

How can information and communication technology contribute to small-scale fisheries in Indonesia?

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Abstract. This study aims to formulate a social engineering strategy for increasing the use of technology in the small-scale fisheries sector. Small-scale fisheries in Pati Regency utilize technology to enhance fishing operations. The technology is used both before going to sea, at sea, and after landing. Pati Regency was chosen as the research location. A mixed-methods approach, combining quantitative and qualitative methods, was used to analyze the data. The quantitative analysis used descriptive statistics, while the qualitative analysis used Atlas. Ti triangulation. Data was collected using purposive sampling, in-depth interviews with key informants (stakeholders), and semi-structured interviews with respondents (100 fishers). Furthermore, the results of this study are expected to be especially informative in informing government policies, particularly in small-scale fisheries. This study found that the use of Information and Communication Technology (ICT) in fishing activities is based on the type of fishing gear and the fisher's geographic location. The size of the ship, the length of experience as a fisherman, and the distance from the potential fishing grounds are among the factors determining whether fishers use ICT as a tool for fishing. The use of ICT by small-scale fishers can be enhanced through strategies that provide capital, training, and mentoring in the effective use of ICT.

Key Words: role, information, and communication technologies, small-scale fishers, Pati regency, strategy.

Introduction. Global change often has greater-than-expected impacts and impacts on various aspects of life, including fishing communities (Ospina & Heeks 2010; Huq et al 2015; Xu et al 2021). Fishermen's dependence on nature makes them highly vulnerable to income uncertainty and external pressures, such as climate change, biodiversity loss, conflicts with large-scale fisheries, global industrial expansion, and unfavourable government policies (Chuenpagdee & Juntarashote 2011; Nayak & Berkes 2019; Susilowati et al 2020a). This vulnerability is particularly experienced by small-scale fisheries, which are the backbone of the global fisheries sector.

Small-scale fisheries are a dominant sector in global fisheries, contributing approximately 60% of the world's total catch and employing up to 95% of the workforce, or more than 200 million people, primarily in developing countries. In addition to its crucial role in food security, this sector is also a significant source of employment and a poverty alleviation strategy (Pauly & Zeller 2016; Tietze 2016; Cohen et al 2019; Hara 2022). As a sector that contributes significantly to food security and community livelihoods, small-scale fisheries have distinct characteristics across regions. These differences are reflected in how fishers respond to environmental conditions, their ownership of vessels and fishing gear, their financial management capabilities, and local institutional support (Guyader et al 2013). However, despite their unique characteristics, small-scale fisheries are often characterised as vulnerable due to their dependence on environmental, social, and economic factors. This level of vulnerability is determined by exposure to impacts, sensitivity, and adaptive capacity (Fang et al 2011; Khattabi & Jobbins 2011; Dias et al 2022). Therefore, their survival can only be maintained if they can maintain their

livelihoods amidst the dynamics of global change (Millán 2019; Romanis 2020). In this context, the use of Information and Communication Technology (ICT) is a crucial strategy for enhancing the resilience of small-scale fisheries. ICT can assist fishermen in information management, decision-making, and improving adaptation to climate change through the Smart Fisherman Information System (Dewi 2018). Smart Fishers is a technology that provides essential information for fishing, including details on fishing grounds, weather forecasts, fish prices, ocean dynamics, and fishing e-logbooks.

The use of ICT has become a crucial adaptive tool for small-scale fishers in the face of economic, environmental, and policy pressures, while strengthening the resilience of their livelihoods. More broadly, ICT also contributes to the development of knowledge-based societies by facilitating the flow of information, influencing economic, social, and sustainable development (Omar et al 2011; Farhadi & Ismail 2014; FAO 2020). ICT encompasses a wide range of tools, from traditional media such as radio and television to modern technologies such as computers and the internet, which enable more effective communication and information processing (Ratheeswari 2018). The role of ICT is particularly relevant for fishers, who are important food providers but face significant challenges due to climate change, shifting patterns of fisheries resources, pollution, the use of illegal fishing gear, and overfishing practices. This condition creates uncertainty regarding catches, even forcing fishermen to venture further out to sea. Consequently, the use of ICT can serve as an adaptation strategy to support the sustainability of their livelihoods. (Segala et al 2016; Asirin & Argo 2018; Kinseng et al 2019; Nadiarti et al 2021). The development of modern technology in fisheries, such as sonar for detecting fish, GPS for navigation, mobile phones and radio for communication and information exchange, and internet-based platforms, has opened up opportunities for fishermen to increase productivity, security, and market access (Omar et al 2011; Food and Agriculture Organization & Worldfish 2020). Furthermore, ICT serves as a means of learning, self-organisation, and asset management, supporting the socio-economic sustainability of fishing communities (Asirin & Argo 2018). However, the adoption of this technology is not without obstacles, such as limited education, low income, high technology costs, limited networks at sea, and the need for time to adapt to new technologies (Salas & Gaertner 2004; Varjopuro 2011; Chhachhar et al 2014; Susilowati et al 2017; Salam 2018; Halim et al 2020; Susilowati et al 2020b; Nugroho et al 2021). Furthermore, many small-scale fishermen still rely on traditional knowledge (*ilmu titen*). *Ilmu titen* is a traditional science used by fishermen, involving sensitivity to natural signs to determine weather conditions at sea and fish source areas, which are learned through observation and passed down from one generation to the next.

The northern coast of Central Java cannot be separated from the impact of global changes. Pati Regency is Central Java's northern coastal area with different characteristics (Ministry of Marine Affairs and Fisheries 2013). Fluctuations in fishery production indicate the ecological impact of global changes. In 2016-2020, the fishery production of Pati Regency tended to increase from 34,611 tons to 95,070 tons, or an increase of around 175%. In addition, as many as 6,936 fishers in Pati Regency who depend on the fisheries sector also have the potential to experience the impact of global changes (Suherman & Mudzakir 2022). To face these challenges through the use of information technology to improve the welfare of fishers.

Using a mixed method approach, this study aims to analyse the characteristics of fishers in Pati Regency, identify the use of ICT by small-scale fishers, identify the relationship between the characteristics of fishers and the use of ICT, and analyse strategies for using ICT in small-scale fishers.

Material and Method

Description of the study sites. This research was conducted on the north coast of Central Java Province, Juwana subdistrict, Pati Regency. Pati Regency is one of the areas with the largest fisheries production in Central Java Province. The focus of this research is on fishermen on the Juwana River, which is the center of fisheries in Pati Regency, using various fishing gear and ICT. The study area is presented in Figure 1.

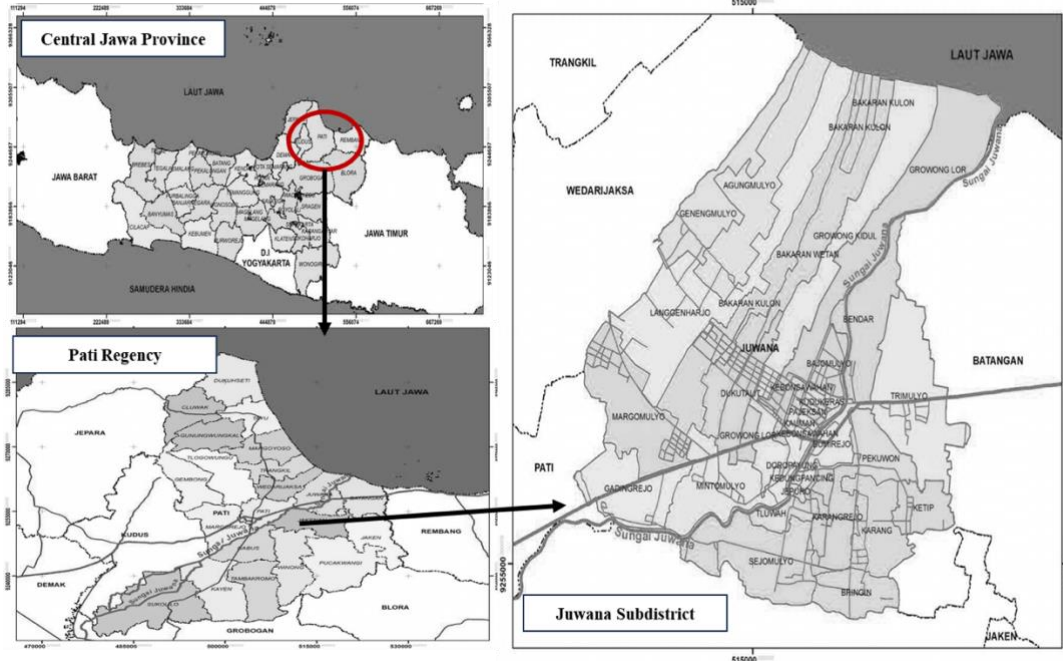


Figure 1. The location of the Regency, Central Java Province, Indonesia.

Mixed methods were used to answer the research objectives, combining qualitative and quantitative analysis (Creswel 2017). The first objective is to analyze the characteristics of fishers, using descriptive statistics. The second objective is the role of information and communication technology in the adaptation efforts of small-scale fishers, analyzed using descriptive statistics and simple triangulation. The third objective of the relationship between respondent characteristics and the use of ICT is answered with a chi-square test using SPSS 24. The fourth objective is to analyze the strategy for using ICT in small-scale fishing, starting with data collection using in-depth interviews with stakeholders, including elements of academia, business, government, and the community, which was then analyzed using stakeholder analysis with the help of the Mactor and ATLAS. Ti analysis tools. The data collection technique in this study was to determine a sample of 100 respondents (fishers) using accidental sampling and purposive sampling to determine key informants. The data used in this study are primary and secondary. Primary data were obtained through interviews with respondents, documentation, and in-depth interviews with key informants. Secondary data from the Department of Marine Affairs and Fisheries of Pati Regency, Central Java Province.

Results

Characteristics of respondents. The respondents' characteristics in this study include age, level of education, long-term experience as a fisherman at sea, and the distance to fishing grounds. The average age of the respondents is 44 years, which means that the respondents are at a productive age. The education level of most respondents is at the elementary school level, indicating that they have a relatively low level of education. Respondents are experienced fishers, with an average experience of 27 years. Respondents are one-day fishers because the average time at sea is 6 hours daily. At the same time, the average fishing distance for the respondents is 17 miles. Table 1 Table 1 shows the characteristics of respondents

Table 1

Characteristics of respondents

<i>Variables</i>	<i>Min</i>	<i>Max</i>	<i>Mean</i>	<i>Std. Deviation</i>
Age (year)	23	66	43.79	10.574
School (year)	0	12	7.56	3.551
Experience (year)	3	52	27.54	12.691
Durations (days)	1	60	5.80	12.912

Note: n=100

ICT used by Small-scale fishers. ICTs are now being developed to make it easier for fishers to know the natural conditions (Muawanah et al 2017). They then use the information fishers obtain to decide their activities, namely, whether it is possible to go to sea or not. This means that fishers use ICT to adapt to climate change. Based on in-depth interviews with respondents, how fishers use information and communication technology varies. This information technology is based on the individual needs of the fishers, such as differences in the fishing gear used, the size of the vessel, the type of catch, and the fisher's geographical location. so that the information and communication technology tools used are also different. The following are information and communication technology tools used by respondents.

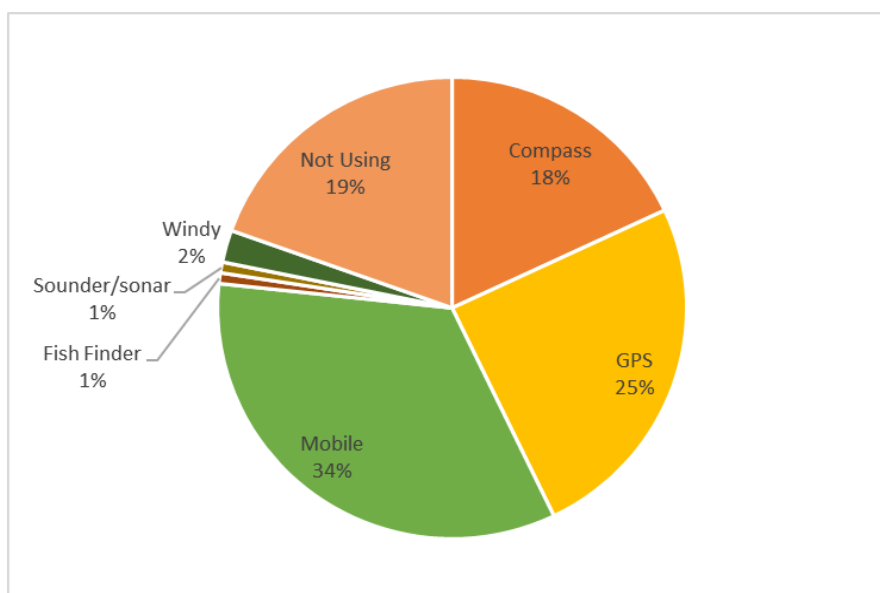


Figure 2. Information and communication technology used by respondents.

Note: n= 100

Respondents' most widely used ICTs are GPS, compass, and mobile phones. Besides that, there are still respondents who do not use ICT; they usually rely on experience or what is known as *ilmu titen* (local empirical knowledge derived from long-term observation). *Ilmu titen* is the ability of fishers to forecast the weather in their fishing areas and waters. Some fishers use more than one type of ICT to get the extra information they need to help them catch more fish.

Table 2 displays the combination of ICT use based on the fishing gear used. GPS is a type of ICT that fishers use on all of their fishing equipment. The Global Positioning System (GPS) is a system that can be used everywhere on Earth and is always connected to satellites. The benefits of using GPS include generating cruise route maps, offering fishing location information, and providing emergency assistance (Habibie et al 2021)

Fishers who do not use ICT aids in their fishing activities get information about the water's weather, such as wind direction, wind speed, and fishing areas, by using *ilmu titen*. *Ilmu titen* is a traditional science used by fishermen, involving sensitivity to natural signs to determine weather conditions at sea and fish source areas, which are learned through

observation and passed down from one generation to the next. This ability is obtained by fishers because of their long experience as fishermen and is also taught by their parents, who previously also made a living as fishermen. So by looking at cloud conditions before going to sea and seeing the waves, they can find the weather in the waters of potential fishing areas.

Table 2

Use of ICT by fishing

<i>Catching tool</i>	<i>ICT used</i>
Crab trap	GPS and compass
Purse seine	GPS, fish finder, radio
Gillnet	GPS, radio, compass
Mini Bottom trawl	GPS
Trammel nets	GPS, compass, radio
Fishing rod	GPS, Fish Finder

Note: n=100

Table 3

Utilization of ICT by type of ICT used

<i>Type of ICT Used</i>	<i>Utilization</i>
GPS	Mark and record the coordinate points where you will place the bubu Knowing the coordinates of the fishing grounds in the past day
Compass	Knowing the direction when fishers will go to sea and also return to land
Fish Finder	To find out the potential of fish in the sea
Sounder/Sonar	To find out the potential of fish in the sea
Mobile	Exchanging information with related fishers Weather information and potential areas for fish in the sea; Providing news to families left at home; informing them of the weather in the area of Mountain Wungkal
Windy	Knowing the speed and direction of the wind

The use of ICT by small-scale fishers is shown in Table 3. Crab fishers use GPS to mark and record the coordinates of the point where they put the trap, so that when fishers want to pick up the crab trap, they can see the position of the trap. Has been deployed. In addition, GPS is used to find out the coordinates of the fishing area for the past day. This is similar to what Sabu & Shaijumon (2017) stated, that the positions of boats and fish shoals are determined using GPS. Fishers use the compass to find where they will go to sea and return to land.

ICT, in the form of the Windy application, is used by fishers to determine the speed and direction of the wind before going to sea (while on land). Meanwhile, fishers who go to sea for more than six days use the help of people on land to convey information to fishermen who are at sea using radio. The BMKG provides weather forecast information to fishers in addition to Windy.

Fishers use mobile phones to exchange information with fellow fishers regarding weather information and potential fish areas in the sea. Additionally, fishers often use mobile phones to keep their families at home informed. When at sea (in an area with a mobile network available), fishers use their mobile phones to contact their families and other fishers, as well as the seashore (Azril et al 2012; Sabu & Shaijumon 2017). Mobiles are one of the most useful ICT tools, and mobile phones can be useful for a variety of purposes.

Fishers in Tayu District, Pati Regency, use mobile phones to check the weather in the Wungkal Mountain area. This is because fishers anchor their boats in the river that

originates from Mount Wungkal. Rainy weather on Mount Wungkal usually causes flooding in this river. ICT was created to improve the safety of fishers at sea. Cell phones and radios also allow for better communication with other ships and shores (Ejiogu-Okereke et al., 2016). Mobile phones are a useful tool for keeping in touch with clients' friends and family. By using this technology, fishers' basic means of subsistence are indirectly improved. Fishers use their smartphones to share information on where to find fish as well as to learn about the weather and current market values (Azril et al 2012).

Fishers use sonar and fish finders to locate potential fish in the sea. Both of these tools are used by trammel net or net fishers, as well as boats larger than 30 GT. The high price is one of the reasons why fishers who use vessels less than 30 GT (small fishers) do not use this tool.

The significant use of respondents' characteristics and ICT use. The behaviour of using ICT is related to the characteristics of respondents, following the results of the asymptotic sign (2-sided) between the variables of ICT use and the respondent's profile using SPSS 24. Table 4 shows a relationship between ICT use and respondent characteristics with chi-square sig.

Table 4
Relationship between respondent characteristics and ICT connection use

<i>Cross tabulation</i>	<i>Asymp.Sig. (2-sided)</i>	<i>Relationship between</i>
use of ICT with age	0.272	No
use of ICT by education level	0.278	No
use of ICT with long duration at sea	0.000	Yes
use of ICT with experience as a fisherman	0.001	Yes
use of ICT at ship size	0.639	No
use of ICT with fishing area distance	0.000	Yes

Note: n=100; Significance at 5%.

Variables in the profiles of respondents were tested using a dependency test using the chi-square tools in the statistical software SPSS to determine whether there is a relationship between the variables in the respondents' profiles and the use of ICT. According to Sabu and Shaijumon (2017), the adoption of ICT tools in the fisheries sector depends on several variables, such as ship size, number of crew members, fishers' education, area specifications, duration of days per trip, and fishing distance. Table 4 shows the asymp.sig. (2-sided) or p-value of the chi-square calculation of the variables age, level of education, and ship size, which are 0.272, 0.278, and 0.639 > 0.05, respectively. These results suggest that, within the scope of this study, age and education level do not show a statistically significant association with the use of ICT. However, this does not necessarily imply that such relationships do not exist, but rather that they were not evidenced in this data set. Although the chi-square test results indicate that age and education level are not statistically significant factors in the adoption of ICT among fishers in this dataset, field observations reveal more nuanced dynamics. Older fishers tend to rely on traditional knowledge and forecasting skills developed through long years of experience, making them less dependent on ICT. In contrast, younger fishers, despite the statistical insignificance, appear more open to ICT adoption, aligning with patterns reported in previous studies. Similarly, fishers with higher levels of education show a greater tendency to adopt ICT, as their skills and familiarity with technology allow them to operate such tools more effectively compared to those with lower educational attainment. These field-based insights suggest that while age and education do not emerge as significant predictors in the statistical analysis, they remain important contextual factors influencing ICT adoption at the practical level. Ship size has no relationship with ICT use. The size of the boat, whether under or over 10 GT, has no bearing on its use by fishers. Fishers will use ICT if it provides real benefits to them.

The length of time at sea per trip, experience as a fisherman, and the distance to fishing grounds have asymptotic values. Sig. (2-sided) Alternatively, the p-value of the chi-square is 0.000, 0.001, and 0.000, respectively, which means that there is a relationship between the three variables and the use of ICT. The relationship between fishing experience and the use of ICT tends to vary by age group. Older fishermen, despite their long experience, are often reluctant to adopt ICT because they rely on traditional knowledge and practices to forecast weather and identify potential fishing areas. In contrast, younger or less experienced fishermen are generally more open to using ICT-based tools, as they are more familiar with digital technology and perceive it as an efficient way to improve fishing productivity. Although our findings indicate no significant relationship between vessel size, age, or education and the level of ICT use among fishermen, the results align partially with Sabu et al (2018), who emphasized that ICT adoption in the fisheries sector may be influenced by multiple contextual factors, including the distance to fishing grounds, duration of trips, and local area characteristics. This suggests that while certain variables may not show statistical significance in our dataset, they can still play an indirect or situational role in shaping fishers' decisions to adopt ICT.

Discussion. ICT use by fishers to assist their activities while at sea plays an important role (Muawanah et al 2017; Sabu et al 2018; Susilowati et al 2020b; Nugroho et al 2021). Various important pieces of information, such as sea conditions, weather conditions, wind direction, and potential fish areas, are very useful for fishers. Information on potential fish grounds and wind direction is useful because it can make it easier for fishers to get to where they are.

In addition, many fishers still have not been able to take advantage of ICT. The high cost of ICT equipment makes it difficult for many fishers to use it. Low income and low education also contribute to a lack of technological literacy, which further hinders ICT adoption. The age factor is also one of the barriers for fishers in using technology, with older fishers being less able to use technology than younger fishers. This was stated by one of the interviewees as follows:

"Yes, yes, ma'am, do you want to be given capital like that or equipment from the government? That's an expensive tool, ma'am. If my income is that much, it's not enough to buy it, and it's just mediocre for daily meals."

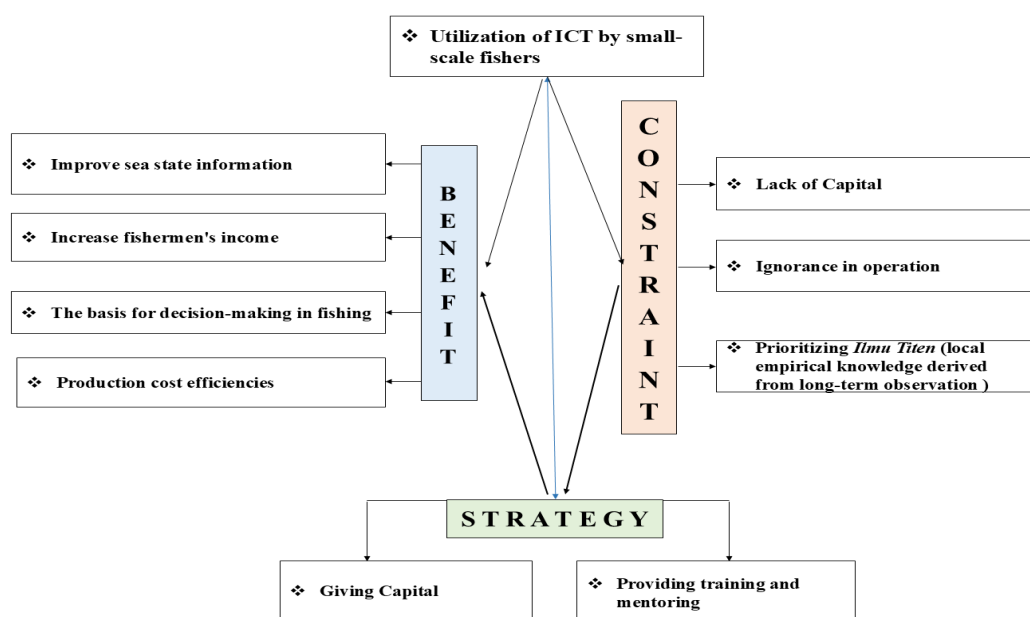


Figure 3. ICT strategy for overcoming vulnerability in small-scale fishers (Source: Primary Data, processed 2022).

Figure 3 explains strategies for using ICT by fishers. The strategy that needs to be carried out by stakeholders is using ICT to overcome the vulnerability of small-scale fishers, namely by providing capital, training, and assistance in using ICT. As stated by one of the key informants interviewed, as follows:

"To overcome the difficulties of fishers, I think capital needs to be given to fishers, Ms. In fact, there is already a program like that from the government. It is just that not all fishers get it."

Meanwhile, training and mentoring have been carried out by the government for the head of the fishing group. And then the head of the fishing group conveys it to the fishers.

"We have regular meetings, miss, once a month. So that meeting, apart from establishing a relationship between fishers in my fishing group, at the same time, for you taught me what I got from the government Ms. Sometimes I take part in the training at the Department of Fisheries and Maritime Affairs, so I pass it on to my other friends. Sometimes the government itself comes to give direct training. That is how it is, ma'am."

Conclusions. The association between respondent characteristics and ICT connection use. One way to overcome the vulnerability of fishers is by utilizing ICT to obtain information about the weather on the waters. Weather information is very important for fishers to make fishing decisions. The ICTs fishers use include GPS, fish finders, sonars, compasses, cell phones, and the Windy application, where cell phones are the most widely used ICTs. At the same time, the factors that relate to using ICT are the length of experience as a fisherman, the distance to the potential fish area, and the long duration of fishing. ICT's role in providing information to fishers is very useful. However, small-scale fishers still face some obstacles in utilizing existing ICT. To overcome these obstacles, several strategies relevant to stakeholders can be carried out, namely, providing capital, training, and mentoring in using ICT.

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