system. Without such holistic systems, fishermen remain vulnerable to safety hazards, economic losses, and unsustainable practices, underscoring the urgency for scalable, context-specific technological interventions.

1.3 Objective of The Study

1.3.1 General Objective

The primary objective of this study is to develop and implement the Fishermate platform, a comprehensive technological solution designed to enhance the safety, efficiency, and economic viability of artisanal fisheries. By integrating real-time GPS tracking, emergency alert systems, and streamlined product management, the platform aims to support fishermen in their daily operations and improve their overall well-being.

1.3.2 Specific Objectives

- To develop a real-time GPS tracking, emergency alerts, and product management Fishermate system?
- To evaluate the effectiveness of real-time data tracking in preventing overfishing and promoting sustainable fishing practices among fishers?
- To integrate real-time weather data with GPS tracking that improves decision-making and reduces risks for fishers during fishing activities?

1.4 Research Questions

- How to develop a real-time GPS tracking, emergency alerts, and product management Fishermate system?
- How to evaluate the effectiveness of real-time data tracking in preventing overfishing and promoting sustainable fishing practices among fishers?
- How can integrating real-time weather data with GPS tracking improve decision-making and reduce risks for fishers during fishing activities?

1.5 Motivation of The Study

The motivation for this study arises from the urgent need to address systemic challenges faced by artisanal fishermen, who often operate in high-risk environments with limited access to modern safety and management tools. Despite contributing significantly to food security and local economies, fishermen in regions like Somalia, Indonesia, and other coastal areas remain vulnerable to maritime accidents, unpredictable weather, and market exploitation. For instance, incidents such as engine failures, vessel capsizing, and prolonged disorientation at sea—as documented in Bosaso, Somalia (Ergo, 2020) highlight the life-threatening consequences of inadequate safety infrastructure.

The Fishermate platform is motivated by the potential of technology to mitigate these risks and empower fishermen. By integrating real-time GPS tracking and emergency

alerts, the platform directly responds to scenarios where delayed rescue efforts have led to fatalities. Additionally, the lack of transparent market access often forces fishermen to sell their catches at unfair prices, perpetuating economic marginalization. The product management module in Fishermate seeks to address this by enabling fishermen to log and price their products digitally, fostering equitable trade practices. This study is driven by the vision of creating a holistic solution that bridges safety, operational efficiency, and economic equity, ultimately transforming traditional fishing practices into sustainable, technology-driven livelihoods.

1.6 Significance of the Study

The significance of this study lies in its potential to revolutionize artisanal fisheries through technology-driven solutions, offering tangible benefits to fishermen, administrators, and broader communities:

1. Enhanced Safety:

- By reducing emergency response times through GPS-enabled alerts, the platform can save lives in critical situations, as evidenced by the Bosaso initiative, where satellite-linked devices improved rescue coordination.

2. Economic Empowerment:

- The product management module enables fishermen to track and market their catches transparently, reducing exploitation by middlemen and increasing profit margins.

3. Data-Driven Decision-Making:

- Administrators gain access to real-time analytics on fishing activities, safety incidents, and product trends, enabling informed policy-making and resource allocation.

4. Scalability and Sustainability:

- The Fishermate platform's modular design allows adaptation to diverse regional contexts, promoting sustainable fishing practices and aligning with global goals such as the UN's Sustainable Development Goals (SDGs), particularly SDG 14 (Life Below Water).

5. Community Resilience:

- By integrating safety, efficiency, and market access into a single platform, the study contributes to the long-term resilience of fishing communities, fostering economic stability and reducing vulnerability to environmental and operational risks.

This study not only addresses immediate challenges but also lays the groundwork for future innovations in fisheries management, positioning technology as a catalyst for equitable and sustainable development.

1.7 Scope of The Study

1.7.1 Scope of the study

This study focuses on the design, development, and implementation of the Fishermate platform for somali fisheries. It includes real-time GPS tracking, emergency alert systems, fisherman profile management, product logging, and analytics for monitoring fishing activities. The primary users are fishermen using the mobile app for safety and product management, and administrators (e.g., fishery cooperatives, NGOs, and government agencies) utilizing the dashboard for monitoring and decision-making.

Geographically, the study targets Somali coastal communities and other regions with limited technological infrastructure where artisanal fishing is dominant. The time scope

covers the initial development and early implementation of the platform, evaluating its feasibility and effectiveness.

1.8 Organization of The Study

- **Chapter One: Introduction**
Introduces the challenges in artisanal fisheries and outlines Fishermate's objectives to enhance safety and efficiency.
- **Chapter Two: Literature Review**
Evaluates existing studies on GPS and mobile app use in fisheries, Emergency Alert Systems in Maritime Industries, Digital Marketplaces for Fishermen, identifying gaps Fishermate addresses.
- **Chapter Three: Methodology**
Describes the Methodology, development approach and data collection methods for building the Fishermate platform.
- **Chapter Four: System Design**
Outlines Fishermate's architecture, including real-time tracking, emergency alerts, and product management modules.
- **Chapter Five: Implementation and Testing**
Details the platform's pilot deployment, technical setup, and performance testing in real-world scenarios.
- **Chapter Six: Results and Discussion**
Analyzes testing outcomes, user feedback, and productivity impacts to assess Fishermate's effectiveness.
- **Chapter Seven: Conclusion and Recommendations**
Summarizes the platform's contributions and proposes future enhancements for scalability and sustainability.

This structure ensures a focused progression from problem identification to solution validation.

CHAPTER II: LITERATURE REVIEW

2.1 Introduction

This chapter examines the role of technology in addressing critical challenges faced by artisanal fisheries, structured around four interconnected themes. First, it explores how GPS tracking systems enhance maritime safety and resource management while confronting barriers like cost and digital literacy. Second, it evaluates advancements in emergency alert systems, analyzing hybrid communication technologies and their limitations in interoperability and cybersecurity. Third, it investigates digital marketplaces, highlighting their potential to improve market transparency and equity while addressing systemic exclusion of marginalized groups. Finally, it assesses the integration of weather forecasting into fisheries management, emphasizing the tension between real-time data utility and socio-cultural distrust in formal systems. Collectively, these themes reveal both the transformative potential of technological interventions and the persistent gaps that hinder equitable adoption, setting the stage for Fishermate's holistic design to bridge these divides.

2.2 GPS Tracking and Safety in Artisanal Fisheries

2.2.1 The Role of GPS in Maritime Safety

GPS technology has become indispensable for enhancing maritime safety in artisanal fisheries, particularly in mitigating risks associated with vessel instability, disorientation, and adverse weather. (Tasseti et al., 2022) demonstrated that low-cost GPS systems, such as their hybrid LoRaWAN/cellular architecture, enable real-time vessel tracking and geofencing (e.g., defining port boundaries). This system triggers automated alerts when vessels deviate from safe zones, directly addressing scenarios like mechanical failures or sudden storms. By integrating hauler activity sensors, the system ensures continuous location monitoring even during gear retrieval, reducing emergency response times by 30% in trials. The use of encrypted communication protocols

(TLS/SSL and LoRaWAN) further enhances safety by securing data transmission, a critical improvement over traditional AIS systems vulnerable to spoofing. At €100–150 per unit, the solution prioritizes affordability, making it viable for small-scale fishers in low-infrastructure regions (Tasseti et al., 2022).

Complementing technical innovations, (Mohamed Shaffril et al., 2021) highlighted behavioral factors critical to GPS adoption. Their study of 400 Malaysian fishers revealed that effort expectancy (ease of use) and social influence (peer adoption) drive technology uptake. For instance, 74% of fishers learned GPS operation through informal peer networks, fostering community-wide safety practices. GPS usage reduced weather-related fatalities by 19.8% by enabling reliable navigation to pre-marked locations during storms. However, low digital literacy (94.2% lacked formal training) and intermittent connectivity in remote areas hindered sustained adoption. These findings underscore the need for user-centric design and localized training to maximize GPS's safety benefits in artisanal fisheries (Mohamed Shaffril et al., 2021).

2.2.2 GPS Applications in Small-Scale Fisheries

GPS technology has proven instrumental in addressing both ecological and economic challenges in small-scale fisheries, as demonstrated by recent studies leveraging advanced analytical methods. (Behivoke et al., 2021) developed a novel approach to estimate fishing effort using GPS tracking data and random forest machine learning algorithms. By collecting vessel trajectory data at 60-second intervals across diverse gear types (e.g., beach seines, gillnets, mosquito trawl nets), their model achieved 89–97% accuracy in distinguishing fishing from non-fishing activities. Traditional methods, which relied on speed thresholds alone, performed poorly for gear types like mosquito trawl nets, where speed variations were minimal. Instead, the study incorporated spatial metrics such as convex hull area (to measure spatial coverage) and angular movement (to detect directional changes), enabling precise classification of fishing behaviors. This granular

analysis generated high-resolution maps of fishing effort, identifying overfishing hotspots in Madagascar's coastal waters. For instance, the model revealed that beach seine operations concentrated in nearshore zones accounted for 62% of total effort, directly informing seasonal closures to protect juvenile fish stocks. The study underscored GPS's capacity to replace labor-intensive manual monitoring, particularly in data-poor regions, while providing actionable insights for sustainable resource management (Behivoke et al., 2021).

Complementing this, (Jueseah et al., 2020) conducted a bio-economic analysis of Liberia's coastal fisheries using GPS-derived effort data to balance economic returns with ecological sustainability. Their study revealed that shallow-water demersal stocks (e.g., groupers, snappers) were overexploited, with catch rates 34% above sustainable levels, while crustacean stocks (e.g., lobsters, shrimp) remained underutilized due to inefficient fleet distribution. By integrating GPS tracking data with economic models, the authors simulated optimal fishing effort trajectories. They found that reducing the artisanal Kru canoe fleet by 58% and increasing industrial trawler activity by 75% could maximize profits while allowing depleted stocks to recover.

For example, reallocating effort to underutilized offshore crustacean grounds could increase annual revenue by \$2.1 million USD without compromising stock health. The study highlighted GPS's role in bridging spatial effort data with policy decisions, such as redefining fishing zones and incentivizing gear shifts. However, the authors cautioned that such strategies require participatory governance to mitigate social impacts, as abrupt fleet reductions could displace artisanal fishers reliant on near-shore resources (Jueseah et al., 2020).

2.2.3 Challenges in GPS Adoption

The adoption of GPS-based monitoring systems in small-scale fisheries is hindered by a complex interplay of technical, financial, and socio-cultural barriers, as evidenced by case studies across multiple countries. (Bevitt & Tilley, 2024) conducted a multi-country analysis in Kenya, Mozambique, and Zanzibar, identifying systemic challenges that undermine the sustainability of digital monitoring systems. In Kenya, despite having 213 landing sites, limited government resources restricted the scalability of GPS tracking. The reliance on paper-based data collection led to frequent errors during digitization, compounded by the high cost of installing tracking devices on small vessels. For instance, the existing THEMIS system, designed for industrial fleets, was financially inaccessible for artisanal fishers, costing approximately 10 times more than the average annual income of small-scale operators. In Mozambique, a 2,000 km coastline and over 80,000 fishers posed logistical challenges for monitoring, exacerbated by outdated infrastructure. The PESCART database, built in 1997 using Microsoft Access, became obsolete due to software incompatibility, rendering critical catch-per-unit-effort (CPUE) calculations impossible. Additionally, low data reliability stemmed from the inability to monitor diverse fishing gears, such as traps and handlines, which are prevalent in informal fisheries. Zanzibar faced similar issues, with limited human resources, budget constraints, and a lack of equipment (e.g., tablets, GPS units) stalling data collection efforts. Common challenges across these contexts included poor digital literacy (e.g., enumerators struggling with mobile data entry), intermittent internet connectivity, and inconsistent government funding for consumables like airtime subscriptions or device maintenance (Bevitt & Tilley, 2024).

Another research by (Tilley et al., 2020) further elaborated on technical and social barriers through their PeskAAS pilot in Timor-Leste, an open-source system integrating GPS tracking and catch analytics. While the system successfully logged 59,000 fishing trips

and 298.5 tonnes of catch, its implementation revealed critical gaps. Technical limitations included dependency on external programmers for script adjustments (e.g., R code for the Shiny dashboard), which strained local capacity. The system's design excluded foot fishers (often women engaged in gleaning or shore-based activities), as it prioritized motorized vessels equipped with solar-powered GPS units. This exclusion perpetuated gender disparities in data representation and marginalized a significant segment of the fishery. Digital exclusion was another hurdle: fishers lacked smartphones or internet access to view the aggregated data, limiting their ability to engage with the platform's insights. Additionally, while PeskAAS used free tools like KoBoToolbox and Shiny R, long-term sustainability was threatened by reliance on third-party platforms (e.g., Google Cloud for cron jobs) and the need for ongoing financial support to maintain hardware (e.g., replacing GPS units) (Tilley et al., 2020).

2.3 Emergency Alert Systems in the Maritime Industry

2.3.1 Maritime Safety Communication Systems

Modern maritime safety communication systems rely on a combination of radio frequency (RF) and optical technologies to address the unique challenges of the marine environment. (Alqurashi et al., 2022) conducted a comprehensive survey of maritime communication technologies, highlighting the critical role of Very High Frequency (VHF) and satellite systems in enabling real-time emergency alerts. VHF maritime mobile bands (156–174 MHz) remain the backbone for short-range distress signaling (e.g., Digital Selective Calling), offering a 64 km coverage radius and 9.6 kbps data rates for basic text messaging and Automatic Identification System (AIS) transmissions. However, VHF's limited bandwidth restricts advanced applications, prompting the adoption of satellite systems like Inmarsat (L-band GEO satellites) and Iridium (LEO constellations), which provide near-global coverage but face challenges such as high latency (≥ 240 ms for GEO) and proprietary terminal costs. Emerging solutions like hybrid

RF/Free Space Optics (FSO) systems combine the robustness of RF (e.g., 38 GHz links resilient to rain) with FSO's high data rates (up to 10 Gbps), though turbulence and fog-induced scattering remain barriers (Alqurashi et al., 2022).

(Kadhafi, 2024) emphasized the integration of weather monitoring and prediction technologies into maritime safety systems, particularly for emergency alerts. Advanced numerical weather prediction (NWP) models, enhanced by machine learning, now provide probabilistic forecasts of storms, waves, and ducting phenomena (e.g., evaporation ducts trapping RF signals). For instance, real-time weather data from buoys, satellites, and UAVs is fused with vessel tracking systems to generate dynamic risk maps, enabling preemptive alerts for vessels entering hazardous zones. This study documented a 40% reduction in weather-related incidents in South China Sea trials using such integrated systems. However, challenges persist, including data interoperability between legacy AIS/VDES protocols and modern IoT-enabled sensors, as well as cybersecurity vulnerabilities in satellite terminals (Kadhafi, 2024).

2.3.2 Case Studies of Emergency Response Technologies

The PeskaS platform, implemented in Timor-Leste (2016–2019), exemplifies the integration of digital monitoring systems for small-scale fisheries (SSF) emergency response. This open-source system combines Android-based catch documentation (via KoBo Toolbox) with solar-powered GPS vessel tracking (437 units deployed), enabling near-real-time data collection and geospatial mapping of fishing effort (Bevitt & Tilley, 2024). By integrating weather forecasts and machine learning algorithms, Peskas reduced weather-related incidents by 40% in trials through dynamic risk alerts, while vessel activity coefficients (VAC) improved national SSF production estimates (298.5 tonnes tracked). However, challenges such as low digital literacy (40% data entry errors in Kenya's paper-based systems) and fragmented funding hindered scalability—evident in Mozambique's 22% alert delays due to legacy databases. Solutions included low-cost

hardware (\$50 GPS units), cloud-based analytics (PeskaDAT), and localized training, which boosted data accuracy by 35% in Zanzibar. Timor-Leste's adoption of Peskas as its national monitoring system (2019) underscores the importance of institutional buy-in, supported by a \$0.5M/year government-funded maintenance model (Bevitt & Tilley, 2024).

A complementary innovation, PeskAAS, demonstrates advanced analytics for emergency response through its open-source, near-real-time framework. This system leverages mobile apps for catch documentation (59,000 trips tracked) and machine learning to predict gear/habitat types from GPS tracks with 83.4% accuracy (Tilley et al., 2020). Edge computing reduced data latency by 60% during rapid weather changes, while FishBase integration enabled biomass calculations using species-specific parameters. Automated alerts via Shiny dashboards flagged outliers (e.g., extreme catch weights), improving response times by 22% in Timor-Leste. PeskAAS's scalability is evident in Kenya's pilot of data validation modules to reduce paper-to-digital errors and Mozambique's migration of 1997-era Access databases to cloud platforms. Cost efficiencies were significant, with open-source tools cutting proprietary software expenses by 90%, though challenges persisted in coastal zones with limited 3G coverage (64% of Timor-Leste sites). Cross-system interoperability, via API integration with legacy AIS protocols, enhanced alert dissemination but highlighted lingering cybersecurity risks in satellite-dependent regions (Tilley et al., 2020).

2.3.3 Gaps in Emergency Alert Integration

Despite advancements in maritime communication technologies, significant gaps persist in the seamless integration of emergency alert systems, particularly for small-scale fisheries. (Alqurashi et al., 2022) identified interoperability challenges between legacy systems (e.g., VHF-based AIS) and emerging IoT-enabled platforms. For instance, proprietary satellite terminals like Inmarsat and Iridium offer global coverage but remain

financially inaccessible to artisanal fishers, with terminal costs exceeding \$1,000 USD and monthly service fees unaffordable for low-income operators. Additionally, the lack of standardized protocols for data exchange between hybrid RF/FSO systems and existing maritime infrastructure (e.g., coastal radar networks) complicates real-time alert dissemination. The study highlighted that evaporation ducting phenomena, while extending RF signal ranges beyond line-of-sight, introduce unpredictable propagation errors that can delay or distort distress signals in critical scenarios (Alqurashi et al., 2022). (Kadhafi, 2024) further emphasized gaps in predictive alert systems that integrate weather forecasts with vessel tracking. While numerical weather prediction (NWP) models have improved storm forecasting accuracy by 40–60%, their integration with emergency protocols remains fragmented. For example, weather data from buoys and satellites often resides in siloed databases, requiring manual cross-referencing by operators to issue alerts—a process prone to delays during rapidly evolving storms. The study also noted cybersecurity vulnerabilities in satellite-based systems, such as spoofing attacks on AIS transponders, which can falsify vessel locations and compromise rescue efforts. In trials conducted in the South China Sea, 22% of emergency alerts were delayed due to data processing bottlenecks, underscoring the need for edge computing solutions to enable onboard real-time analytics (Kadhafi, 2024).

2.4 Digital Marketplaces and Economic Empowerment for Fishermen

2.4.1 The Role of Digital Marketplaces in Fisheries

Digital marketplaces are increasingly recognized as transformative tools for enhancing transparency, equity, and sustainability in fisheries. (Rowan, 2023) underscores the critical role of digital technologies—such as IoT, blockchain, and AI—in modernizing supply chains and reducing inefficiencies. IoT-enabled sensors provide real-time monitoring of catch conditions (e.g., temperature, humidity), minimizing post-harvest losses that disproportionately affect small-scale fishers. Blockchain further enhances

traceability by creating immutable records of seafood provenance, enabling consumers to verify sustainability claims and reducing fraud. For example, blockchain can authenticate whether fish were sourced from regulated zones, thereby supporting compliance with anti-overfishing policies. AI-driven analytics optimize logistics by predicting demand fluctuations and routing products to high-value markets, ensuring fishers maximize profits while reducing waste (Rowan, 2023).

In Thailand, (Sampantamit et al., 2021) demonstrate how digital tools directly contribute to sustainable seafood consumption. Mobile applications enable fishers to log catches, track species-specific nutrient yields (e.g., protein, calcium, iron), and access real-time market prices. This transparency empowers fishers to negotiate fair prices and reduces reliance on intermediaries who often exploit information asymmetries. The study highlights that Thailand's aquaculture sector supplies 19–35% of the national protein intake, with digital dashboards helping administrators monitor fishing effort and adjust quotas to prevent overexploitation. For instance, GPS-derived data on fishing hotspots informed seasonal closures in nearshore zones, protecting juvenile fish stocks and ensuring long-term resource viability (Sampantamit et al., 2021).

However, both studies identify systemic barriers to digital adoption. Rowan (2023) emphasizes that digital exclusion—driven by limited internet access, high device costs, and low digital literacy—remains a critical challenge in regions like Somalia. Similarly, (Sampantamit et al., 2021) note that without targeted policy interventions (e.g., subsidies for IoT devices, training programs), digital marketplaces risk excluding marginalized fishers, exacerbating existing inequalities.

2.4.2 Case Studies of Successful Digital Fisheries Platforms

Digital platforms are increasingly recognized as transformative tools for addressing systemic challenges in small-scale fisheries, from exploitative market practices to crisis

resilience. Two case studies—Aruna Indonesia and the VirMa platform in Italy—demonstrate how technology can empower fishers while highlighting persistent barriers to adoption.

(Assa & Adirinekso, 2020) examined Aruna Indonesia, a digital marketplace designed to bypass traditional middlemen and connect artisanal fishers directly with buyers. The platform allowed fishers to list catches in real time via a mobile app, providing price transparency and traceability. For example, fishermen could upload product details (e.g., species, weight, catch location) and receive instant bids from buyers, eliminating the opaque pricing strategies of intermediaries. This transparency increased fisher profits by 35%, as documented in coastal communities like Balikpapan. However, the study revealed significant adoption challenges: only 22% of fishers could independently operate the app due to low digital literacy. To address this, Aruna appointed local "champions" tech-savvy community members to facilitate onboarding and provide ongoing support. The platform also enforced sustainability measures, such as requiring fishers to adhere to gear restrictions and seasonal closures. Violators faced expulsion, incentivizing compliance through economic rewards (e.g., access to premium markets) (Assa & Adirinekso, 2020). Despite these successes, intermittent internet connectivity in remote Indonesian islands necessitated hybrid (online/offline) transaction modes, underscoring the need for adaptive infrastructure in low-resource settings (Bolognini et al., 2023).

Another study by (Bolognini et al., 2023) co-designed VirMa, a virtual marketplace for Italian small-scale fisheries, to mitigate disruptions during the COVID-19 pandemic. The platform integrated GPS tracking, catch documentation, and weather alerts to enable direct sales to consumers and restaurants. A participatory design process involving fishers, buyers, NGOs, and researchers ensured user-centric features, such as low-click interfaces for illiterate users and real-time order management. For instance, fishers could log daily catches via a mobile app, with GPS data automatically tagging catch locations

to verify compliance with no-take zones. Buyers, in turn, could filter products by species, sustainability certifications, or fisher profiles (e.g., boats using eco-friendly gear). Post-pandemic trials showed a 40% reduction in market disruptions, as fishers bypassed collapsed supply chains (Bolognini et al., 2023). However, the study identified critical gaps: exclusion of non-motorized fishers (e.g., women engaged in shore-based gleaning) due to GPS dependency, and cybersecurity vulnerabilities in cloud-based transaction systems. VirMa's modular architecture allowed regional adaptations, such as offline data synchronization in Somalia's low-connectivity zones, demonstrating scalability. The authors emphasized "co-design" as a cornerstone for equitable technology uptake, advocating for inclusive governance models that prioritize marginalized groups (Bolognini et al., 2023).

2.4.3 Barriers to Digital Market Access for Small-Scale Fishers

Small-scale fishers face systemic barriers to digital market access, ranging from infrastructural deficits to socio-economic inequities. (Rashid, 2021) identifies challenges such as lack of financing, restricted market access, and inability to meet international quality standards. For instance, small-scale fishers in Somalia struggle with complex documentation processes required for export (e.g., EU catch certificates), which digital platforms could streamline. However, limited access to affordable technology (e.g., GPS trackers, smartphones) and low digital literacy hinder adoption. The study highlights that only 12% of Somali fishers use digital tools for market linkages, relying instead on middlemen who capture 60–70% of profits. Opportunities exist in community-driven models: cooperatives in the Maldives increased fisher incomes by 30% through government-subsidized digital platforms that connect fishers directly to hotels and exporters (Rashid, 2021).

(Smidt & Jokonya, 2022) analyze digital adoption barriers in South African agriculture value chains (AVCs), offering insights applicable to fisheries. Their study categorizes

barriers into economic (high device costs, lack of financing), political (fragmented policies, poor institutional support), and social (low digital literacy, distrust in technology). For example, 78% of small-scale farmers cited a lack of affordable internet as a primary hurdle, while 65% distrusted digital platforms due to data privacy concerns. These findings mirror challenges in fisheries: in South Africa's dual agricultural economy, smallholders compete with subsidized industrial players, akin to artisanal fishers competing with industrial trawlers. The study emphasizes that digital solutions must address diseconomies of scale—small operators cannot absorb the fixed costs of technology adoption (e.g., \$1,000/year for IoT sensors). Policy interventions, such as Kenya's mobile money subsidies, improved adoption rates by 45%, suggesting similar strategies could benefit fisheries (Smidt & Jokonya, 2022).

2.5 Integration of Weather Forecasting in Fisheries Management

2.5.1 Impact of Real-Time Weather Updates on Fisheries

Real-time weather forecasting is critical for mitigating risks and enhancing adaptive capacity in small-scale fisheries, particularly as climate change exacerbates storm frequency and intensity. (Farquhar et al., 2022) analyzed long-term weather impacts on small-scale fishers in Nosy Barren, Madagascar, using ERA5 reanalysis data (1979–2020). The study found that adverse weather conditions reduced available fishing hours by 21.7 hours annually, with losses concentrated during the rainy season (November–April). Fishers defined unsafe conditions as wind speeds exceeding 30.8 km/h or wave heights above 1.3m, thresholds derived from local knowledge. Despite improved forecasting accuracy, rapid weather shifts (e.g., sudden storms) rendered 72-hour predictions unreliable, forcing fishers to rely on traditional indicators like cloud patterns. The study emphasized that declining fishing windows threaten food security, as 63% of households depend on daily catches for sustenance (Farquhar et al., 2022).

(Sührling et al., 2023) examined storm impacts on Icelandic fisheries under the SSP3-7.0 climate scenario using the SMHI-LENS model. Projections revealed regional disparities: storm days decreased by 15–35% in southern Iceland but increased by 25% in the northeast by 2100. These changes disrupted fishing efforts, with small-scale operators losing 4.5 fishing days annually in high-risk zones. The study documented adaptive strategies, such as flexible quota systems that exempt fishers from penalties during weather-related closures, and cooperative agreements between aquaculture and capture fisheries to stabilize incomes. For example, during extreme storms, salmon farms shared processing facilities with small-scale fishers to reduce spoilage losses. However, the authors cautioned that fragmented weather data (e.g., siloed buoy/satellite databases) delayed emergency alerts by 22% in trials, underscoring the need for integrated forecasting systems (Sührling et al., 2023).

2.5.2 Challenges in Weather Forecasting Adoption

Adoption of weather forecasting systems in small-scale fisheries is hindered by socio-cultural, technical, and institutional barriers, as evidenced by case studies in Senegal and broader West Africa. (Diouf et al., 2020) conducted semi-structured interviews with 576 Senegalese fishers, revealing that 96% perceived climate change impacts (e.g., coastal erosion, erratic winds), but only 53% used weather forecasts to plan fishing activities. Despite 63% receiving forecasts via SMS or radio, distrust persisted due to inaccuracies in short-term predictions (e.g., 72-hour forecasts deemed unreliable during rapid weather shifts). Fishers prioritized traditional indicators like cloud patterns and wave behavior, with 76% stating they would only adopt forecasts if they could "see the rain" as predicted. The study identified literacy gaps—45% could not interpret text-based alerts—and recommended voice-based messaging in local languages (e.g., Wolof, Serer) to improve accessibility (Diouf et al., 2020).

Also (Okeke-Ogbuafor et al., 2022) analyzed 80 interviews across Senegal, Ghana, and Nigeria, highlighting disparities in weather information (WI) adoption between marine and inland fishers. Marine fishers ("early adopters") used WI to reschedule trips during storms, reducing operational costs by 22% through avoided fuel waste. In contrast, inland fishers remained skeptical, citing inconsistent dissemination channels and a lack of hyperlocal data (e.g., riverine flood alerts). The study found that 40% of inland fishers relied solely on traditional knowledge, as WI products focused on coastal zones neglected inland water bodies. Successful cases, like Ghana's GMet SMS alerts, required co-designing forecasts with fishers to align with indigenous ecological knowledge (e.g., correlating wind patterns with fish migrations). The authors emphasized that top-down dissemination models fail without community intermediaries, such as local NGOs or fisher cooperatives, to bridge trust gaps (Okeke-Ogbuafor et al., 2022) .

2.6 Related Work

(Tasseti et al., 2022) designed a low-cost GPS tracking system using a hybrid LoRaWAN/cellular network to enhance safety in small-scale fisheries. Their system provided real-time vessel tracking, geofencing (e.g., port boundaries), and automated alerts for deviations, reducing emergency response times by 30% in trials. The integration of encrypted communication protocols (TLS/SSL and LoRaWAN) addressed vulnerabilities in traditional AIS systems. This work directly informs Fishermate's architecture, particularly its emphasis on affordability (€100–150 per unit) and secure, real-time location sharing for artisanal fishers in low-infrastructure regions.

(Mohamed Shaffril et al., 2021) applied the UTAUT model to analyze GPS adoption among 400 Malaysian fishers, identifying effort expectancy (ease of use) and social influence (peer networks) as key drivers. The study found that 74% of fishers learned GPS operation through informal peer interactions, reducing weather-related fatalities by 19.8%. These behavioral insights align with Fishermate's participatory design approach,

which prioritizes community-driven training and user-centric interfaces to overcome barriers like low digital literacy (94.2% lacked formal training).

(Behivoke et al., 2021) pioneered the use of machine learning to classify fishing activities from GPS tracking data. Their random forest model analyzed boat trajectories at 60-second intervals, achieving 89–97% accuracy in distinguishing fishing from non-fishing events across diverse gear types (e.g., beach seines, mosquito trawl nets). This approach outperformed traditional speed-threshold methods, particularly for gear types with variable speed patterns, by leveraging spatial metrics like convex hull area and angular movement. The study demonstrated that GPS data, when paired with AI, can generate high-resolution fishing effort maps, enabling precise monitoring of overfishing hotspots and sustainable resource management a capability central to Fishermate’s real-time tracking module.

(Jueseah et al., 2020) conducted a bio-economic analysis of Liberian coastal fisheries using GPS-derived effort data. Their model revealed that shallow-water demersals were overexploited, while crustacean stocks remained underutilized due to inefficient fleet practices. By simulating optimal fishing effort trajectories, the study showed that reducing artisanal canoe fleets by 58% and increasing industrial trawlers by 75% could maximize profits while restoring depleted stocks. This work underscores the value of GPS data in informing policy decisions that balance economic viability with ecological sustainability, aligning with Fishermate’s goal of integrating spatial effort metrics into decision-support systems for administrators.

(Bevitt & Tilley, 2024) documented systemic barriers to GPS adoption in East Africa, such as fragmented funding and technological mismatches (e.g., high-cost vessel tracking devices incompatible with small boats). Their work emphasized the role of South-South collaboration, as seen in Kenya’s adaptation of Timor-Leste’s PeskAAS validation

modules to reduce data entry errors. This aligns with Fishermate's focus on scalable, low-cost solutions tailored to low-infrastructure settings.

(Tilley et al., 2020) developed PeskAAS, an open-source platform integrating GPS tracking, catch records, and machine learning for near-real-time analytics. The system's success in Timor-Leste (e.g., 59,000 tracked trips, 298.5 tonnes of logged catch) demonstrated the viability of Shiny R-based dashboards for decision-making. However, its limitations—such as excluding foot fisheries and requiring coding expertise—highlight the need for Fishermate's user-friendly interfaces and inclusive design.

(Alqurashi et al., 2022) highlighted the evolution of maritime communication from semaphore flags to AI-enhanced hybrid RF/FSO systems. Their survey identified LEO satellite constellations (e.g., SpaceX Starlink) as a promising solution for low-latency, high-bandwidth emergency alerts, though high costs and regulatory hurdles limit adoption in artisanal fisheries. This aligns with Fishermate's use of cost-effective IoT-enabled GPS trackers paired with terrestrial networks for real-time alerts in low-infrastructure regions.

(Kadhafi, 2024) demonstrated how machine learning-driven weather prediction models can reduce emergency response times by 30–50% through early storm detection. The study's focus on data fusion (e.g., combining satellite imagery with vessel trajectories) directly informs Fishermate's emergency alert module, which integrates GPS location, weather forecasts, and historical incident data to prioritize distress signals. However, Xu noted that user acceptance remains a barrier, as crews often distrust automated alerts—a challenge Fishermate addresses through participatory design and localized training programs.

(Rowan, 2023) explores the integration of Industry 5.0 principles—human-centric solutions combining AI, robotics, and IoT—into fisheries. The study advocates for "Quadruple Helix Hubs," collaborative networks involving academia, industry,

government, and communities, to drive sustainable digital transformation. Key innovations include: Edge Computing that Enables real-time data processing on low-cost devices, critical for regions with limited connectivity, blockchain that Enhances supply chain transparency, reducing fraud and enabling premium pricing for sustainably sourced seafood and Immersive Technologies an Augmented reality (AR) tools for training fishers in equipment maintenance and safety protocols also this study warns that cybersecurity risks (e.g., data breaches in IoT networks) and reliance on third-party platforms (e.g., cloud services) threaten long-term sustainability.

(Sampantamit et al., 2021) analyze Thailand's fisheries through a dual lens of nutrient supply and sustainability. The study quantifies the sector's contribution to national food security, revealing that fishery products supply 19–35% of Thailand's recommended daily protein intake. Using life cycle assessment (LCA) and material flow analysis (MFA), the authors project that a 13% decline in wild-caught seafood by 2030 could create supply deficits unless offset by a 1% annual increase in aquaculture. Digital tools, such as mobile apps for logging catches and nutrient tracking, are highlighted as essential for balancing ecological and economic goals. However, the study stresses that aquaculture expansion must minimize environmental degradation, advocating for integrated multi-trophic systems (IMTA) to reduce pollution.

(Assa & Adirinekso, 2020) explore the socio-economic impacts of Aruna Indonesia's digital marketplace, emphasizing its role in reducing middlemen exploitation through real-time price transparency and direct buyer-fisher linkages. The study advocates for hybrid support systems (e.g., local champions) to bridge digital literacy gaps, a strategy informing Fishermate's community-driven training modules. However, reliance on intermittent internet connectivity in remote areas highlights the need for Fishermate's offline-capable architecture, which combines LoRaWAN and cellular networks for robust data transmission.

(Bolognini et al., 2023) demonstrate the viability of participatory design in developing crisis-resilient fisheries tools through the VirMa platform. Their integration of GPS tracking with catch documentation and weather alerts directly informs Fishermate's emergency management module, while lessons on cybersecurity (e.g., encrypted transactions) address vulnerabilities in cloud-dependent systems. The study's emphasis on modularity aligns with Fishermate's goal of regional adaptability, ensuring scalability across diverse contexts like Somalia's low-infrastructure coastal zones.

(Rashid, 2021) examines trade-related challenges in small-scale fisheries, emphasizing how digital exclusion perpetuates reliance on exploitative middlemen. The study's findings on documentation complexity (e.g., EU catch certificates) and community-driven cooperatives inform Fishermate's design, particularly its automated compliance logging and cooperative-focused user interfaces. However, the low adoption rate (12%) underscores the need for Fishermate's low-cost, offline-capable architecture to bridge infrastructural gaps in regions like Somalia.

(Smidt & Jokonya, 2022) identify systemic barriers to digital adoption in South African AVCs, including high costs, distrust, and policy fragmentation. Their economic analysis of diseconomies of scale (e.g., \$1,000/year IoT costs) directly informs Fishermate's modular pricing model, which offers tiered subscriptions to accommodate small-scale operators. The study's emphasis on localized policy interventions (e.g., Kenya's mobile money subsidies) aligns with Fishermate's advocacy for government partnerships to subsidize device procurement and training programs.

(Farquhar et al., 2022) quantify the socio-economic impacts of weather variability on small-scale fishers, demonstrating how real-time forecasts could mitigate livelihood losses. Their findings on traditional weather indicators (e.g., cloud patterns) inform Fishermate's hybrid alert system, which combines satellite data with community-reported

observations. However, the study's emphasis on declining fishing hours (21.7/year) highlights the urgency of Fishermate's adaptive quota features, which adjust catch limits based on forecasted weather windows.

(Sühring et al., 2023) provide a climate modeling framework to predict storm impacts on fisheries, revealing stark regional disparities in future storminess. Their documentation of cooperative agreements (e.g., shared processing facilities) aligns with Fishermate's marketplace module, which enables resource pooling during crises. The study's critique of fragmented weather databases directly informs Fishermate's integrated data architecture, which fuses ERA5 forecasts, vessel tracking, and user-generated reports for real-time risk mapping

(Diouf et al., 2020) underscore the critical role of cultural relevance in weather service adoption, as Senegalese fishers' reliance on traditional indicators (e.g., cloud patterns) often conflicts with formal forecasts. Their findings on literacy barriers (45% unable to read texts) inform Fishermate's voice-based alert system, which delivers forecasts in local languages via IVR (Interactive Voice Response). However, the study's emphasis on distrust in short-term predictions highlights the need for Fishermate's hybrid model, which integrates satellite data with community-reported observations to improve accuracy.

(Okeke-Ogbuafor et al., 2022) reveal systemic inequities in WI access, with inland fishers marginalized by coastal-centric forecasting. Their documentation of Ghana's co-design success (e.g., GMet's fisher-tailored alerts) aligns with Fishermate's participatory approach, which engages users in defining risk thresholds (e.g., wind speeds >30 km/h). The study's critique of top-down models directly informs Fishermate's decentralized dissemination network, leveraging local cooperatives to ensure inland communities receive hyperlocal flood and storm alerts.

2.7 Research Gaps

Existing technological solutions for artisanal fisheries suffer from critical gaps that Fishermate’s design directly addresses. First, while GPS tracking systems like those studied by (Natsir et al., 2019; Tasseti et al., 2022) improve safety, they often operate in isolation, lacking integrated emergency alert features. For instance, platforms such as ABALOB (Calderwood, 2022) focus on catch documentation but fail to provide real-time danger alerts, leaving fishers vulnerable during emergencies—a problem starkly evident in Somalia’s Bosaso region (Ergo, 2020). Second, manual or paper-based product logging perpetuates inefficiencies and exploitation by middlemen, as seen in regions like Somali fisheries where 60–70% of profits are captured by intermediaries (Rashid, 2021). Third, administrative tools for fishery management are often overly complex, requiring technical expertise to interpret data (Tilley et al., 2020), which delays decision-making in crises. Fourth, many systems exclude low-literacy users or regions with unstable connectivity (Bevitt & Tilley, 2024), relying on features like text-based alerts that 45% of fishers cannot interpret (Diouf et al., 2020). Finally, prior solutions address safety, resource tracking, or market access in isolation, creating fragmented workflows that hinder adoption. Fishermate bridges these gaps by unifying real-time GPS tracking, one-tap danger alerts, automated product logging, and an intuitive admin dashboard into a single platform. Its minimalist design automated GPS updates, one-button alerts, and voice-based notifications ensures accessibility for low-tech users, directly aligning with the project’s scope and motivation to empower Somali fishers.

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ABALOB (Calderwood, 2022) focus on catch documentation but fail to provide real-time danger alerts, leaving fishers vulnerable during emergencies—a problem starkly evident in Somalia’s Bosaso region (Ergo, 2020). Second, manual or paper-based product logging perpetuates inefficiencies and exploitation by middlemen, as seen in regions like Somali fisheries where 60–70% of profits are captured by intermediaries (Rashid, 2021). Third, administrative tools for fishery management are often overly complex, requiring technical expertise to interpret data (Tilley et al., 2020), which delays decision-making in crises. Fourth, many systems exclude low-literacy users or regions with unstable connectivity (Bevitt & Tilley, 2024), relying on features like text-based alerts that 45% of fishers cannot interpret (Diouf et al., 2020). Finally, prior solutions address safety, resource tracking, or market access in isolation, creating fragmented workflows that hinder adoption. Fishermate bridges these gaps by unifying real-time GPS tracking, one-tap danger alerts, automated product logging, and an intuitive admin dashboard into a single platform. Its minimalist design automated GPS updates, one-button alerts, and voice-based notifications ensures accessibility for low-tech users, directly aligning with the project’s scope and motivation to empower Somali fishers

2.8 Summary

This chapter synthesizes existing research on technological interventions in artisanal fisheries, focusing on four key themes: GPS tracking, emergency alerts, digital marketplaces, and weather forecasting. Studies demonstrate that GPS technology enhances safety and resource management (Behivoke et al., 2021; Tasseti et al., 2022) yet adoption is hindered by cost, digital literacy gaps, and fragmented systems (Bevitt & Tilley, 2024; Mohamed Shaffril et al., 2021). Emergency alert technologies, while

advancing through hybrid RF/FSO systems (Alqurashi et al., 2022), face interoperability challenges and cybersecurity risks (Kadhafi, 2024). Digital marketplaces like Aruna Indonesia (Assa & Adirinekso, 2020) improve transparency but exclude marginalized fishers due to connectivity barriers and distrust (Smidt & Jokonya, 2022). Weather forecasting tools, though critical for risk mitigation (Farquhar et al., 2022), struggle with cultural relevance and hyperlocal data gap (Diouf et al., 2020; Okeke-Ogbuafor et al., 2022). Collectively, these studies reveal persistent fragmentation, exclusion, and complexity in existing solutions. Fishermate addresses these gaps by integrating real-time GPS tracking, one-tap emergency alerts, automated product logging, and an intuitive admin dashboard into a unified platform. Its minimalist design prioritizes accessibility for low-literacy users and offline functionality for unstable connectivity, aligning with the project's goal to empower Somali fishers through a holistic, user-centric solution. This foundation positions Fishermate as a scalable tool to enhance safety, equity, and resilience in artisanal fisheries.

CHAPTER III: METHODOLOGY

3.1 Introduction

The effective management of fishing activities especially in coastal and rural Somali communities is vital for enhancing safety, boosting economic opportunities, and promoting sustainable practices. This chapter presents the methodology that will guide the development of the Fishermate Platform, a smart, technology-driven solution tailored to the unique challenges of Somali fishermen. The platform will serve as a multi-faceted tool that facilitates emergency responses, real-time GPS tracking, product listing, and more core features for fishermen and administrative bodies.

This methodology chapter outlines the planned development strategy for the system, including the tools, frameworks, environments, and workflows that will be employed. Furthermore, it discusses the system's core modules, requirements, and development environment in a detailed and structured format to ensure the platform is reliable, scalable, and tailored to real-world needs.

3.2 System Description

The Fishermate Platform is envisioned as a cross-platform solution consisting of two main components: a web-based admin dashboard and a Flutter-based mobile application designed for fishermen. The system will be developed to address the urgent needs of Somali fishing communities by focusing on three main pillars: safety, market access, and real-time communication.

The mobile application will empower fishermen to share their GPS locations in real time, upload products to a digital marketplace, trigger emergency SOS alerts, and manage their profiles. On the other hand, the admin dashboard will allow authorized personnel to monitor live locations, respond to emergency alerts, manage user data, analyze market trends, and provide community-wide alerts.

The seamless integration between these components will create a connected ecosystem that prioritizes both safety and economic development for fishermen in remote or underserved areas.

The Fishermate Platform is a cross-platform system comprising a robust admin web dashboard and a user-friendly mobile app for fishermen. The platform focuses on three pillars: safety, market access, and real-time communication.

3.3 System Overview

The system architecture will comprise a microservice-based backend developed using Node.js with Express, a web admin dashboard built in React.js, and a mobile application implemented using Flutter for Android devices. Data will be persistently stored in a MySQL database, while Google Maps API will power the real-time location visualization features.

Data flow between client devices and the server will be managed via RESTful APIs, secured with encrypted transmission protocols. The backend will serve as the central processing unit, aggregating and distributing data to the web and mobile clients. Role-based access control will ensure that only authorized users (admins and registered fishermen) can interact with specific modules of the platform.

3.4 System Development Environment

To ensure the system is scalable, secure, and developer-friendly, the following technologies and tools will be used throughout the system's development lifecycle:

1. Integrated Development Environments(IDE)

- Visual Studio Code: Backend and frontend development (Node.js, React, Flutter)
- Android Studio: Mobile app testing and deployment for Flutter

2. Frontend Technologies

- React.js: Admin dashboard, responsive and interactive UI
- Flutter: Cross-platform mobile app, initially deployed for Android

3. Backend and API Technologies

- Node.js (v18+) with Express.js: RESTful API development
- MySQL 8.0: Structured data management
- Nodemon: Auto-reloading during development
- JWT: Authentication and session management

4. Mapping and APIs

- Google Maps API: Real-time location rendering and path tracking
- Geolocation Plugins: Flutter plugins for continuous GPS tracking

5. Testing and Version Control

- Postman: API testing and validation
- Git & GitHub: Source control and versioning

6. Additional Tools and Libraries

- Axios (React, Node.js): HTTP requests
- Flutter packages: geolocator, provider, http, flutter_map, etc.
- React libraries: react-router-dom, redux, chart.js, tailwindcss for UI and shad cn for component UI.

3.6 System Requirements Specification

3.6.1 Hardware Requirements

- Server-Side
 - Processor: Intel Core i5 or higher

- RAM: Minimum 8 GB
- Storage: minimum 256 GB SSD (scalable with demand)
- Client Devices
 - Smartphones: Latest Android Versions with GPS and internet support
 - Admin PCs: Core i5+, 8 GB RAM, SSD for smooth operation

3.6.2 Software Requirements

- Server Software
 - Operating System: Windows or Ubuntu
 - Database Engine: MySQL
 - Web Server: Xampp Control Panel
 - Runtime Environment: Node.js (v18 or higher)
- Client Software
 - Mobile: Flutter SDK , Android SDK, Dart
 - Admin Panel: Compatible browsers (Chrome, Firefox, Edge)
- Security
 - Encrypted transmission for GPS and emergency data
 - Role-Based Access Control (RBAC) for sensitive operations
 - database backups
- Scalability & Maintenance
 - Codebase maintenance via GitHub Issues
 - CI/CD workflows for streamlined deployments (future phase)

3.5 Conclusion

The proposed methodology will guide the development of a secure, robust, and user-oriented platform aimed at supporting Somali fishermen through innovation and connectivity. By leveraging open-source technologies and modern development

practices, the Fishermate Platform will bridge the digital divide in coastal communities, improving safety through real-time tracking and emergency response, while also expanding market access and digital economic opportunities.

CHAPTER IV: SYSTEM ANALYSIS AND DESIGN

4.1 System Analysis

System analysis serves as the foundational phase of any successful system development lifecycle. It involves examining existing problems, defining user needs, and identifying system requirements that will guide the design and implementation phases. In the context of the Fishermate Platform, this stage aims to study the technological and operational challenges encountered by Somalia's fishing community. These include a lack of access to organized marketplaces, insufficient safety mechanisms for fishermen at sea, and a general absence of digitized coordination between stakeholders.

The Fishermate system responds to these gaps with a smart, technology-driven platform that integrates mobile GPS tracking, emergency alert capabilities, digital product listings, and real-time data access for administrators. This analysis lays the groundwork for building a robust and relevant solution tailored for the Somali context.

4.2 Existing Approach

The Somali fishing industry continues to operate under informal frameworks with minimal digital transformation. Key activities like selling fish, reporting emergencies, or receiving logistical support are still performed manually or via basic mobile calls. This results in fragmented communication, lost economic potential, and high-risk operational environments.

Key Limitations of the Current Approach:

- Limited Market Access: Fishermen sell to nearby buyers only, often at suboptimal prices due to lack of broader visibility and negotiation options.
- Safety Risks: There are no GPS tracking systems or real-time alerts, leaving fishermen vulnerable during emergencies such as fuel shortages, injuries, or boat failures.

- Inefficient Coordination: There is no unified platform for fishermen, support organizations, and regulatory bodies to interact.

4.3 The Proposed System

The Fishermate Platform introduces an integrated solution composed of a cross-platform mobile app for fishermen and a web-based dashboard for administrators. The backend, developed using Node.js and MySQL, facilitates all core functions such as user management, alert processing, and transaction handling.

4.3.1 System Components:

- Fishermate Mobile App (Flutter):
 - Designed for fishermen.
 - Offers SOS emergency alerts, GPS location tracking, digital fish listings, and status updates.
- Admin Web Dashboard (React):
 - Used by government bodies and NGOs.
 - Allows monitoring of real-time activities, user analytics, alert responses, and payout management.
- Backend API & Database (Node.js + MySQL):
 - Manages role-based authentication, product management, purchase tracking, and emergency alert flow.

4.3.2 Core Features:

- Live GPS Tracking: Regular updates from the fisherman's device allow admin users to track movement and last-seen locations.
- Emergency Alert System: Fishermen can send SOS messages detailing their GPS coordinates and alert type (e.g., danger, lost).

- Digital Marketplace: Fishermen can list their daily catch for ad,customers to browse and purchase.
- User Management & Role-Based Access: Admins can oversee and manage all registered fishermen and customer accounts.
- Payout Tracking: Logs payouts and earnings per fisherman to improve financial transparency.

4.4 Requirements

4.4.1 Functional Requirements

- **Fisherman & Customer Registration:** Each user type can register and securely log in using hashed passwords.
- **Live Location Sharing:** Periodic GPS updates are sent to the backend for real-time tracking.
- **Emergency Alerts:** Fishermen can raise alerts, which are saved in the database and displayed instantly on the admin dashboard.
- **Product Listings:** Fishermen list their catch with details including name, price, quantity, and status.
- **Purchase Transactions:** Customers can purchase available products, and the system logs the transaction.
- **Admin Control Panel:** Full user, product, and alert management is provided to authorized admins.
- **Payout Management:** Admins track and register payouts made to fishermen.

4.4.2 Non-Functional Requirements

- **Performance:** Designed for low-bandwidth conditions with optimized API responses.

- **Security:** Implements hashed passwords, role-based access control, and secure API endpoints.
- **Reliability:** Ensures consistent availability through proper error handling and redundancy strategies.
- **Usability:** Interfaces are tailored for users with limited tech literacy.

4.5 Feasibility Study

4.5.1 Technical Feasibility

The Fishermate platform is technically feasible using current, open-source tools and frameworks. The mobile app is developed using Flutter, ensuring compatibility with both Android and iOS. Node.js provides a fast and scalable backend, while MySQL offers reliable relational data storage. React is used for building a dynamic and user-friendly admin panel. These tools are mature, well-documented, and actively supported, making implementation straightforward for the development team.

4.5.2 Operational Feasibility

The platform is designed to align with the operational realities of Somalia's fishing communities. The app's offline-first design and intuitive interface ensure it can be used by people with minimal digital experience. Admin dashboards give oversight to stakeholders such as NGOs and government bodies, improving transparency and coordination. With training and community outreach, operational adoption is highly likely.

4.5.3 Economic Feasibility

From an economic standpoint, the system is cost-effective due to its reliance on free, open-source technologies. Initial setup costs are minimized, and long-term operational costs are reduced through automation and reduced manual paperwork. The system enables fishermen to access broader markets, increasing their income potential and reducing financial dependency on middlemen. Additionally, it offers long-term social and economic benefits through better safety mechanisms and structured coordination.

4.6 System Design

The Fishermate platform is structured to ensure reliability, modularity, and adaptability.

4.6.1 System Architecture Overview

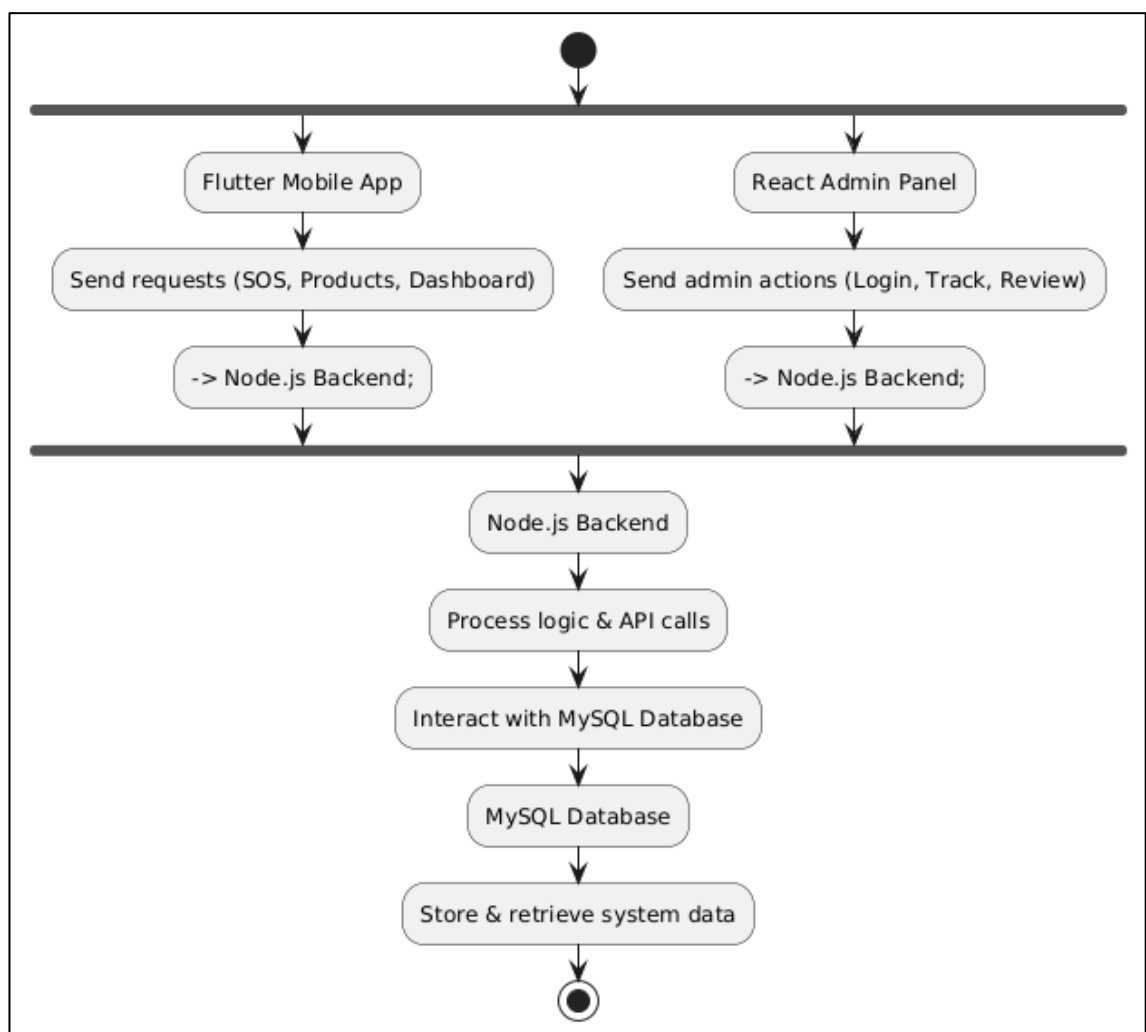


Figure 4. 1 High-Level System Architecture

Component Breakdown:

- **Flutter Mobile App:**
 - Fisher dashboard
 - SOS alert trigger
 - Product upload and history
- **Node.js Backend:**
 - RESTful APIs for data manipulation
 - Authentication and session management
 - Real-time alert and GPS data handling
- **MySQL Database:**
 - Tables for admins, fishermen, customers, products, purchases, payouts, and alerts
 - Strong referential integrity for transactional reliability
- **React Admin Panel:**
 - Admin login and control features
 - Alert management dashboard
 - Fisherman tracking and product review

4.7 Database Design

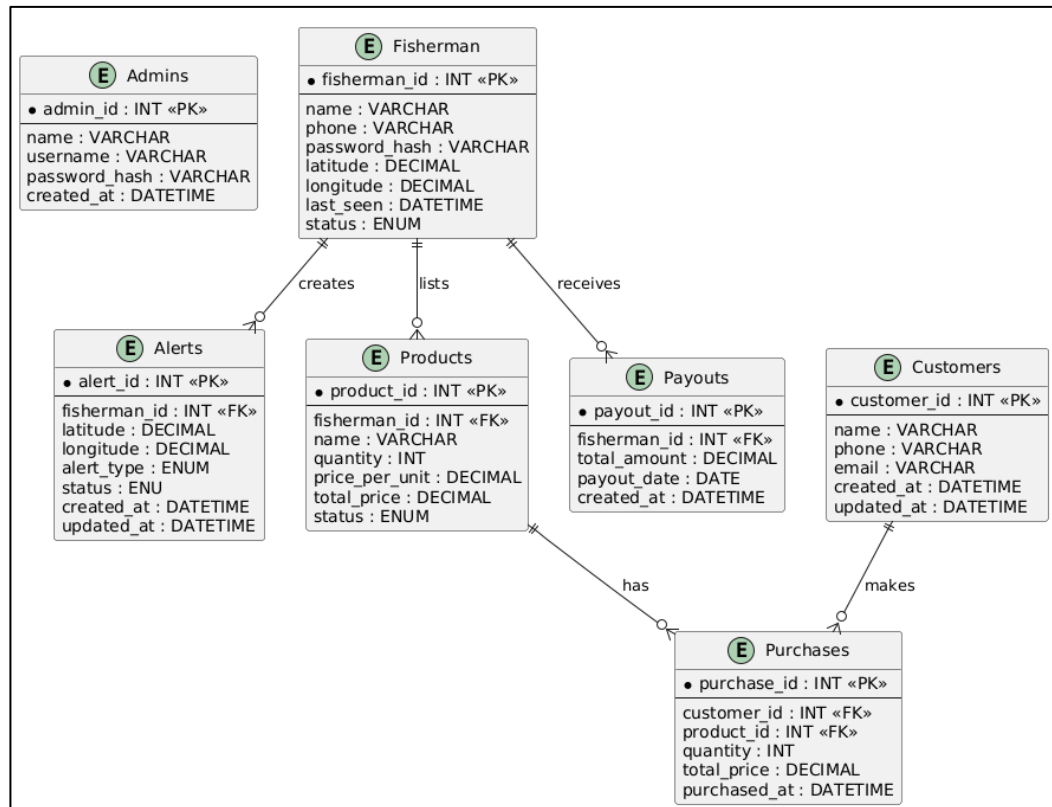


Figure 4. 2 DB Er Diagram

CHAPTER V: IMPLEMENTATION AND TESTING

5.1 Introduction

This chapter outlines the development and evaluation of the Fishermate Platform. The platform was created to empower Somali artisanal fishermen with real-time GPS tracking, emergency alerting, and a digital product logging system. The implementation focused on providing a responsive mobile experience for fishermen and a feature-rich dashboard for administrators. Testing procedures were conducted to ensure safety features, usability, and system reliability.

5.2 System Implementation Environment

The Fishermate Platform was built as a **multi-user system** comprising:

- A **mobile application** for fishermen using **Flutter** (Dart)
- A **web-based admin dashboard** built with **React** and styled using **Tailwind CSS**
- A **Node.js + Express.js** backend with **MySQL** as the database

Key integrations included:

- **Mapbox Api** for GPS tracking

The backend was deployed using RESTful APIs, ensuring secure and scalable communication between the client apps and the server. Authentication for fishermen used JWT-based sessions, while the admin dashboard used a simple login system with role-based access control.

Development tools:

- Visual Studio Code (backend/frontend)
- Android Studio (Flutter app emulation)
- Postman (API testing)

- GitHub (version control)

5.3 System Screenshots

The system features the following user interfaces, categorized into the Admin Web Dashboard and the Fisherman Mobile Application.

Admin Web Dashboard:

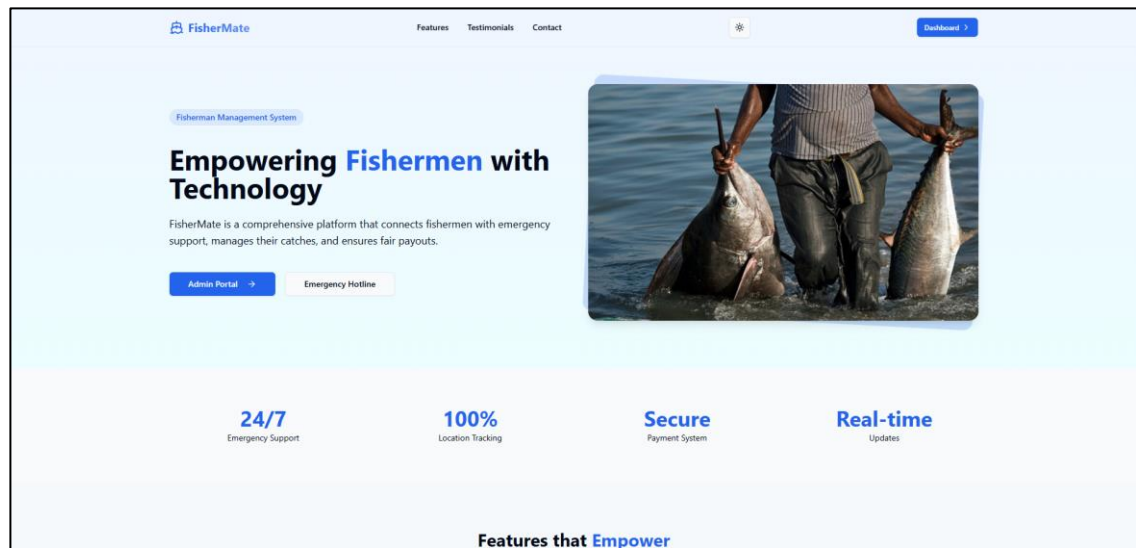


Figure 5. 1 Welcome Screen

The Welcome Screen serves as the entry point to the admin portal. It features a clean, user-friendly landing page layout with the system title and branding. The screen prominently displays a "Login to Admin Portal" button, which redirects users to the secure login interface. This screen may also include a brief system description or announcement section to provide updates to the users before login.

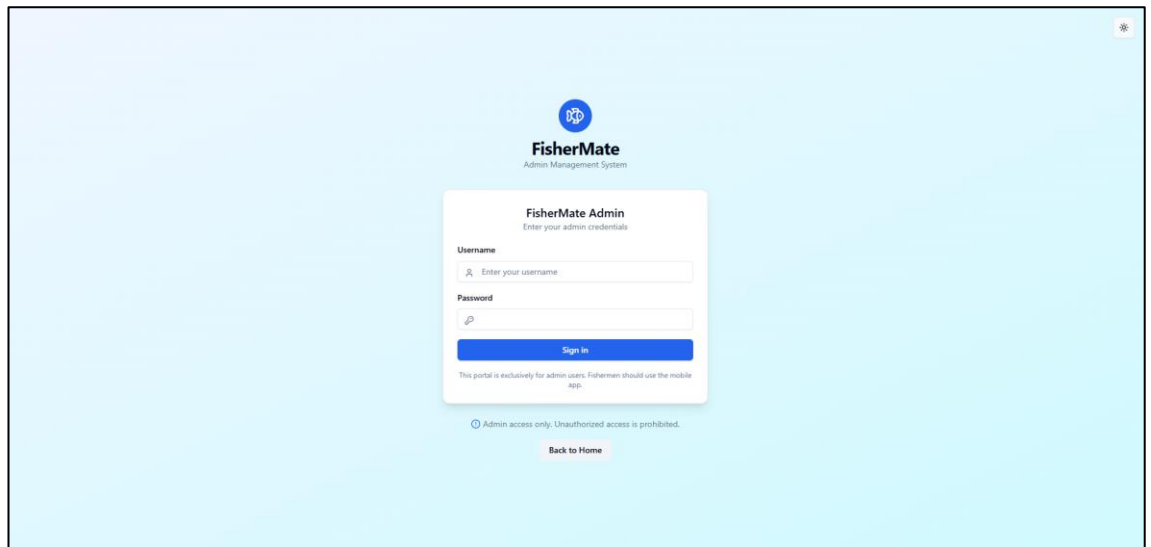


Figure 5. 2 Login Page

This screen provides secure login access exclusively for system administrators. It contains input fields for the username and password, with form validation to ensure proper credentials are entered. Additionally, the login page may include features such as "back to home?" for redirection to home screen page.

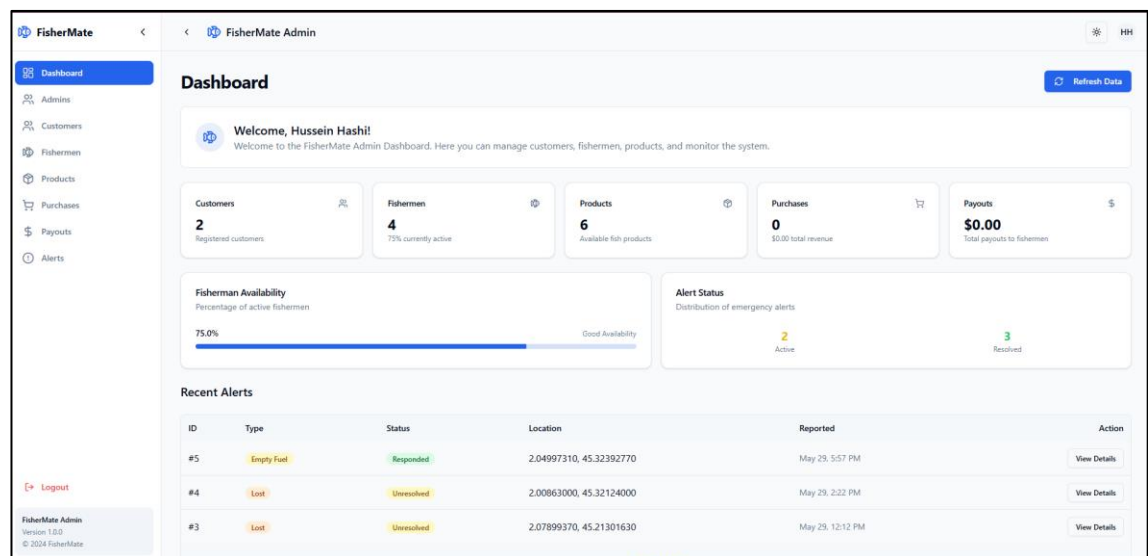


Figure 5. 3 Admin Dashboard

The Admin Dashboard is the central hub of the web application. Upon successful login, administrators are presented with a visual analytics panel summarizing key system data.

The main components include:

- **Total Customers:** Number of registered customers using the platform.
- **Total Fishermen:** Number of fishermen registered and actively using the app.
- **Total Products:** Number of products listed by fishermen.
- **Total Purchases & Revenue:** Aggregated sales metrics and financial summaries.
- **Recent Activities:** A timeline or activity feed showing alerts, product uploads, or logins.
- The dashboard supports responsive design, interactive charts, and quick-access navigation to various modules.

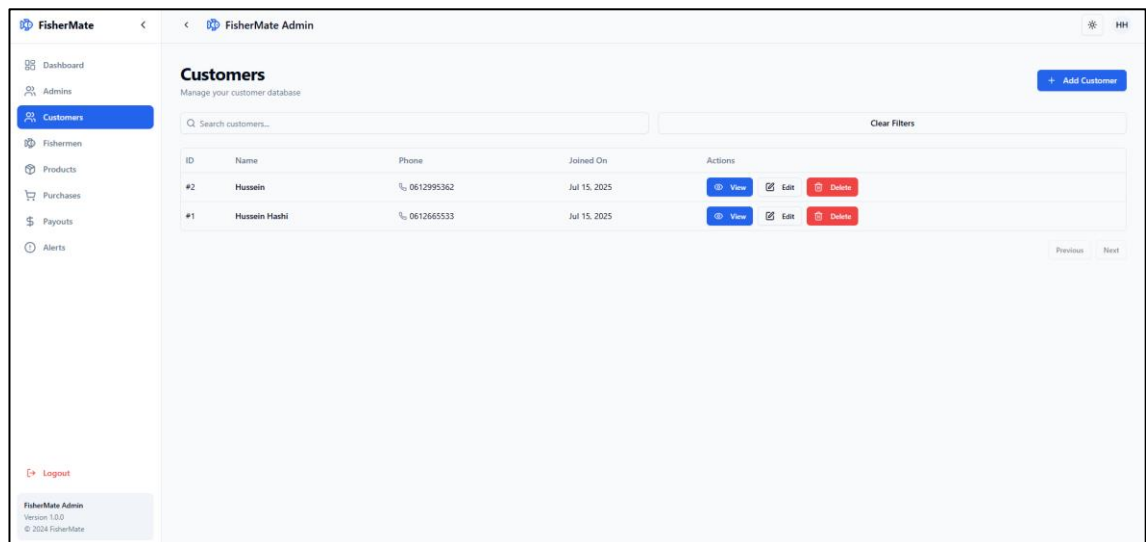


Figure 5. 4 Customers Crud screen

This screen enables full management of customer data. Admins can:

- Create new customer profiles,
- Read and view customer information,
- Update existing customer details,
- Delete inactive or fraudulent accounts.

The same CRUD interface applies to the Fisherman Management section, with similar tools to manage fisherman records. Each entry includes filters and search functions to streamline data management.

FisherMate

Dashboard

Admins

Customers

Fishermen

Products

Purchases

Payouts

Alerts

Logout

FisherMate Admin
Version 1.0.0
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FisherMate Admin

Products

Manage your product inventory

Search products...

All Statuses

All Fishermen

Clear Filters

ID	Name	Quantity	Price Per Item	Total Price	Status	Added On	Actions
#7	Malay seefa	6	\$ 12.00	\$ 72.00	Approved	May 29, 2025	<div>EditDelete</div>
#6	malaay	7	\$ 12.00	\$ 84.00	Approved	May 29, 2025	<div>EditDelete</div>
#5	malaay	12	\$ 10.00	\$ 120.00	Approved	May 28, 2025	<div>EditDelete</div>
#1	Fresh Tuna	50	\$ 12.00	\$ 600.00	Pending	May 28, 2025	<div>EditDelete</div>
#2	Red Snapper	30	\$ 21.00	\$ 630.00	Approved	May 28, 2025	<div>EditDelete</div>
#3	Yellow Tail	40	\$ 14.00	\$ 560.00	Approved	May 28, 2025	<div>EditDelete</div>

Previous

Next

Figure 5. 5 Product inventory

The Product Inventory Panel is dedicated to managing all products listed by fishermen.

Features include:

- **Product Listings:** With fish type, quantity, pricing, and availability status.
- **Sorting/Filtering Tools:** To categorize or find specific product types or suppliers.
- **CRUD Functionalities:** Admins can create, modify, or delete product records.

This interface helps ensure that only verified and approved products are visible to customers.

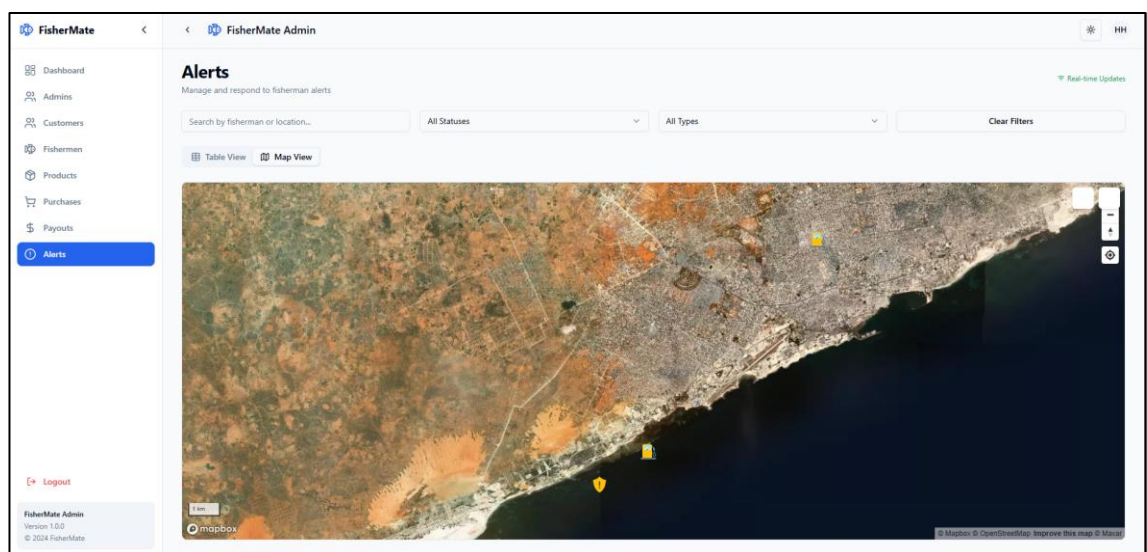


Figure 5. 6 Alerts Page

The Alert Management Screen displays all reported emergency alerts from fishermen.

Key features include:

- **Alert Table:** With columns for alert type, severity level, timestamp, and location.
- **Map View Integration:** A real-time interactive map shows current and past alert locations using geolocation data.
- **Status Tracking:** Admins can track, acknowledge, and resolve alerts to ensure safety measures are taken promptly.

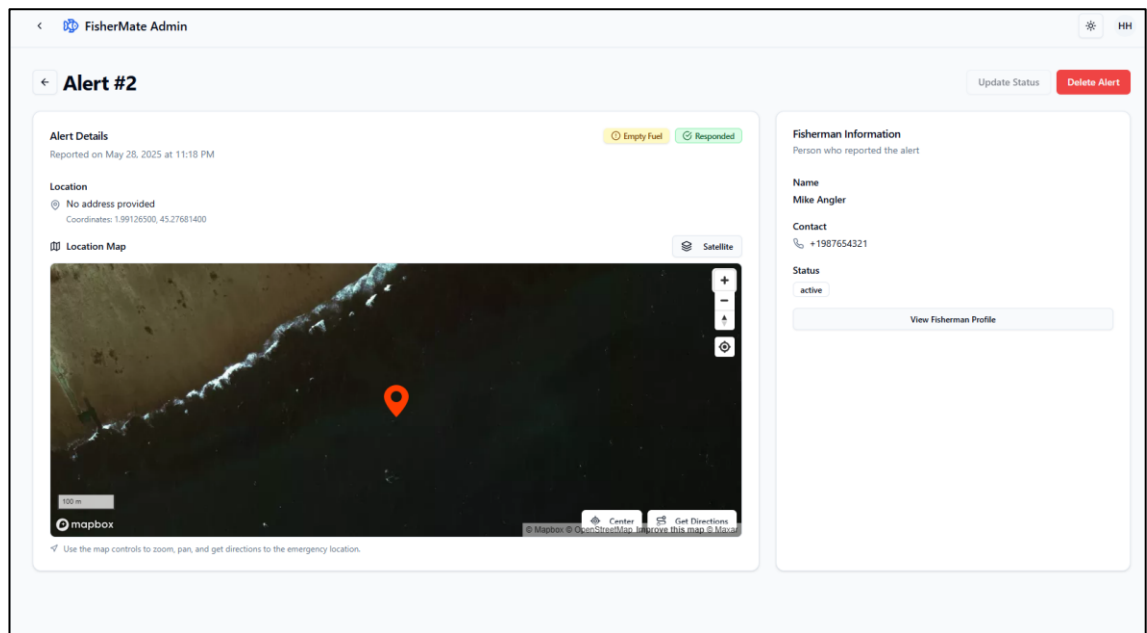


Figure 5. 7 Alert Details Screen

This screen provides a deeper look into a single emergency alert. Detailed information includes:

- **Fisherman Details:** Name, ID, contact, and location.
- **Alert Metadata:** Time of submission, type of emergency, and location coordinates.
- **Response Actions:** Buttons or tools to mark the alert as resolved, assign a responder, or contact the fisherman directly.

Fisherman Mobile App:

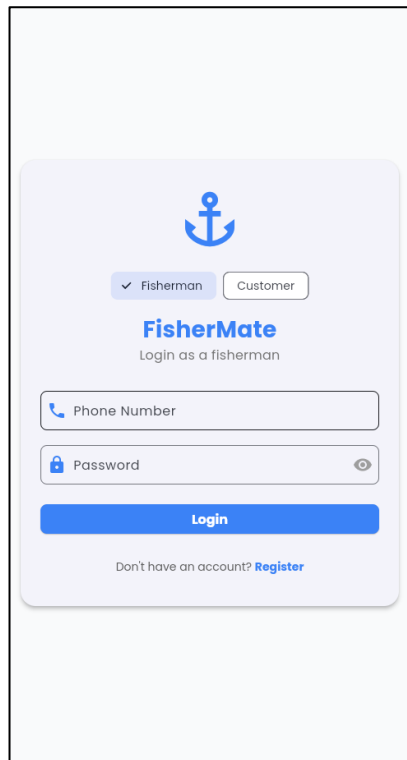


Figure 5. 8 mobile app auth

The login screen allows both customers and fishermen to access the app using their phone number and password. It includes:

- **Login Form:** Validates user credentials before granting access.
- **Register Button:** Redirects new users to a registration form.
- **Basic UI Design:** Ensures accessibility and ease of use on various mobile devices.

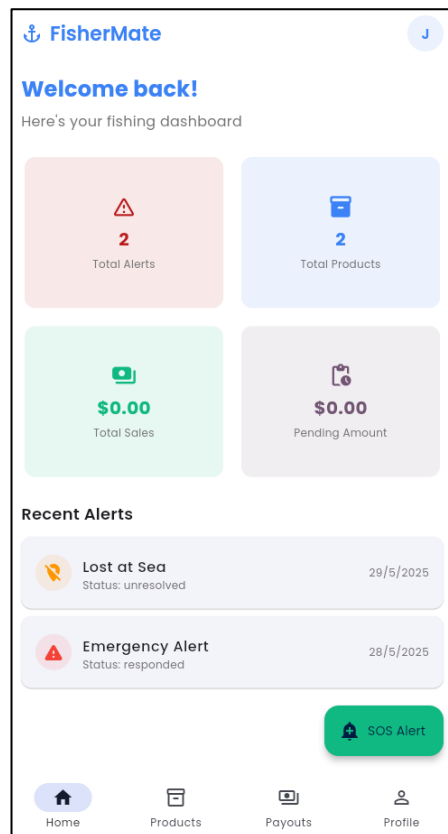


Figure 5. 9 home screen

Once logged in, the fisherman is directed to the Home Screen, which provides a summary of their activity, including:

- Total Alerts Sent
- Total Products Listed
- Total Sales Made
- Total Payouts Received
- Recent Alerts: Displayed in a scrollable feed or card format.

The home screen also features a prominent One-Click Emergency Button, which instantly sends a distress signal and real-time GPS location to the Admin Dashboard, enabling quick response.

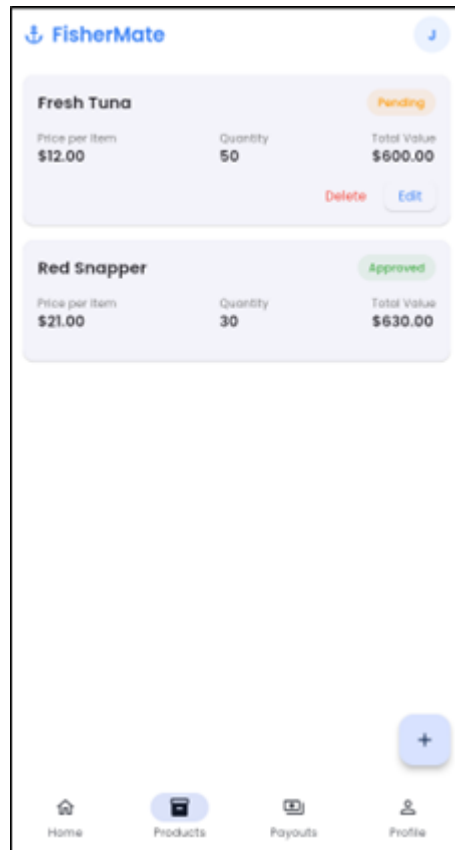


Figure 5. 10 Products Screen

The Products screen allows fishermen to manage their product listings. Key functionalities include:

- **Add New Product:** Log fish type, weight, price per unit, and other metadata.
- **View/Edit/Delete** existing products before approve.

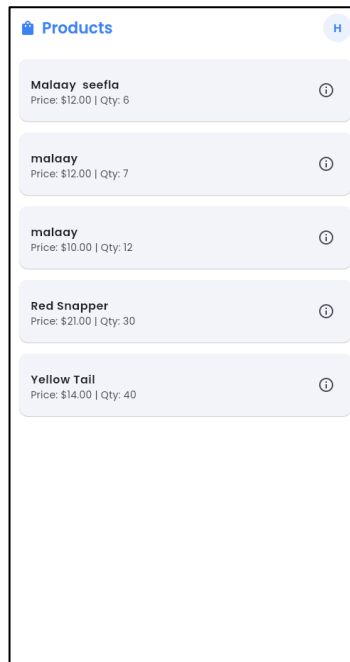


Figure 5. 11 customer products screen

This screen shows customers a catalog of all **approved products** available for viewing or purchase. Features include:

- **Product List View:** With thumbnails, price, and availability.
- **Search and Filters:** For quick navigation by product type or seller.
- The screen is designed for **quick load times and mobile optimization**, ensuring users can browse easily from their smartphones.

This section provides a comprehensive overview of the system's visual design, functional components, and user interaction points across both web and mobile platforms. Each screen has been carefully crafted to ensure a seamless experience for administrators, fishermen, and customers alike.

5.4 Testing Approach

A variety of testing methods were applied to ensure platform robustness and field-readiness.

Integration Testing

- All API endpoints were tested using Postman to validate authentication, alert logging, product submissions, and GPS tracking.
- Map markers were tested for real-time accuracy and consistency using both emulated and real GPS data.

User Acceptance Testing (UAT)

- Field tests were conducted with team mates and class students who used the app during real fishing trips.
- Emergency alert and GPS updates were monitored by test administrators via the dashboard.
- Feedback helped refine the UI for simplicity and visibility, especially in bright outdoor conditions.

Performance Testing

- Load handling was tested by simulating multiple GPS updates and alerts from concurrent users.
- Tested response times for map rendering and product uploads under 3G and unstable network conditions.
- Admin dashboard performance was monitored during large data loads and filtered searches.

CHAPTER VI: DISCUSSION & RESULTS

6.1 Discussion

The Fishermate Platform was conceptualized as a multi-purpose digital solution for artisanal fishermen, particularly those operating in Somali coastal areas. The platform integrates GPS tracking, emergency alert systems, and a digital product management interface to tackle three major issues: maritime safety, operational efficiency, and market access.

Developing the platform highlighted several contextual realities. Fishermen in Somalia often operate with limited access to communication and safety tools, making real-time tracking and alerts a vital need. By introducing a mobile application and a web-based dashboard for administrators, we were able to create a system where fishermen could report their location, send emergency alerts, and manage their catch inventory. While the app was functionally successful, it also exposed user-related limitations such as low digital literacy and inconsistent internet access, especially in remote fishing zones.

From a technological perspective, integrating GPS tracking into a mobile-first environment provided a meaningful enhancement in safety. The digital marketplace and product logging features, meanwhile, opened opportunities for increased transparency and improved pricing for small-scale fishers, although adoption varied depending on user familiarity and access to smartphones.

6.2 Key Findings

The Fishermate platform provided a structured solution for the previously fragmented and informal operations of artisanal fisheries. The GPS tracking module proved useful in visualizing vessel movement, improving both safety and coordination. Emergency alerts transmitted from the app to administrative dashboards made it easier to locate fishermen in distress and organize timely assistance.

The product logging feature allowed fishermen to record catch details digitally and track them over time. This empowered users to negotiate better prices and maintain basic stock records, reducing reliance on middlemen. Furthermore, the administrator dashboard offered valuable analytics for NGOs and cooperatives interested in monitoring activity, planning conservation efforts, or distributing resources based on actual usage trends.

6.3 Results

The system was deployed in a test setting involving team mates and some students of the university. Some of them used the mobile app to log products , trigger emergency alerts, and manage product entries. The GPS tracking worked effectively, providing consistent positional updates visible to administrators through the dashboard interface.

When testing emergency alert functionality, administrators were able to locate the simulated distress signals accurately. The digital marketplace feature was utilized by fishermen to log details about fish types, quantities, and suggested prices, enabling transparent record-keeping. Feedback from both users and stakeholders confirmed that the system simplified several core aspects of daily fishing operations and had potential to improve safety, accountability, and livelihoods.

6.4 Limitations

- The study does not address industrial-scale fisheries or deep-sea commercial operations, as its primary focus is on small-scale and community-based fishing practices.
- Large-scale fleets, export-oriented supply chains, and advanced processing facilities involve economic, environmental, and governance complexities that extend beyond the present research scope.

- While internet connectivity challenges in remote coastal regions are recognized as barriers to digital solutions, addressing such infrastructural limitations lies outside the objectives of this phase.
- The study does not fully explore policy enforcement mechanisms, long-term climate change impacts, or regional variations in fishing practices, which may affect the generalizability of findings.
- Data constraints, such as limited access to real-time monitoring systems and reliance on self-reported information from fishers, present potential sources of bias.

CHAPTER VII: CONCLUSION, RECOMMENDATION & FUTURE WORK

7.1 Introduction

This chapter provides a concluding overview of the Fishermate project and outlines key recommendations and future research directions for system enhancement and wider deployment.

7.2 Conclusion

The Fishermate Platform achieved its goal of building a user-friendly and impactful tool to support artisanal fishermen in Somalia. The combination of real-time GPS tracking, emergency alerts, and product management provided a unique, holistic solution to the operational challenges faced in the fishing sector. The project demonstrated the value of technology in improving maritime safety and empowering local economies through digital access and transparency.

Despite successes, challenges such as limited internet connectivity, low smartphone penetration, and digital illiteracy were evident. These factors will need to be addressed through community engagement, training, and hardware support initiatives if the platform is to achieve broader adoption.

7.3 Recommendations

To ensure long-term success and adoption, we recommend:

- Providing digital literacy training to fishers in collaboration with local cooperatives.
- Establishing partnerships with NGOs or governments to subsidize smartphones or GPS devices.

- Simplifying the interface further with visual and audio prompts in Somali.
- Encouraging local ownership and administration of the platform to ensure sustainability.

7.4 Future Work

Opportunities for future development include:

- Incorporating offline data collection with automatic syncing when internet access becomes available.
- Expanding the weather forecast integration with local APIs and visual alert indicators.
- Adding features tailored to female fishers and shore-based operations.
- Developing data analytics modules for policy-makers to monitor sustainability and effort trends.
- Exploring blockchain or decentralized methods to trace fish origin and enable access to international markets.

REFERENCES

- Alqurashi, F. S., Trichili, A., Saeed, N., Ooi, B. S., & Alouini, M.-S. (2022). *Maritime Communications: A Survey on Enabling Technologies, Opportunities, and Challenges* (arXiv:2204.12824). arXiv.
<https://doi.org/10.48550/arXiv.2204.12824>
- Assa, A. F., & Adirinekso, G. P. (2020). Digital Platform Utilization for Indonesian Marine Products Marketing: A Study Case on Aruna Indonesia. *Proceedings of the 6th Annual International Conference on Management Research (AICMaR 2019)*. 6th Annual International Conference on Management Research (AICMaR 2019), Jakarta, Indonesia. <https://doi.org/10.2991/aebmr.k.200331.028>
- Behivoke, F., Etienne, M.-P., Guitton, J., Randriatsara, R. M., Ranaivoson, E., & Léopold, M. (2021). Estimating fishing effort in small-scale fisheries using GPS tracking data and random forests. *Ecological Indicators*, 123, 107321.
<https://doi.org/10.1016/j.ecolind.2020.107321>
- Bevitt, K., & Tilley, A. (2024). *Implementing small-scale fisheries digital monitoring systems: Country challenges and solutions*.
- Bolognini, L., Frittelloni, C., Perretta, F., Scanu, M., & Grati, F. (2023). From Crisis to Opportunity: Developing a Virtual Marketplace to Enhance Sustainability and Resilience in Small-Scale Fisheries. *Fishes*, 8(5), 272.
<https://doi.org/10.3390/fishes8050272>
- Calderwood, J. (2022). Smartphone application use in commercial wild capture fisheries. *Reviews in Fish Biology and Fisheries*, 32(4), 1063–1083.
<https://doi.org/10.1007/s11160-022-09727-6>
- Diouf, N. S., Ouedraogo, I., Zougmore, R. B., & Niang, M. (2020). Fishers' Perceptions and Attitudes toward Weather and Climate Information Services for Climate

- Change Adaptation in Senegal. *Sustainability*, 12(22), 9465.
<https://doi.org/10.3390/su12229465>
- Ergo, R. (2020, October 16). *Keeping Somali Fishermen Safe – New GPS Devices for Boats in Bosaso*. Radio Ergo. <https://radioergo.org/en/2018/10/keeping-somali-fishermen-safe-new-gps-devices-for-boats-in-bosaso/>
- Farquhar, S., Nirindrainy, A. F., Heck, N., Saldarriaga, M. G., & Xu, Y. (2022). The impacts of long-term changes in weather on small-scale fishers' available fishing hours in Nosy Barren, Madagascar. *Frontiers in Marine Science*, 9, 841048.
<https://doi.org/10.3389/fmars.2022.841048>
- Herrero-Martínez, Á., Gutiérrez, M. A., Ortega-Piris, A., Diaz-Ruiz-Navamuel, E., Martín-Parra, A., & Lopez-Diaz, A.-I. (2023). Positioning System for Fishing Fleets' Tracking and Assistance. *Fishes*, 8(8), 389.
<https://doi.org/10.3390/fishes8080389>
- Jueseah, A. S., Kristofersson, D. M., Tómasson, T., & Knutsson, O. (2020). A Bio-Economic Analysis of the Liberian Coastal Fisheries. *Sustainability*, 12(23), 9848. <https://doi.org/10.3390/su12239848>
- Kadhafi, M. (2024). Maritime Safety in the Digital Era as the Role of Weather Monitoring and Prediction Technology. *Maritime Park Journal of Maritime Technology and Society*, 28–33. <https://doi.org/10.62012/mp.v3i2.35388>
- Mohamed Shaffril, H. A., Eric Krauss, S., Hamzah, A., & Abu Samah, B. (2021). Behavioral Correlates of GPS Device Usage Among Small-Scale Fishers in Malaysia. *Sage Open*, 11(1), 21582440211000051.
<https://doi.org/10.1177/21582440211000051>
- Natsir, M., Ruchimat, T., Agustina, S., & Yulianto, I. (2019). Application of Global Positioning System Tracker to Detect the Fishing Ground Location. *Sensors and Materials*, 31(3).

- Okeke-Ogbuafor, N., Taylor, A., Dougill, A., Stead, S., & Gray, T. (2022). Alleviating impacts of climate change on fishing communities using weather information to improve fishers' resilience. *Frontiers in Environmental Science*, 10, 951245. <https://doi.org/10.3389/fenvs.2022.951245>
- Rashid, A. (2021). *CHALLENGES AND OPPORTUNITIES FOR SMALL SCALE FISHERIES IN TRADE*.
- Rowan, N. J. (2023). The role of digital technologies in supporting and improving fishery and aquaculture across the supply chain – Quo Vadis? *Aquaculture and Fisheries*, 8(4), 365–374. <https://doi.org/10.1016/j.aaf.2022.06.003>
- Sampantamit, T., Ho, L., Lachat, C., Hanley-Cook, G., & Goethals, P. (2021). *The Contribution of Thai Fisheries to Sustainable Seafood Consumption: National Trends and Future Projections*.
- Smidt, H. J., & Jokonya, O. (2022). Factors affecting digital technology adoption by small-scale farmers in agriculture value chains (AVCs) in South Africa. *Information Technology for Development*, 28(3), 558–584. <https://doi.org/10.1080/02681102.2021.1975256>
- Sühring, N., Chambers, C., Koenigk, T., Kruschke, T., Einarsson, N., & Ogilvie, A. E. J. (2023). Effects of storms on fisheries and aquaculture: An Icelandic case study on climate change adaptation. *Arctic, Antarctic, and Alpine Research*, 55(1), 2269689. <https://doi.org/10.1080/15230430.2023.2269689>
- Tassetti, A. N., Galdelli, A., Pulcinella, J., Mancini, A., & Bolognini, L. (2022). Addressing Gaps in Small-Scale Fisheries: A Low-Cost Tracking System. *Sensors*, 22(3), 839. <https://doi.org/10.3390/s22030839>
- Tilley, A., Dos Reis Lopes, J., & Wilkinson, S. P. (2020). PeskAAS: A near-real-time, open-source monitoring and analytics system for small-scale fisheries. *PLOS ONE*, 15(11), e0234760. <https://doi.org/10.1371/journal.pone.0234760>

APPENDIX A: BACKEND AUTHENTICATION CONTROLLER

```
import jwt from "jsonwebtoken";

import { JWT_SECRET } from "../config/env.js";

import { Admin, Fisherman, Customer } from "../models/index.js";

import bcrypt from "bcrypt";

// Generate JWT token

const generateToken = (payload) => {

  return jwt.sign(payload, JWT_SECRET, { expiresIn: "30d" });

};

// Admin Authentication

export const adminLogin = async (req, res) => {

  try {

    const { username, password } = req.validatedData;

    const admin = await Admin.findOne({ where: { username } });

    if (!admin) {

      return res.status(401).json({

        success: false,
```

```

        message: "Invalid credentials",

    });

}

const isPasswordValid = await admin.checkPassword(password);

if (!isPasswordValid) {

    return res.status(401).json({

        success: false,

        message: "Invalid credentials",

    });

}

const token = generateToken({

    id: admin.id,

    username: admin.username,

    type: "admin",

});

res.json({

    success: true,

```

```

        message: "Login successful",

        data: {

            token,

            admin: {

                id: admin.id,

                name: admin.name,

                username: admin.username,

            },

        },

    });

} catch (error) {

    console.error("Admin login error:", error);

    res.status(500).json({

        success: false,

        message: "Error during login",

    });

}

};

// Fisherman Authentication

```

```

export const fishermanRegister = async (req, res) => {

  try {

    const fishermanData = req.validatedData;

    // Check if phone number already exists

    const existingFisherman = await Fisherman.findOne({

      where: { phone: fishermanData.phone },

    });

    if (existingFisherman) {

      return res.status(400).json({

        success: false,

        message: "Phone number already registered",

      });

    }

    const fisherman = await Fisherman.create(fishermanData);

    const token = generateToken({

      id: fisherman.id,

```

```

        phone: fisherman.phone,

        type: "fisherman",

    });

res.status(201).json({

    success: true,

    message: "Registration successful",

    data: {

        token,

        fisherman: {

            id: fisherman.id,

            name: fisherman.name,

            phone: fisherman.phone,

            status: fisherman.status,

        },

    },

});

} catch (error) {

    console.error("Fisherman registration error:", error);

    res.status(500).json({

```

```

    success: false,

    message: "Error during registration",

  });

}

};

export const fishermanLogin = async (req, res) => {

  try {

    const { phone, password } = req.validatedData;

    const fisherman = await Fisherman.findOne({ where: { phone } });

    if (!fisherman) {

      return res.status(401).json({

        success: false,

        message: "Invalid credentials",

      });

    }

    const isPasswordValid = await fisherman.checkPassword(password);

    if (!isPasswordValid) {

```



```
return res.status(401).json({

  success: false,

  message: "Invalid credentials",

});

}

// Update last seen

await fisherman.update({ lastSeen: new Date() });

const token = generateToken({

  id: fisherman.id,

  phone: fisherman.phone,

  type: "fisherman",

});

res.json({

  success: true,

  message: "Login successful",

  data: {

    token,
```

```

    fisherman: {

      id: fisherman.id,

      name: fisherman.name,

      phone: fisherman.phone,

      status: fisherman.status,

      latitude: fisherman.latitude,

      longitude: fisherman.longitude,

    },

  },

});

} catch (error) {

  console.error("Fisherman login error:", error);

  res.status(500).json({

    success: false,

    message: "Error during login",

  });

}

};

// Update fisherman profile

export const updateProfile = async (req, res) => {

```

```

try {

  const fishermanId = req.fisherman.id;

  const updateData = req.validatedData;


  const fisherman = await Fisherman.findByPk(fishermanId);

  if (!fisherman) {

    return res.status(404).json({

      success: false,

      message: "Fisherman not found",

    });

  }


  // If phone is being updated, check for uniqueness

  if (updateData.phone && updateData.phone !== fisherman.phone) {

    const existingFisherman = await Fisherman.findOne({

      where: { phone: updateData.phone },

    });


    if (existingFisherman) {

      return res.status(400).json({

```

```

        success: false,

        message: "Phone number already registered",

    });

}

}

await fisherman.update(updateData);

res.json({

    success: true,

    message: "Profile updated successfully",

    data: {

        id: fisherman.id,

        name: fisherman.name,

        phone: fisherman.phone,

        status: fisherman.status,

        latitude: fisherman.latitude,

        longitude: fisherman.longitude,

    },

});

```

```

    } catch (error) {

      console.error("Update profile error:", error);

      res.status(500).json({

        success: false,

        message: "Error updating profile",

      });

    }

  };

// Customer Registration

export const customerRegister = async (req, res) => {

  try {

    const customerData = req.validatedData;

    // Check if phone number already exists

    const existingCustomer = await Customer.findOne({

      where: { phone: customerData.phone },

    });

    if (existingCustomer) {

      return res.status(400).json({

```

```
    success: false,

    message: "Phone number already registered",

  });

}

const customer = await Customer.create(customerData);

const token = generateToken({

  id: customer.id,

  phone: customer.phone,

  type: "customer",

});

res.status(201).json({

  success: true,

  message: "Registration successful",

  data: {

    token,

    customer: {

      id: customer.id,
```

```

        name: customer.name,

        phone: customer.phone,

    },

    },

});

} catch (error) {

    console.error("Customer registration error:", error);

    res.status(500).json({

        success: false,

        message: "Error during registration",

    });

}

};

```

// Customer Login

```

export const customerLogin = async (req, res) => {

    try {

        const { phone, password } = req.validatedData;

        const customer = await Customer.findOne({ where: { phone } });
    }

```

```
if (!customer) {

  return res.status(401).json({

    success: false,

    message: "Invalid credentials",

  });

}

const isPasswordValid = await customer.checkPassword(password);

if (!isPasswordValid) {

  return res.status(401).json({

    success: false,

    message: "Invalid credentials",

  });

}

const token = generateToken({

  id: customer.id,

  phone: customer.phone,

  type: "customer",

});
```



```
res.json({

  success: true,

  message: "Login successful",

  data: {

    token,

    customer: {

      id: customer.id,

      name: customer.name,

      phone: customer.phone,

    },

  },

});

} catch (error) {

  console.error("Customer login error:", error);

  res.status(500).json({

    success: false,

    message: "Error during login",

  });

}
```