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ANALYSIS FOR A SAILING SAFETY INFORMATION SYSTEM IN KARANGHARJO VILLAGE, KRAGAN SUBDISTRICT, REMBANG REGENCY

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ABSTRACT

Karangharjo Village, located in Kragan Subdistrict, Rembang Regency, is a community where the majority of residents work as small-scale fishermen using vessels under 5 GT. These fishermen face a high risk of maritime accidents due to a limited understanding of and access to sailing safety technology. Based on a social mapping survey conducted in 2024, the village has 25 fishing groups with a total of 250 fishermen. Every year, maritime accidents occur, resulting in physical disabilities, fatalities, and an increasing number of orphans. Advanced satellite-based safety mitigation and navigation technologies, which are commonly used by larger vessels, are difficult for these small-scale fishermen to access due to informational and economic constraints. The Marine Affairs and Fisheries Agency of Rembang Regency states that 30% of maritime accidents are caused by a lack of information and inadequate navigation devices, a situation worsened by the fishermen's highly fluctuating income. The problems are formulated as follows: how can sailing safety technology be implemented for small-scale fishing groups, and how can an information system workflow be designed for maritime emergencies? The problem-solving approach for this research involves a needs analysis of small-scale fishermen and the development of an information block model for emergency response. Based on these issues, the objectives of this study are to reduce the rate of maritime accidents in Karangharjo Village and to accelerate the handling of emergency situations. This study uses a mixed-methods approach, combining quantitative and qualitative techniques with the Sustainable Livelihood Approach (SLA). The expected outputs of this research are a publication in an accredited international journal and a copyright, falling under the category of Key Performance Indicator (IKU) 5, as research results that are utilized by the community.

Keywords: Fishermen, information system, sailing safety, needs analysis

Introduction

Karangharjo Village, located in Kragan Subdistrict, Rembang Regency, is a coastal area where the majority of residents work as small-scale fishermen, operating vessels with engine capacities of less than 5 GT. Based on the results of a social mapping survey in 2024, there are 25 groups with a total of 250 small-scale fishermen in this village [1]. However, sailing safety has not yet become a primary concern, even though fishing is a high-risk occupation with a significant potential for accidents [2-5]. Interviews with the Head of Karangharjo Village (2024) revealed that maritime accidents occur every year, leading to physical disabilities, fatalities, and social impacts, including 73 families who have been left orphaned.

Various safety technologies have been widely adopted by larger vessels, such as satellite systems, emergency calls, and modern navigation tools. However, such technologies remain inaccessible to small-scale fishermen due to financial constraints and limited access to information. The Marine Affairs and Fisheries Agency of Rembang Regency reported that around 30% of maritime accidents are caused by a lack of safety information and navigation equipment. Moreover, fishermen's incomes fluctuate significantly, from around 90 kg of fish per day during peak harvest seasons to only 10 kg during the west wind season [6]. This condition forces fishermen to prioritize basic needs over investment in safety equipment [7].

Previous studies have emphasized the importance of technology in supporting maritime safety, such as GPS-based monitoring systems [8], maritime weather prediction applications [9], and emergency communication systems based on mobile applications [10-13]. In addition, smartphone applications have been developed to improve maritime safety [14], including Internet of Things (IoT)-based vessel tracking systems [15]. Nevertheless, most of these innovations are not fully relevant to the context of Indonesian small-scale fishermen. Therefore, this study proposes a more contextual approach that adapts to the local conditions of Karangharjo fishermen. A relevant example can be seen in coastal community empowerment in the Kenjeran Area, where training in the use of GPS for sailing safety was conducted [16].

The main problems of this research are how to map the needs of small-scale fishermen to implement a sailing safety information system that aligns with their socio-economic conditions, and how an information system workflow can be designed to support emergency response at sea. The approach used includes a needs analysis of Karangharjo's small-scale fishermen for a safety system that is adaptive to resource limitations, followed by the development of an information block model in the form of an emergency response workflow diagram. The goal of this research is expected to reduce the rate of maritime accidents and accelerate response during emergency conditions.

Methodology

The research location is Karangharjo Village, Kragan Subdistrict, Rembang Regency. The study was conducted from July to August 2025 using a mixed-methods approach, combining quantitative and qualitative methods to obtain comprehensive data [17].

The data used consisted of both primary and secondary sources. Primary data were collected through observations, questionnaire surveys, interviews, and Focus Group Discussions (FGDs) with the Village Government, the Marine and Fisheries Agency of Rembang Regency, and fishermen groups. Secondary data were obtained from literature reviews and official documents from various institutions. Informants were selected using purposive sampling, meaning that respondents or informants were determined as the main data sources without deviating from the research objectives [18]. The selection of respondents was based on their proximity to information sources [19], complemented by the snowball technique. The total number of survey respondents was 30, selected based on socioeconomic criteria and location. Data collection techniques included secondary data inventory, in-depth interviews with government officials and community leaders, as well as focus group discussions [20]. Needs analysis was carried out using the Sustainable Livelihood Approach (SLA) systematically, as presented in the following scheme.

Figure 1. Sustainable Livelihood Approach (SLA)

The methodology can be divided into one or more parts according to the research requirements. The needs analysis was conducted using the Sustainable Livelihood Approach (SLA) (Figure 1) through three methods: Mind Mapping to connect and structure problem concepts, the Risk Assessment Framework to evaluate the level of risk, and Expert Judgment to strengthen and validate the analysis results.

Result and Discussion

a. Respondent Characteristics

This study involved a total of 23 respondents, all of whom work as fishermen in Karangharjo Village. All respondents were male, accounting for 23 individuals (100%). The largest age group was 51–60 years (36.4%), followed by 41–50 years (27.3%), while the smallest group was 21–30 years with 3 respondents (13.6%). Educational attainment was relatively low, with the majority having completed only elementary school (60.9%), junior high school (21.7%), senior high school (4.3%), while 13% had never received formal education. In terms of sailing experience, most respondents had between 1–10 years of experience (42.9%). This condition indicates the limited human resource capacity, which directly affects their understanding and adoption of sailing safety technologies.

b. Sailing Activities

The majority of fishermen (Figure 2) use the Jaring Kantong (bag net) method for fishing, reported by 82.6% of respondents. Several other methods were also identified, such as Jaring Poursin, Garu, Jaring Payung, and Jaring Anak Harimau, though these were used by only a few fishermen. The sailing range of fishermen for fishing activities is mostly within 6–15 miles (39.1%) and up to 5 miles (34.8%). The main commodity caught by fishermen is squid, reported by 73.9% of respondents, along with several fish species such as Batek, Petek, Kamojan, Layang, Rajungan (blue crab), and Trisi.

Figure 2. The fisherman

Regarding government assistance and participation in safety training, fishermen reported very limited access. As many as 78.3% of respondents stated that they had never received nor participated in government-led assistance or training on sailing safety.

c. Fishing Production Facilities

The fishing production facilities exhibit relatively uniform characteristics across several aspects (Table 1). All vessels used by the 23 respondents are made of teak wood, with an average gross tonnage of 6.61 GT and years of construction ranging from 2001 to 2023. The vessel length varies between 6.5 and 12 meters, with widths ranging from 1.9 to 5.5 meters and depths between 0.7 and 1.75 meters. The majority of vessels are powered by 23 HP engines, used by 82.6% of fishermen, with diesel fuel as the primary energy source.

Furthermore, in terms of vessel maintenance, most fishermen (52.2%) carried out irregular maintenance, while 47.8% only performed maintenance and repairs when the vessel experienced damage. The limited innovation in vessel structure, combined with a reactive maintenance pattern, increases the vulnerability to accidents during sailing.

d. Availability of Safety Equipment on Fishing Vessels

The analysis of vessel safety aspects reveals a significant gap between the availability of basic safety equipment and modern safety devices (Table 2). The ownership level of safety equipment is very low. None of the fishermen possessed nautical charts, lifeboats, immersion suits, or thermal protective aids. Only 26.1% of respondents owned a compass, while ownership of echosounders and fire extinguishers (APAR) was even lower, at 13%. Emergency signaling devices such as flare guns, smoke signals, and emergency whistles were found on only one vessel (4.3%).

Conversely, simple equipment such as ropes and emergency flashlights were owned by all respondents. Buckets with ropes, which are also vital tools in emergency situations, were owned by almost all fishermen (91.3%). This condition highlights a substantial disparity between actual practices and international maritime safety standards.

Table 1. Fishing production facilities

Year Built	Length (m)	Width (m)	Depth (m)	Height (m)	GT	Material	Brand	Type/Model	Power (HP)	Fuel Type
2019	7	3	1	1	4	Teak Wood	MKK, Wangli	ZS	23 HP	Diesel
2014	7	2,5	1,1	1	6	Teak Wood	Imoto, Yamaoke, Pedang, JP	ZS	23 HP	Diesel
2020	7,25	2,8	0,8	1,5	6	Teak Wood	Yamamoto, Pedang, Paus	ZS	23 HP	Diesel
2015	7,5	2,8	0,8	1,5	6	Teak Wood	JP, Namaoke, TR	ZS	23 HP	Diesel
2022	7,25	2,8	1	1,1	6	Teak Wood	Pedang, Imoto	ZS	23 HP	Diesel
2019	7,5	3	0,8	1,2	6	Teak Wood	Ninja, Turbo, Jettop	ZS	23 HP	Diesel
2010	7,5	2,2	1	1	4	Teak Wood	Ninja	ZS	23 HP	Diesel
2012	7	2,5	0,8	1,15	6	Teak Wood	Wangli, Jettop	ZS	23 HP	Diesel
2023	7	2,5	1	1	6	Teak Wood	Wangli, Ninja	ZS	23 HP	Diesel
2025	7,25	2,90	0,8	1,15	10	Teak Wood	Ninja	ZS	23 HP	Diesel
2010	12	5,5	1,75	2	30	Teak Wood	Mitsubishi, Fuso	D16	50 HP	Diesel
2019	7,5	2,9	0,8	1	4	Teak Wood	Ninja	Z5	23 HP	Diesel
2023	6,5	2,7	1,75	2	3	Teak Wood	Yamaoki	Z6	23 HP	Diesel
2011	7	1,9	0,7	0,9	4	Teak Wood	Amex	Z7	16 HP	Diesel
2021	7,25	2,8	1	1,15	6	Teak Wood	JF	Z8	24 HP	Diesel
2019	7	2,5	0,8	1	6	Teak Wood	Marcy, JP	Z9	23 HP	Diesel
2018	7,5	2,5	0,8	1	6	Teak Wood	Marcy, Ninja	Z10	23 HP	Diesel
2020	7,3	3	1	1,1	6	Teak Wood	Ninja	Z11	23 HP	Diesel
2013	7	2,6	0,8	1	6	Teak Wood	Batja	Z12	23 HP	Diesel
2007	7	2,7	0,8	1	6	Teak Wood	JP, Marcy	Z13	23 HP	Diesel

Year Built	Length (m)	Width (m)	Depth (m)	Height (m)	GT	Material	Brand	Type/Model	Power (HP)	Fuel Type
2017	7	2,7	1	1,15	6	Teak Wood	Ninja, JF	Z5	23 HP	Diesel
2019	6,75	2,8	0,7	0,95	3	Teak Wood	Ninja, JF	Z6	24 HP	Diesel
2001	7	3	1	1,1	6	Teak Wood	Wangli, Jettop	ZS	23 HP	Diesel

Table 2. Safety equipment on fishing vessels

Safety Equipment	Number of Owners	Ownership Percentage (%)
Mooring Rope	23	100
Emergency Flashligth	23	100
Bucket with Rope	21	91.3
Compass	6	26.1
Paddle	4	17.4
Echosounder	3	13
Fire Extinguisher (APAR)	3	13
Emergency Whistle	1	4.3
Flare Gun	1	4.3
Smoke Signal	1	4.3
Nautical Chart	0	0
Lifeboat	0	0
Immersion Suit	0	0
Thermal Protective Aid	0	0

e. Availability of Personal Safety Equipment and Personal Protective Equipment (PPE)

In terms of personal safety, the data indicate an unfavorable condition, as the ownership level of life-saving equipment is very low (Table 3). Only 4.3% of respondents owned a life jacket, and 8.7% owned either a life buoy or a first aid kit. This reflects the low awareness of and limited access to basic safety equipment.

Meanwhile, the availability of Personal Protective Equipment (PPE) is relatively better and generally adapted to daily work needs. Raincoats were owned by 95.7% of respondents, gloves by 78.3%, and work shoes by 69.6%. However, more specific protective equipment remained scarce, with only 8.7% of respondents owning a safety helmet, and none owning protective goggles. aids. Only 26.1% of respondents owned a compass, while ownership of echosounders and fire extinguishers (APAR) was even lower, at 13%. Emergency signaling devices such as flare guns, smoke signals, and emergency whistles were found on only one vessel (4.3%).

Table 3. Personal safety equipment

Safety Equipment	Number of Owners	Ownership Percentage (%)
Raincoat	22	95.7
Gloves	18	78.3
Work Shoes	16	69.6
Safety Helmet	2	8.7
Protective Goggles	0	0

f. Level of Work Equipment Availability

An analysis of work equipment shows a noticeable gap between basic tools and modern mechanical equipment in supporting fishing operations (Table 4). All fishers (100%) possess essential equipment such as hand tools, workshop kits, and ropes, which are used for both operational activities and emergency repairs. However, the adoption of modern mechanical equipment remains very low, with only 8.7% of respondents owning power blocks and rollers, while none of the fishers possess a stand joy. These findings indicate that fishing activities are still predominantly carried out manually, with very limited utilization of mechanical technology.

Table 4. Work equipment availability

Work Equipment	Number of Owners	Ownership Percentage (%)
Tool and workshop kits	23	100
Ropes	23	100
Power block	2	8.7
Roller	2	8.7
Stand joy	0	0

g. Level of Work Equipment Availability

In terms of emergency communication, the data indicate a very high dependence on mobile devices. Mobile phones serve as the primary means of communication for all respondents (100%), while the use of specialized maritime devices is very limited, with radios owned by only 8.7% of respondents and dedicated GPS units by 4.3%. Reliance on mobile devices is hindered by poor network quality at sea. Under normal conditions, GPS signals are accessible to all respondents (100%), and mobile phone signals are relatively strong (87%); however, internet access is entirely unavailable. During adverse weather conditions, mobile phone signals decrease drastically, with only 8.7% of respondents able to access them, although GPS signals remain stable. These findings highlight the high vulnerability of fishermen's emergency communication systems.

This study identifies the needs for a safety information system for small-scale fishermen through the Sustainable Livelihood Approach (SLA), which emphasizes the interconnection of five livelihood capitals.

1. Human Capital as a Determinant Factor
   A survey of 23 fishermen revealed that human capital is a critical factor, with the majority having only primary education (60.9%) or no formal education (13%), and 78.3% having never attended any training. As a result, safety awareness and technology adoption remain low. The study also found a positive correlation between education and safety awareness, consistent with previous findings that emphasize the role of human capital as a catalyst for sustainable livelihood transformation.

2. Dynamics of Natural Capital and Operational Challenges
   Karangharjo Village possesses natural capital in the form of access to the Java Sea, which is rich in fish resources. However, variability in sea conditions poses a major challenge to sailing safety. A total of 39.1% of fishermen sail 6–15 miles offshore and 26.1% more than 15 miles, which increases accident risks, especially given the lack of safety equipment. Climate change has disrupted weather patterns, rendering traditional prediction methods less accurate, while fishermen still rely heavily on intuition. This condition highlights the urgent need for a data-driven, real-time weather information and early warning system to mitigate risks.

3. Comprehensive Analysis of Physical Capital and Safety Gaps
   An evaluation of physical capital indicates a substantial gap between fishing production facilities and safety equipment. Most fishing boats are made of teak wood, with an average tonnage of 6.61 GT, but safety innovations are minimal. Modern equipment is almost absent; only 26.1% own a compass, 13% have an echo sounder or fire extinguisher (APAR), while nautical charts, life rafts, and standard lifesaving devices are entirely unavailable. At the individual level, only 4.3% of respondents own a life jacket, far lower than raincoat ownership (95.7%), reflecting a priority on weather protection rather than life safety.

4. Dynamics of Financial Capital and Implications for Safety
   An analysis of financial capital reveals extreme income fluctuations, from 90 kg of fish per day during harvest to only 10 kg during the west wind season. This 900% fluctuation creates significant economic instability, causing fishermen to prioritize basic needs over safety investments, which are perceived as non-profitable. Consequently, purchases of safety equipment are often postponed, creating a negative spiral that heightens accident risks and financial losses from damaged fishing gear or even loss of life.

5. Social Capital and Collective Potential
   The existence of 25 fishermen's groups with a total of 250 members indicates significant social capital potential. However, coordination and communication between groups remain weak. The absence of an integrated information system hinders emergency response, although this collective strength has the potential to serve as the foundation for a community-based safety system.

h. Synthesis of Safety Information System Needs for Small-Scale Fishermen

Based on the analysis of the five livelihood capitals, the design of a safety information system for small-scale fishermen must be holistic and adaptive to local conditions. The system should be simple, use the local language, and be easy to understand in order to address human capital limitations, while simultaneously strengthening social capital through community-based communication features. From the perspective of natural capital, the system must be able to provide real-time weather and navigation information to minimize risks arising from sea variability. Financial constraints require cost-effective solutions that remain affordable for fishermen with unstable incomes.

In terms of physical capital, the technology applied must be compatible with traditional fishing vessels without imposing additional costs. The main features should include GPS-based position monitoring, real-time weather alerts, an emergency panic button linked to SAR (Search and Rescue), and a user-friendly safety database. The system must also meet the criteria of Usability, Reliability, Affordability, and Scalability, supported by backup energy sources such as solar panels and long-lasting batteries to ensure functionality at sea. A phased implementation strategy is recommended, beginning with pilot projects and gradually expanding to cover the entire coastal area.

i. Synthesis of Safety Information System Needs for Small-Scale Fishermen

Based on the analysis of needs and existing constraints, this study recommends a phased implementation model that begins with strengthening human capital through training and socialization. The initial stage focuses on the use of basic safety equipment such as life jackets, simple GPS trackers, and emergency communication devices. Subsequently, weather and navigation information systems are integrated with an interface tailored to local capacities, followed by the development of community-based communication for monitoring and emergency assistance. The final stage involves the integration of all components into a comprehensive sailing safety system supported by adequate technological infrastructure.

Conclusion

The analysis of safety information system needs in Karangharjo Village shows that the design of such a system cannot be understood solely from a technical perspective but must also consider socio-economic aspects through a sustainable livelihood approach. The sailing safety condition of small-scale fishermen in Karangharjo Village is alarming, as indicated by the minimal ownership of standard maritime safety equipment such as life jackets, nautical charts, and life rafts, which are entirely absent within the community.

The Sustainable Livelihood Approach highlights disparities among livelihood capitals, with low levels of human and financial capital identified as the primary barriers to implementing safety practices. Therefore, the development of a safety information system must adopt a holistic design that accounts for the socio-economic limitations of fishermen, encompassing real-time monitoring, early warning systems, emergency communication, and a safety database with a simple interface and affordable costs.

The recommended implementation model follows a phased approach, starting with the strengthening of human resource capacity and gradually progressing toward the adoption of more advanced technologies in line with improvements in community capacity and sustainable adaptation. The success of this program will depend heavily on synergy among stakeholders, comprehensive policy support, sufficient budget allocation, and long-term commitment from all parties.

This study contributes to the development of a conceptual framework for a safety information system that is contextually relevant to the characteristics of small-scale fishermen in Indonesia and may serve as a blueprint for developing system prototypes, conducting pilot testing, and evaluating the impacts of implementation on sailing safety and fishermen's welfare.

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