

Fish Catch Survey and Analysis: A Tool to Collect and Estimate the Landings of Marine Resources from Artisanal Fisheries in Indian Waters

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Abstract

Artisanal fisheries contribute significantly to marine fish production in India, particularly for species such as tuna and tuna-like resources. Accurate and timely data on landings from this sector are essential for assessing trends, monitoring species distribution, and supporting sustainable management. The *Fish Catch Survey and Analysis* (FCSA) system, developed by the Central Marine Fisheries Research Institute (CMFRI), is a digital tool introduced in 2018 to modernize and streamline marine fishery data collection. Replacing the conventional paper-based approach, FCSA significantly improved efficiency, cost-effectiveness, data accuracy, and processing speed. Field staff (harbour-based observers) receive pre-configured monthly work schedules via a central server and record data using tablets in structured formats. The system allows offline data collection in remote coastal areas with poor connectivity, enabling later synchronization with the server when networks are restored. This has expanded the spatial coverage and reliability of data collection. FCSA marks a transformative shift in fisheries data management by enhancing resolution, reducing errors, and enabling near real-time analytics for marine fishery resource estimation.

Keywords: Artisanal fisheries, FCSA, marine fish landings, digital data collection, climate change, passive geo-referencing.

1. Introduction

The Indian marine fisheries sector sustains the livelihoods of millions, blending subsistence-level operations with commercial and industrial-scale ventures that exploit the shared resources of the country's territorial waters and Exclusive Economic Zone (EEZ). The sector's diversity, spanning operators, gears, and fishing practices, has necessitated structured mechanisms for vessel registration, licensing, and the enforcement of management regulations. These include seasonal fishing bans, protected areas, and bio-reserves, aimed at safeguarding spawning populations and conserving critical resources. Such measures are built upon decades of informed governance, recognizing that reliable data on catches and fishing effort is fundamental for sustainable management. Tropical fisheries, however, present unique challenges due to their multi-species nature and the use of diverse, often non-

selective gears, which harvest a variety of species in a single haul (CMFRI-Kochi and IGO-BOBP, 2017). This makes the systematic collection of validated spatial, temporal, and fishery-level data indispensable. India, in fact, has been a pioneer in this domain, establishing a strong foundation for scientific data assimilation since the early 1950s.

India's marine fisheries span a vast ecological gradient, from near-temperate northern waters to the tropical southern tip. The country has 9 maritime states, 2 Union Territories, and 2 island groups, encompassing a coastline of 11,098 km, an EEZ of 2.305 million km², and a continental shelf of 0.5 million km². About 3,900 fishing villages are home to nearly 4 million fishers across 1.2 million households. Fishing operations are facilitated by 1,537 landing centres (Figure 1) including around 50 major fishing harbours. The estimated potential yield of conventional resources stands at 5.31 million tonnes (Estimated in 2018). The fishery sector operates with over 30 different boat–gear combinations (fleets). Among them, liners and nearly 45% of trawlers are engaged in multi-day fishing, averaging 40–60 trips of varying durations annually. The remaining mechanized vessels typically perform about 240 single-day trips each year. Motorized and non-mechanized crafts undertake even higher activity levels, completing up to 300 single-day trips annually. Altogether, fishing vessels collectively account for nearly 5 million trips in a year.

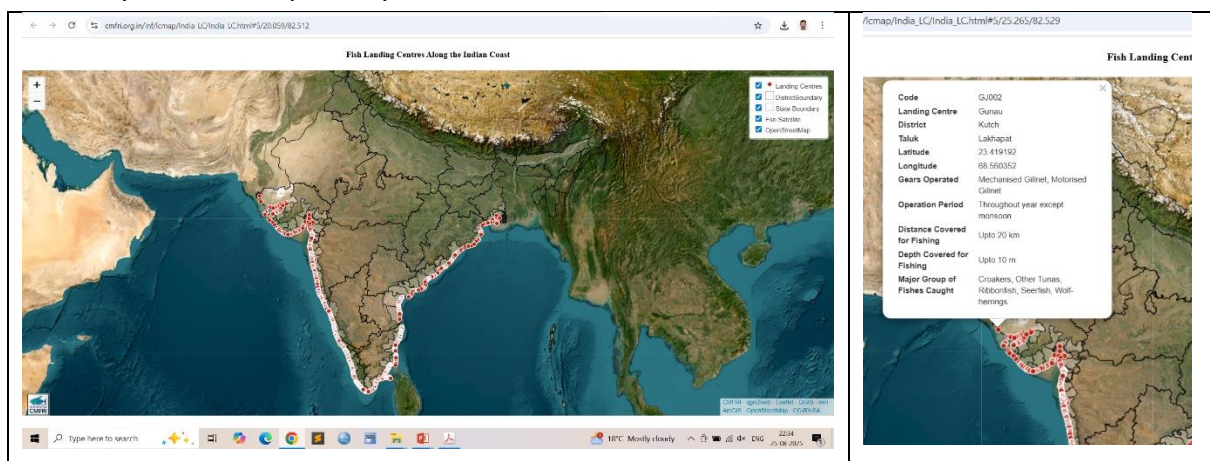


Fig. 1 Fishing Landing Centres along the Indian Mainland Coastline (Available at ICAR – CMFRI website)

Given the scale, heterogeneity, and species richness of Indian fisheries, comprehensive catch monitoring through logbooks or mandatory reporting is logistically challenging, particularly in multi-day operations. The most reliable approach in such tropical, multi-species contexts is scientific data collection through statistically sound stratified sampling frameworks, executed by trained enumerators. This method ensures unbiased, consistent, and validated data that bridge the gap between commercial exploitation and biomass assessment, thereby forming the cornerstone of sustainable fisheries management in India.

The continually evolving diachronic approach holds particular importance, given the remarkable diversity of fisheries along the Indian coast. This is evident from the large number of species recorded in the exploited taxa in recent years (FRAEED-CMFRI, 2025) (Figure 2).

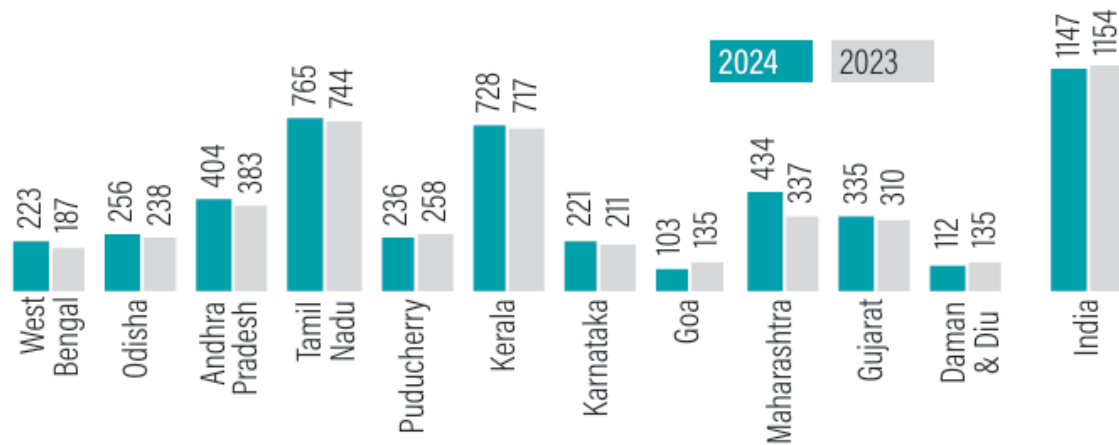


Fig. 2 Species distribution in landings along the maritime states (Adapted from FRAEED-CMFRI, 2025)

2. Methodology for marine fishery data collection and estimation

India has established a comprehensive system for collecting and estimating marine fishery data, which provides monthly information on species-wise landings and gear-wise fishing effort across different maritime states. This framework relies on trained field observers stationed at landing centres and has been in operation since the 1960s. The methodology, originally developed by ICAR–Central Marine Fisheries Research Institute (CMFRI) in collaboration with ICAR–Indian Agricultural Statistics Research Institute (IASRI), is based on the Stratified Multistage Random Sampling Design (SMRSD) (Sukhatme et al., 1958; Srinath et al., 2005). In this design, stratification is carried out across both spatial and temporal dimensions. The sampling frame, constructed from details on fishing villages, landing centres, crafts, gears, and related attributes, is regularly updated through nationwide frame surveys to reflect sectoral changes (CMFRI-FSI-DoF, 2020). Information collected includes species-specific catches, fishing effort, and craft and gear characteristics. The robustness and adaptability of this system have been acknowledged internationally, including recognition by FAO.

The population under assessment is two-dimensional, defined by zone and month. Zones are spatially continuous sub-regions, comparable to districts within Indian states, while months represent temporal strata. Key parameters such as total catch, fishing effort, and catch per unit effort (CPUE) for each zone–month population are estimated through a two-stage sampling procedure. The first stage involves stratification of time intervals within a month, while the second stage selects individual fishing units after a landing centre or harbour is chosen on a particular day, termed a landing centre day (lcd).

For spatial stratification, each maritime state is divided into distinct, non-overlapping fishing zones based on fishing intensity, geography, and the number of landing centres. These zones are further subdivided into substrata depending on local fishing activity. Consequently, the number of landing centres sampled may differ between zones (Figure 3).

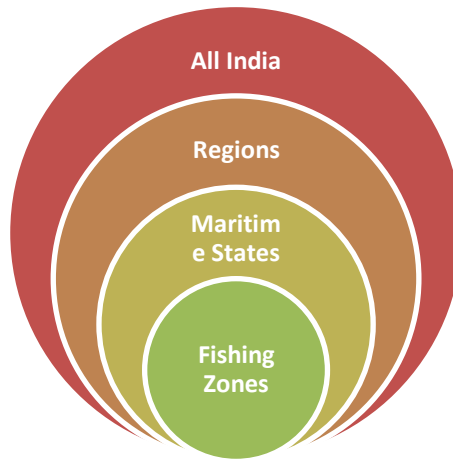


Fig.3 Spatial stratification

Fish landing centres are categorized based on the scale of fishing activity: High-Intensity Centres (with 300 or more operating vessels), Major Centres (100–299 vessels), and Minor Centres (fewer than 100 vessels). Sampling intensity is proportionally distributed, with the highest coverage in High-Intensity Centres, followed by Major Centres, and the least in Minor Centres. Large fisheries harbours and major landing hubs are treated as single-centre zones, where exclusive and detailed sampling is carried out to capture their significant contribution to landings.

Temporal stratification (Figure 4) follows a practical rather than a purely statistical approach. Sampling days, referred to as landing centre days, are systematically spread across the month to ensure representative coverage of fishing activity. This design enables the method to capture cyclical or short-term fluctuations in resource availability within the month, thereby strengthening the reliability of estimates.



Fig.4 Temporal stratification

To illustrate the sampling procedure more clearly, consider a zone with 10 landing centres. Over a 30-day month, this gives rise to 300 landing centre days (10 centres × 30 days). The month is divided into three 10-day blocks. From the first block, a day is randomly selected, followed by the next five consecutive days, which together form clusters of two consecutive days. In the remaining blocks, clusters are chosen systematically at an interval of 10 days. Typically, this yields nine two-day clusters per month. Out of the 10 landing centres in the zone, nine are drawn with replacement and assigned to these cluster days, resulting in nine landing centre days of observation each month. During a landing centre day, data are collected as shown in Table 1.

Table 1. Data collection protocol for a landing centre day

Time Period (24 hrs)	Method
1200–1800 hrs (Day 1)	Direct observation
0600–1200 hrs (Day 2)	Direct observation
1800 hrs (Day 1) – 0600 hrs (Day 2, night landings)	Enquiry on Day 2

When the number of vessels landing during an observation period is large, recording every boat's catch becomes impractical. To address this, random starts with systematic sub-sampling are employed (Alagaraja, 1984). Table 2 presents the approach.

Table 2. Sub-sampling of boats/crafts based on landings

Number of boats/crafts landed	Fraction to be observed
≤ 15	100 %
16 - 19	First 10 and 50% of the remainder
20 - 29	1 in 2
30 - 39	1 in 3, and so on

For single-centre zones, 16–18 days are randomly chosen in a month, and all vessels landing during these days (whether clustered or single) are enumerated.

Data collection is carried out by trained field technicians (harbour-based observers) who visit designated landing centres as per SMRSD schedules. Equipped with taxonomic identification skills, these observers record detailed catch and effort data from sampled vessels. To strengthen their expertise, regular taxonomic training is provided with support from ICAR-CMFRI scientists across resource divisions.

Using these observations, estimates of catch and effort are generated for each fleet on a landing centre day. These are then scaled up to obtain monthly zonal totals. Further

aggregation provides estimates at district, state, and national levels on monthly, quarterly, and annual timeframes. The full estimation methodology is detailed in Srinath et al. (2005).

3. Fish Catch Survey and Analysis (FCSA) Software

Marine fishery data collection in India initially relied on paper-based forms, a process that was both time-consuming and error-prone. Large volumes of paper had to be transported from landing centres to centralized processing units, adding significant logistical costs. In the early years, estimates of landings were compiled manually. Computer-based analysis formally began in 1989, and soon the data processing package was ported to Windows, keeping pace with advances in information technology (Srinath et al., 2005; Srinath and Jayasankar, 2007). Despite these advances, manual acquisition at landing centres still caused at least a three-month delay in generating estimates.

Advancements in information and communication technology opened new possibilities for streamlining fisheries research and data management. To overcome the limitations of manual methods, ICAR–CMFRI developed the web-based application Fish Catch Survey and Analysis (FCSA) (Figure 5), supported by necessary hardware and networking infrastructure. This system was designed to (i) collect and transmit real-time marine fishery data based on the Stratified Multi-Stage Random Sampling Design (SMRSD), suitable for India's complex fisheries, and (ii) enable dynamic monitoring of landings at fast time scales by significantly improving the speed of data acquisition, processing, and analysis across the Indian coast.

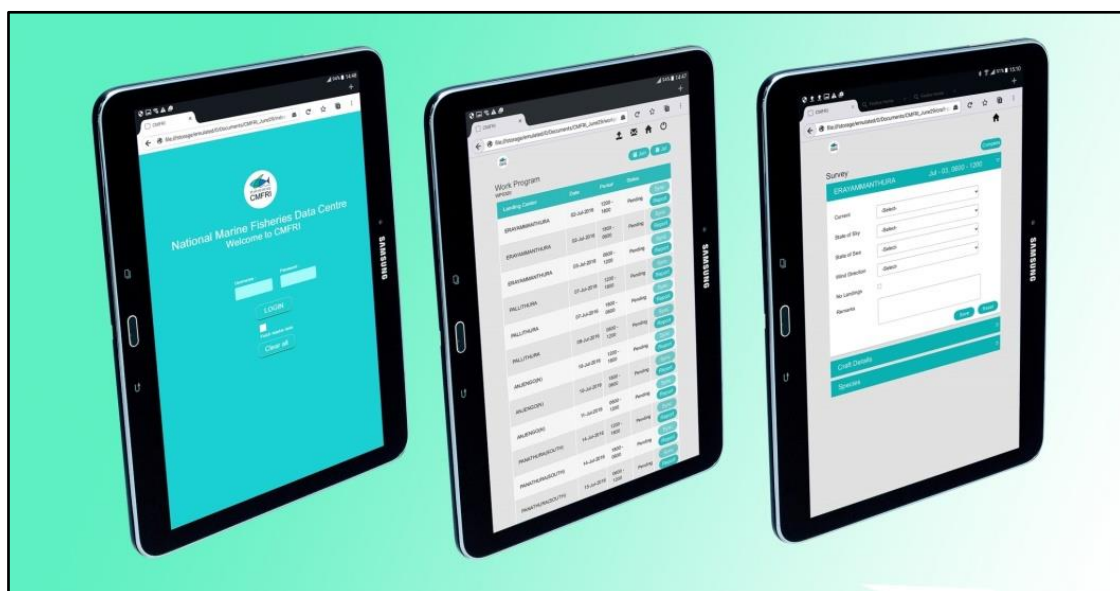


Fig. 5 Fish Catch Survey & Analysis (FCSA) Software

The FCSA Mobile App (FCSA Version 2.0) (Figure 6), developed as part of the upgradation of FCSA, is an Android-based application that can be used on smartphones or tablets. Each

survey staff member can operate the app on only one device at a time, and if they wish to use it on another device, such as a personal mobile, activation can be facilitated accordingly.

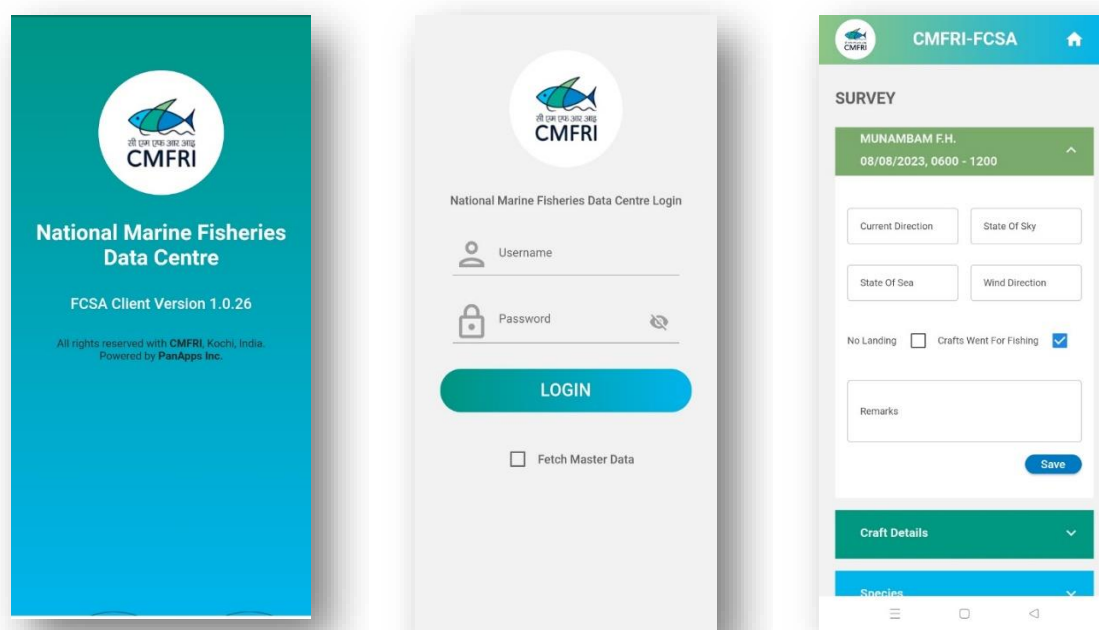


Fig. 6 FCSA version 2.0: FCSA Mobile App

In the FCSA mobile application, users are required to utilize the “Fetch Master Data” option only when collecting or updating a new Work Programme. A stable internet connection is required at this stage to fetch and synchronize data with the central server. Once the master data has been retrieved, subsequent survey operations and data entry can be performed offline, ensuring uninterrupted functionality even in areas with poor or no network connectivity.

Upon successful login, the application displays the main screen with access to the “WORK PROGRAM” button, which provides the list of available Work Programmes. By default, the Work Programme for the current month is displayed. In cases where the Work Programme has not yet been approved, the page will appear blank with the message “Work Programme not available” (Figure 7).

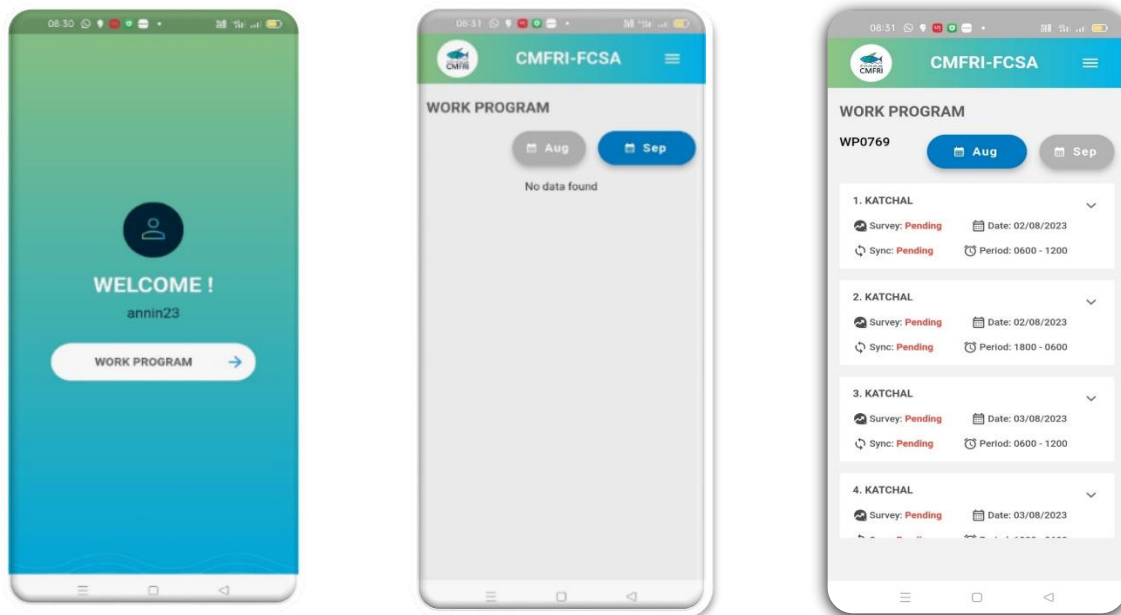


Fig. 7 Work Programme Listing

The FCSA application enables survey staff to send messages directly to the Head of Division (HOD) or Data Analyst (Figure 8). If internet connectivity is available, the message is transmitted immediately. In the absence of connectivity, the message is stored locally on the device and automatically forwarded once the device is reconnected to the internet.

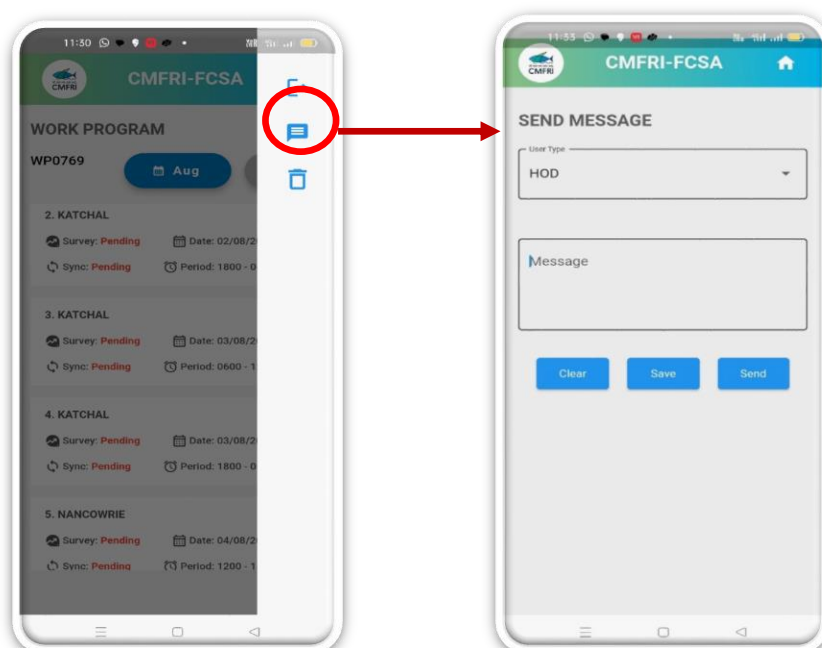


Fig. 8 Sending messages

To begin the survey, the “IN” button must be tapped. This action automatically records the attendance of the field observer along with the time and location. The survey can only be initiated when the field observer is present at the landing centre. A warning message is displayed if the survey is initiated outside the designated area. This occurs in two cases: when the application fails to retrieve the survey location, or when the field observer is not physically present at the landing centre (Figure 9).

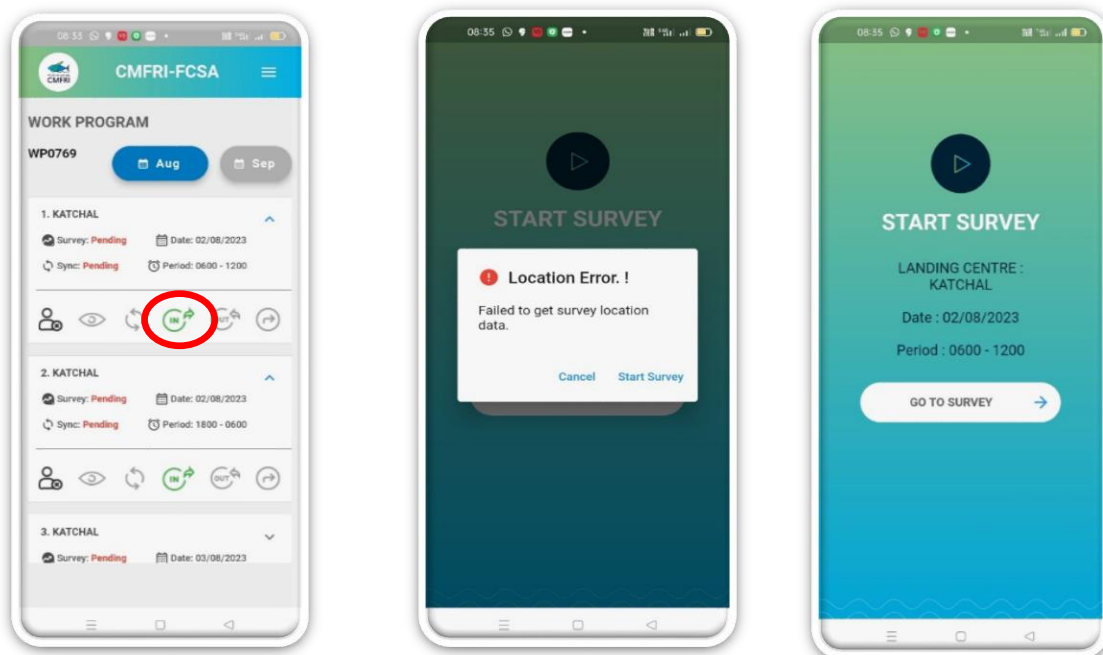


Fig. 9 Starting the survey

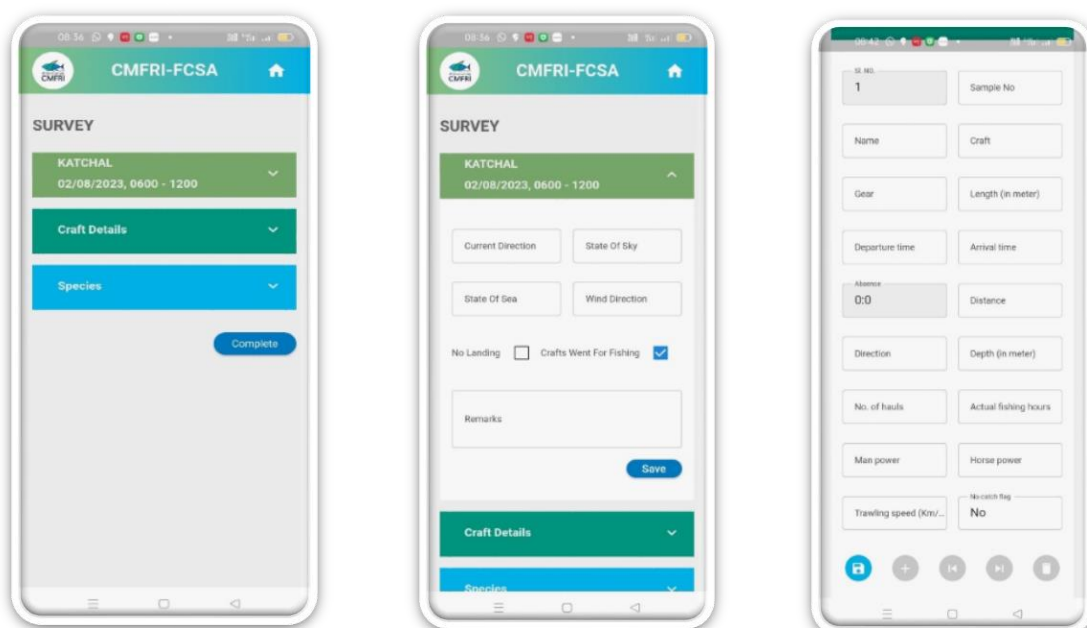


Fig. 10 Survey data entry

Upon selecting the “Go to Survey” button (Figure 10), the survey interface opens. The screen is divided into three key sections for structured data entry:

1. Header Section – Displays information on the landing centre, survey date, and survey period.
2. Craft Details Section – Used for recording the particulars of fishing crafts observed during the landing.
3. Species Details Section – Used for entering species-wise catch information.

A Home button is provided on the top right corner of the screen to navigate back to the Work Programme Listing page.

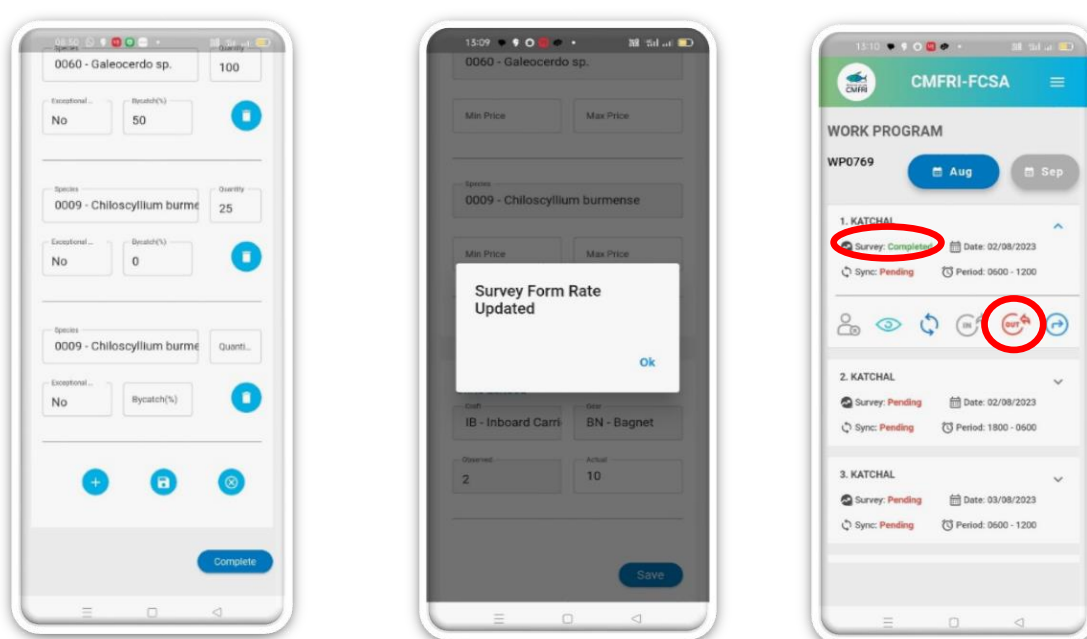


Fig. 11 Completion of survey

In cases where no landing occurs, the header part may be saved with remarks, upon which the work programme page will display the status as Completed. Attendance can then be recorded by selecting the OUT option. When landings are reported, the COMPLETE button should be used after entering details of crafts and species to finalize data entry for that session (Figure 11). Following the entry of minimum and maximum prices and the quantity of units landed, the work programme page will be displayed, from which attendance may again be marked using the OUT option. At the end of any session, irrespective of the extent of data entered, it is also possible to exit by selecting the home button at the top of the screen and marking attendance through the OUT option.

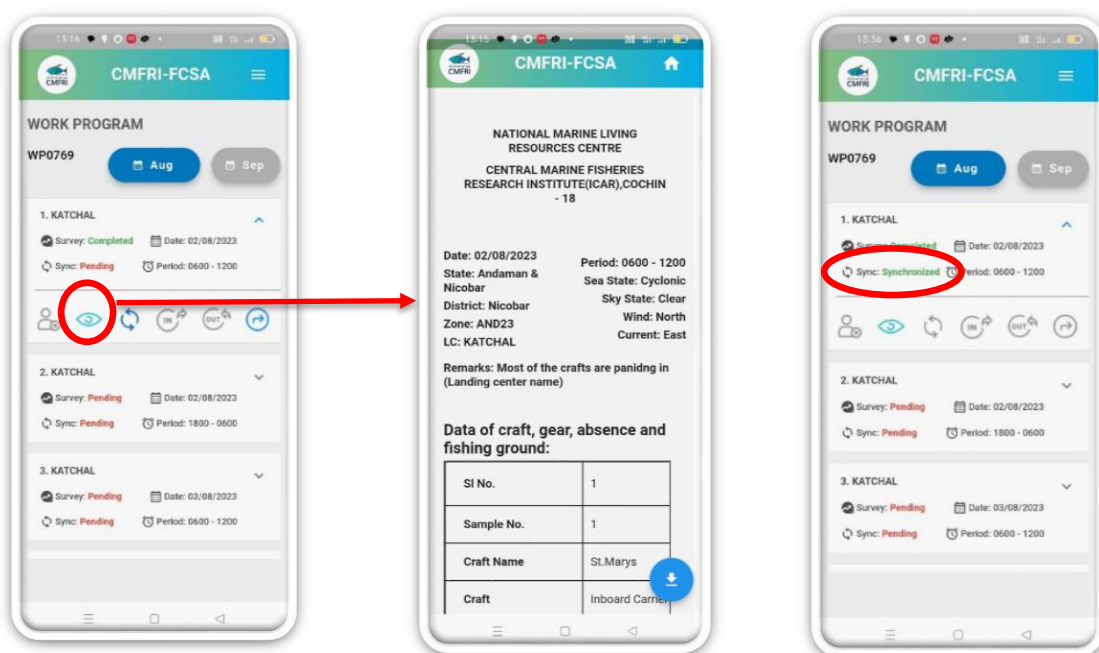


Fig. 11 Preview and Synchronization

Editing of entries can be carried out any number of times, and each edit should be finalized by selecting the COMPLETE button. In cases of No Landing, saving the header part alone is sufficient and completion through the COMPLETE button is not required. Once the survey form is completed, it must be synchronized with the server for final submission using the respective button.

After the field observer submits the data, it becomes accessible to the FCSA state coordinator through the desktop interface for scrutiny and verification. The process begins with checking environmental details such as sea state, sky condition, wind direction, and current. This is followed by verifying technical and operational information, including the overall length (OAL) and engine power of the craft, crew strength, departure and arrival times, distance travelled, direction, number of hauls, and depth of operation. Data related to landings such as species composition, quantity, and market price are also carefully reviewed. A facility is provided for the observer to record unusual fishery events, including exceptionally high catches, unanticipated fishing breaks, and their underlying causes. Once all entries for a given month are validated, the estimation process is carried out, leading to the generation of monthly catch and effort estimates. These estimates are then made available in FCSA for retrieval in standard tabular outputs, categorized by species, groups, gears, and fishing zones.

The Fisheries Catch and Sampling Application (FCSA) has emerged as a highly effective platform for the collection and estimation of marine fishery data (Mini et al., 2023). Compared to the earlier paper-based approach, which was labour-intensive, time-consuming, and prone to errors, the new system represents a major advancement in efficiency and reliability. It

allows monthly work programmes for field staff (harbour-based observers) to be generated at headquarters and downloaded onto handheld devices such as tablets. Observers can record information directly in the prescribed digital format, and once entries are completed, the data can be synchronised with the central server. Importantly, the system enables offline data entry in areas with limited or no internet access, with automatic uploading once connectivity is available. This flexibility improves the overall efficiency of marine fisheries monitoring by ensuring wider coverage, greater accuracy, and finer resolution in data collection and processing.

The architecture of FCSA consists of three main components viz., a central server with its operating system, an RDBMS database, and a custom-developed software package. The software was specifically designed to align with the unique requirements of marine fisheries and the stratified multistage random sampling framework used in India. For adoption in other tropical countries, modifications would be essential at multiple levels, beginning with the design of a context-specific sampling framework through pilot studies, followed by the development of tailored software to suit that design. While significant adjustments to the existing code would be required for implementation elsewhere, the core structure and guiding principles of FCSA remain adaptable and replicable across diverse tropical fisheries.

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