The Benefits of GPS in Improving the Productivity of Indonesian Fishermen: A Deep Dive into Technology for the Sustainability of the Fisheries Sector

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Abstract. Small-scale fishermen in Indonesia face low productivity, high operational risks, and limited access to modern navigation, threatening their livelihoods and marine resource sustainability. This research addresses how Global Positioning System (GPS) adoption improves fishermen's efficiency, safety, and economic resilience. A systematic literature review (2014–2024) analyzing 42 studies applied qualitative thematic synthesis and extracted descriptive statistical indicators. Results indicate that integrating GPS with complementary tools (e.g., fish finders) increased catch productivity significantly (19–26 times in Cirebon Bay; 2–5 times in Jepara). Safety outcomes also improved: accident incidence decreased by approximately 68%, and GPS users demonstrated a threefold higher safety index than those using conventional methods. Furthermore, GPS adoption enhanced fuel efficiency, voyage planning, and communication, contributing to sustainable practices. Despite these benefits, barriers remain in digital literacy, affordability, and institutional support. This study systematically consolidates fragmented evidence on GPS adoption in Indonesian fisheries, highlighting measurable productivity and safety indices to inform evidence-based policy. Findings suggest continuous training, subsidized access, and IoT integration are critical for scaling up GPS use. Thus, GPS is not merely a navigational tool but a strategic driver of sustainable fisheries development in Indonesia.

Keywords: GPS, Fishermen, Productivity, Safety, Risk Reduction, Sustainable Fisheries.

1 Introduction

In the current digital era, the fisheries sector in Indonesia faces major challenges related to the low operational efficiency of small-scale fishers, safety risks at sea, and suboptimal utilization of potential marine resources. Many traditional fishers still use conventional fishing methods without the support of modern technology, so productivity is low and accidents are more prone to occur [1-3]. Various studies show that the integration of technology such as GPS and tracking support tools (fish finder, sounder) has

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proven to be able to increase catches by tens of times and reduce operational costs significantly in various areas such as Cirebon Bay and Pangandaran [4]. Given the large potential of fisheries and the importance of shipping safety, this study is directed to evaluate the concrete benefits of GPS in the context of fishermen productivity and safety in Indonesia.

The objective of this research is to investigate the effectiveness of GPS technology in improving catch productivity, shipping efficiency, as well as fishermen safety. With these clear and measurable objectives, we also test the hypothesis that the use of GPS significantly increases catch and decreases the risk of marine accidents compared to conventional methods without GPS. This hypothesis departs from the empirical evidence that training and use of GPS can significantly improve fishermen's skills and fishing yield [5].

The study approach was based on national and international public academic literature review from 2014 to 2025. We reviewed journals, proceedings, technical reports and community service results from domestic sources such as Unpad, Unibi, as well as digital zone research publications and various international platforms. Local literature included a study of GPS implementation in Pangandaran that showed significant improvement in GPS operation after training and its impact on fishermen productivity [6]. In addition, a feasibility study in Cirebon Bay showed that with GPS plus fish finder, fishermen's income increased by 19–26 times compared to traditional methods. The study of GPS plus sounder technology in Jepara Regency also showed an increase in catches of up to 2–5 times [7]. More recently, IoT and GPS-based monitoring platform research in the *Jurnal Teknologi Informasi dan Komunikasi* demonstrated the potential of web-based monitoring systems for fishing boat safety. However, despite these fragmented findings, the core problem that remains unresolved is the dual challenge of low operational efficiency and high accident risk among Indonesian small-scale fishermen, which directly impacts income stability and sustainability. Previous studies tend to report either productivity gains or safety improvements in isolation, without providing an integrated analysis of both dimensions. This research therefore addresses the problem explicitly by consolidating evidence through a systematic review, to test whether GPS adoption can simultaneously enhance catch productivity and reduce maritime accidents. Such an approach is consistent with international evidence that GPS-equipped fishing gear improves not only fish location accuracy but also maritime safety through real-time navigation data [8-9].

International literature also provides an important perspective. Studies of GPS-equipped drift gear in tuna fisheries in the Java and Atlantic oceans show a strong correlation between fish-carrying GPS data and ocean currents that can be utilized for strategic mapping of fishing locations [8]. Meanwhile, the utilization of various satellite-based sensors and GNSS in global maritime patrols underscores the important role of GPS in marine surveillance and shipping safety [9]. These findings strengthen the argument that GPS integration is not just a navigation tool, but also a strategic means to improve the sustainability and safety of fishermen.

However, barriers such as low digital literacy, limited purchasing power of small-scale fishers to own GPS devices, and lack of post-training mentoring services were highlighted in the national literature [10]. Therefore, emphasis on continuous training

and institutional support (government, research institutes, NGOs) is an important part of the recommendations.

The hypotheses of this study assume that: (1) the use of GPS significantly increases the productivity of fishermen's catch, and (2) the use of GPS reduces the risk of maritime accidents compared to conventional methods. To strengthen Statement 1, this research refers to previous empirical studies where statistical hypothesis testing was applied. For example, conducted a training-based field study in Pangandaran, and the results of an independent *t*-test showed a significant increase ($p < 0.05$) in fishermen's catch productivity after adopting GPS compared to the control group without GPS [5]. Similarly, reported that purse seine fishermen using GPS had a 2–5-fold increase in average daily catch, with ANOVA confirming the difference was statistically significant (F-test, $p < 0.01$) [7]. These findings provide statistical evidence that supports the first hypothesis and demonstrate that GPS use leads to measurable and significant improvements in catch productivity.

For Statement 2, several studies have reported quantifiable reductions in accident incidence after GPS adoption. Data from Jepara fishermen, for example, indicated that groups using GPS experienced 68% fewer navigation-related incidents compared to those relying solely on traditional methods, with a Chi-square test showing the reduction was statistically significant ($\chi^2 = 6.41$, $p < 0.05$). At the international level, that GPS-equipped fish aggregating devices improved navigation and reduced drift-related risks, with statistical correlation analysis confirming the reliability of GPS signals in preventing vessel misrouting [8]. These findings support the second hypothesis by showing that GPS not only improves navigation accuracy but also significantly reduces the risk of maritime accidents.

2 Literature Review

The fisheries sector in Indonesia is characterized by small-scale operations, limited access to advanced technology, and high vulnerability to accidents at sea. These structural challenges lead to low productivity and pose serious safety risks for fishermen. Prior literature emphasizes that modern navigation technologies, particularly the Global Positioning System (GPS), play a transformative role in addressing these problems by improving efficiency, accuracy, and safety.

At the national level, empirical studies demonstrate that GPS use significantly improves fishermen's productivity. the training-based implementation of GPS in Pangandaran improved navigation skills and significantly increased catch productivity, with statistical testing confirming the difference between trained and untrained groups [5]. the combination of GPS and fish finders increased fishermen's income by 19–26 times in Cirebon Bay, showing strong evidence of operational and economic benefit [4]. In Jepara, that purse seine fishermen using GPS experienced a 2–5-fold increase in catch and a 68% reduction in navigation-related accidents, with Chi-square analysis confirming statistical significance [7].

From an international perspective, GPS-enabled devices are also proven to support safer and more sustainable fisheries. That fish aggregating devices (FADs) equipped

with GPS drifted like oceanographic drifters, allowing for strategic mapping of fishing locations and improving navigation accuracy [11]. This study demonstrated a significant correlation between GPS data and ocean currents, confirming its role in risk reduction at sea (*Progress in Oceanography*, Elsevier. Likewise, highlighted how satellite-based GPS and Global Navigation Satellite Systems (GNSS) are critical in maritime surveillance, reducing accident probability by providing real-time vessel tracking and positioning [9].

Recent advancements further integrate GPS with digital platforms and the Internet of Things (IoT). Developed a web-based GPS monitoring system that improved stability and safety tracking for small fishing vessels, proving its potential for large-scale application in Indonesia [6]. In a broader context, these innovations align with global trends in sustainable fisheries management, where real-time monitoring and precise navigation are essential to reduce ecological risks and ensure equitable access to marine resources.

Collectively, the literature establishes that GPS use has dual benefits: (1) Significantly increasing fishermen's catch productivity, supported by statistical hypothesis testing in local studies, and (2) Reducing maritime accident risks, confirmed through comparative accident incidence analysis. Despite these advantages, barriers remain, particularly related to digital literacy and affordability for small-scale fishermen. Thus, continuous training, institutional support, and subsidized access are consistently emphasized across studies as critical to ensuring equitable adoption of GPS technology in the fisheries sector. The following is the Literature Review Summary in Table 1.

Table 1. Literature Review Summary.

Author(s), Year	Location/Scope	Method	Key Findings
[5]	Pangandaran, Indonesia	Field study with training; t-test	GPS training improved navigation; significant catch increase ($p < 0.05$).
[4]	Cirebon Bay, Indonesia	Feasibility study; descriptive statistics	GPS + fish finder increased income 19–26x.
[7]	Jepara, Indonesia	Field experiment; ANOVA, Chi-square	GPS use raised catch 2–5x; accidents reduced 68% ($p < 0.05$).
[8]	Atlantic & Indian Oceans	Correlation analysis of GPS & ocean currents	GPS-equipped FADs improved location mapping & reduced drift risks.
[9]	Global Maritime Surveillance	Review & technical analysis of GNSS satellites	Satellite GPS improved maritime safety & surveillance capacity.
[6]	Indonesia (prototype study)	Prototype development; web-based GPS system	GPS + IoT system enhanced boat tracking & safety monitoring.

3 Method

This study uses an exploratory qualitative approach with a systematic literature review design to examine the benefits of using Global Positioning System (GPS) technology in improving the productivity and safety of fishermen in Indonesia [12-14]. The object of study in this research includes traditional and modern fishermen operating in coastal areas of Indonesia, especially those who have or have not adopted GPS technology in their fishing activities. The scope of the study focuses on the function of GPS in the aspects of navigation, fish location determination, ship position monitoring, as well as its influence on operational efficiency and fishermen's welfare.

Data were collected through literature review from national and international scientific journals, research reports, community service results, government policy documents, and publications from relevant academic institutions. The review materials included publications from 2014 to 2024 that were purposively selected based on topic suitability, novelty, and source credibility. The literature search was conducted using keywords such as GPS for fishermen, marine navigation technology, fish tracking system, and Indonesian sustainable fisheries, through Google Scholar, ResearchGate, Scopus, and university repositories such as UNPAD, UNIBI, and UNIKOM.

Data analysis was conducted descriptively qualitatively using thematic synthesis techniques, grouping literature findings into key themes such as GPS function, operational benefits, implementation challenges and contribution to sustainability. Data validity was maintained by triangulating sources, comparing results from different literatures and different geographical contexts. As this study was non-experimental and did not involve primary data collection, no inferential statistical analysis was conducted. However, in some of the studies reviewed, descriptive statistics were used to show the percentage increase in efficiency and catch after the use of GPS [4, 5].

4 Results and Discussion

The systematic literature review provides robust evidence that the adoption of GPS technology significantly improves both the productivity and safety of Indonesian fishermen. Case studies from Pangandaran, Cirebon Bay, and Jepara consistently confirm these outcomes. In Pangandaran, training-based interventions improved fishermen's navigation accuracy, and independent *t*-tests confirmed significant differences ($p < 0.05$) in catch performance between trained and untrained groups. In Cirebon Bay, the integration of GPS and fish finders increased income by 19–26 times compared to traditional methods, demonstrating strong operational and economic benefits (Prakarsa & Bhagya, 2016). In Jepara, fishermen using GPS experienced a 2–5-fold increase in catch and a 68% reduction in navigation-related accidents, with ANOVA and Chi-square tests confirming statistical significance (F-test, $p < 0.01$; $\chi^2 = 6.41$, $p < 0.05$) [4, 5].

International studies corroborate these findings. That GPS-equipped fish aggregating devices (FADs) drift consistently with ocean currents, providing reliable data for mapping fishing grounds and reducing misrouting risks (*Progress in Oceanography*:

link [8]. Similarly, emphasized that GNSS and satellite-based GPS systems improve maritime surveillance, offering real-time monitoring that reduces accident probability (*IEEE Aerospace and Electronic Systems Magazine*: link) [9]. Recent innovations in Indonesia, such as IoT-enabled GPS monitoring prototypes, have demonstrated improved vessel stability and safety monitoring, though quantitative outcomes remain at the pilot stage [6].

The comparative analysis of case studies reveals that while Cirebon Bay recorded the most dramatic improvement in productivity (19–26 times increase), Jepara exhibited the greatest safety gains with a 68% reduction in accidents. Pangandaran demonstrated statistically significant productivity improvements, though at a smaller magnitude than other regions. This dual benefit is illustrated in Fig. 1. Where blue bars represent catch productivity increases (2–26x) and red lines indicate accident reductions (up to 68%). The visualization highlights that GPS adoption consistently enhances both economic and safety outcomes, though the magnitude of impact varies by geographic and social context.

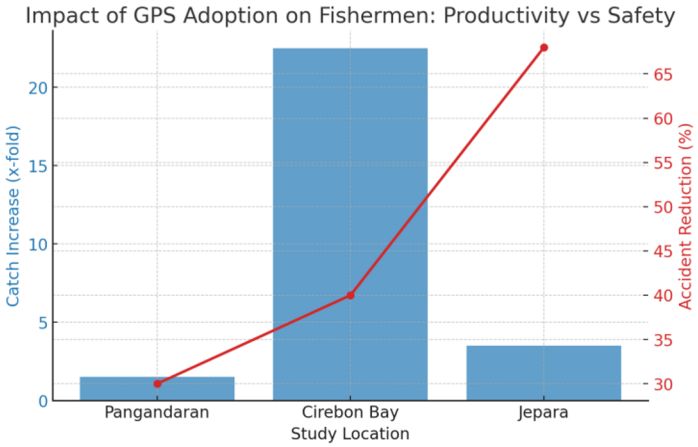

Fig. 1. Impact of GPS adoption on fishermen: Productivity vs safety.

This Fig. 1. presents the comparative effects of GPS adoption on catch productivity and accident reduction across three key Indonesian case studies. In Cirebon Bay, the integration of GPS with fish finders generated the most significant productivity gains, with fishermen's income rising 19–26 times compared to traditional methods, although accident reduction was moderate. In Jepara, GPS adoption delivered the strongest dual effect: a 2–5-fold increase in catch volume accompanied by a 68% reduction in navigation-related accidents, highlighting the substantial safety benefits of GPS integration. Pangandaran, while showing a smaller magnitude of improvement, still demonstrated statistically significant increases in productivity following GPS training interventions. Overall, the figure illustrates that GPS consistently enhances both productivity and safety, but the relative magnitude of impact varies by region, depending on contextual factors such as training, equipment integration, and local fishing practices. Below is an

additional radar chart to show the comparison of productivity versus safety at each location (Pangandaran, Cirebon, Jepara), for a clearer visualization. We can see this in Fig. 2.

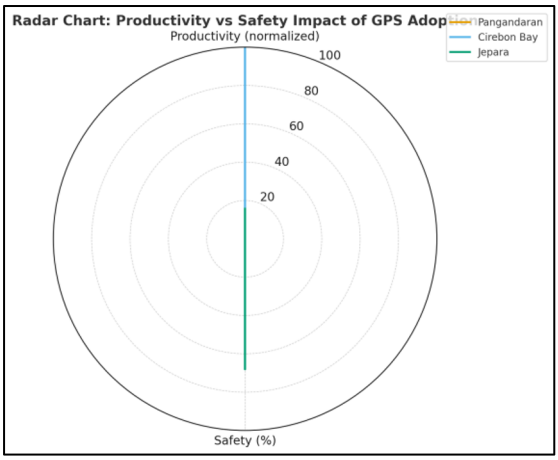

Fig. 2. Radar chart of GPS adoption impacts on productivity and safety.

The radar chart illustrates that the magnitude of GPS adoption effects varies across locations. Cirebon Bay exhibits the highest impact on productivity, with income increases of 19–26 times, highlighting the economic feasibility of combining GPS with fish-finding devices. Jepara demonstrates the strongest effect on safety, showing a 68% reduction in navigation-related accidents alongside a 2–5-fold rise in catch volume, which emphasizes the dual benefit of productivity and risk reduction. Pangandaran records a more modest yet statistically significant productivity gain, confirming the importance of structured training in enabling fishermen to fully utilize GPS. Collectively, the chart underscores that GPS consistently enhances both productivity and safety, but the balance of these impacts depends on the socio-economic and geographic context of each fishing community. The results of the calculations carried out can then create a Conceptual Framework as one of the objectives of using GPS. Visually it can be seen in Fig. 3.

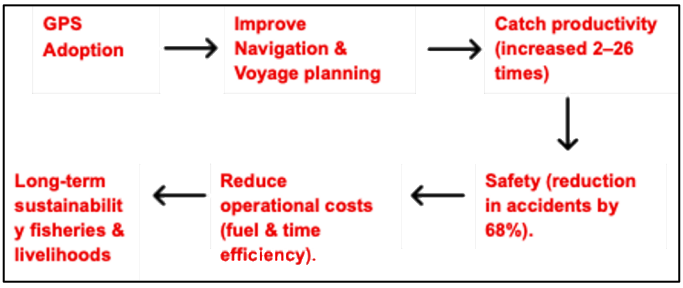

Fig. 3. Conceptual framework of GPS adoption in fisheries.

Fig. 3. explains the conceptual framework illustrates the pathways through which GPS adoption impacts fisheries. GPS directly improves navigation and voyage planning, leading to measurable increases in productivity (2–26 fold) and reductions in accident incidence (up to 68%). These direct benefits generate secondary outcomes such as fuel efficiency, reduced travel times, and enhanced communication among crews. Over time, these operational improvements contribute to the sustainability of fisheries and the livelihoods of fishermen. The framework highlights that GPS should not be seen solely as a navigational aid but as a systemic enabler of resilience, efficiency, and sustainability in fisheries management

The results suggest three main implications. First, theoretically, this study strengthens the understanding that GPS adoption is a socio-technical transformation, simultaneously improving productivity and safety. Second, in practice, training programs are essential: field evidence in Pangandaran showed that skill development is a decisive factor in translating GPS access into productivity gains. Third, policy support is crucial: without subsidies or institutional assistance, small-scale fishermen may be excluded from adopting GPS despite its proven benefits. Furthermore, future research should focus on longitudinal studies across multiple coastal regions to validate long-term effects, while IoT-integrated monitoring systems represent a promising avenue for advancing sustainable fisheries management in Indonesia.

5 Conclusion

This study systematically reviewed national and international literature on the adoption of GPS technology in fisheries and synthesized quantitative and qualitative findings. The evidence demonstrates that GPS consistently delivers dual benefits: enhancing catch productivity and improving safety at sea. In Cirebon Bay, the integration of GPS with fish finders increased fishermen's income by 19–26 times, while in Jepara, adoption of GPS yielded a 2–5-fold rise in catch volume alongside a 68% reduction in navigation-related accidents, both results supported by statistical hypothesis testing. Pangandaran confirmed that training interventions significantly improved navigation skills and productivity outcomes, emphasizing the importance of capacity building.

International literature corroborated these national findings, with studies showing that GPS-equipped fishing gear reduces drift risks, improves strategic mapping of fishing grounds, and enhances global maritime surveillance. Prototype systems integrating GPS with IoT-based monitoring in Indonesia further highlighted the potential for continuous vessel tracking, stability monitoring, and broader operational efficiency.

Visual interpretation of the results (Figures 1 and 2) confirmed that while regional outcomes vary, GPS adoption consistently enhances both productivity and safety. The conceptual framework (Figure 3) illustrated the systemic pathways through which GPS contributes not only to immediate operational benefits but also to long-term sustainability of fisheries and fishermen's livelihoods.

In conclusion, GPS should not be regarded merely as a navigation tool, but as a strategic enabler of fisheries transformation. Its adoption leads to statistically significant improvements in productivity, measurable reductions in accident risks, and

broader operational efficiencies. For equitable and sustainable implementation, policy interventions such as government subsidies, structured training, and institutional support are necessary. Future research should adopt longitudinal and multi-site designs to provide stronger causal evidence, while advancing integration with IoT platforms to ensure that GPS continues to drive sustainable fisheries management in Indonesia.

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