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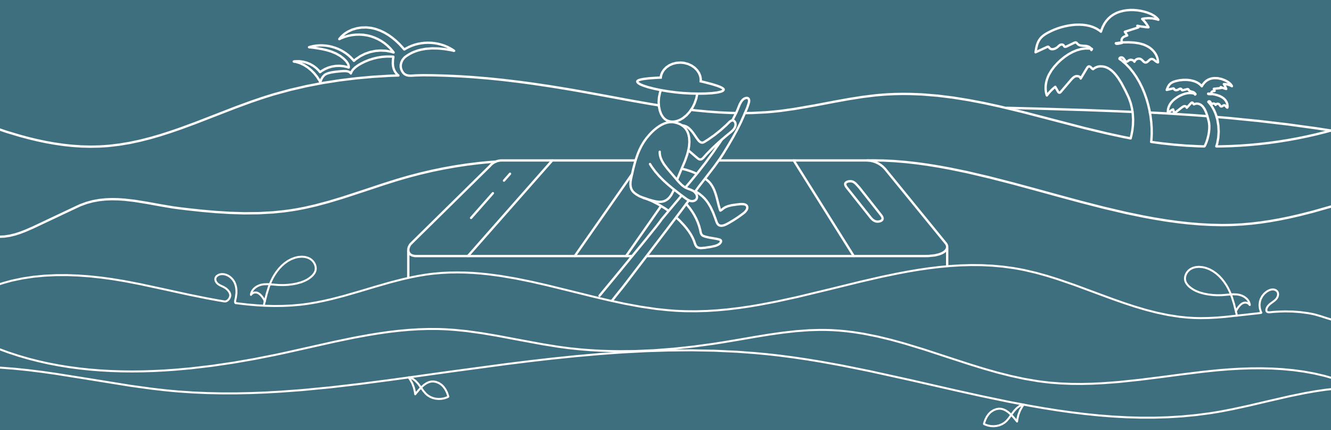

Information and communication technologies for small-scale fisheries (ICT4SSF)

A handbook for fisheries stakeholders

In support of the implementation of the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication

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Preface

Information and communication technologies (ICTs), such as smartphones, applications and cloud analytics, hold enormous potential for transformative gain. They increasingly allow us to automate and augment the collection, collation, communication and analysis of more and better data to inform targeted interventions. Yet the pace of their development and uptake is at the same time often a deterrent for people to engage due to indecision and "too much information." Furthermore, there are significant risks of increasing gender inequalities and marginalizing the poor with digital divides, such as access to technology and digital literacy.

There is an urgent need for governments to be informed, through neutral mechanisms, of the potential uses of the latest technologies in capture fisheries and the outcomes realized so far. It is also important to understand the potential unintended consequences or risks to governments or small-scale fishers and resources linked to the use and proliferation of ICTs.

Within this broader technological advancement, ICTs for small-scale fisheries (ICT4SSF) have advanced substantially in recent years in speed, scale and scope. Increased penetration of power infrastructure and mobile coverage along with the drop-in costs of connectivity have driven a rapid uptake of mobile technologies even in the most remote parts of the globe. Consequently, new ICTs and new uses for existing ICTs are being employed within the fisheries sector in a broad range of ways. This momentum provides stakeholders in the fisheries sector with opportunities to develop, adapt and apply these technologies as a way of leveraging the potential of fisheries to achieve the UN Sustainable Development Goals (SDGs) of zero hunger and no poverty. This will be especially true in a world of more than 9 billion inhabitants, where we will have to produce 60 percent more food by 2050.

This publication comes more than ten years after an FAO report in 2007: "ICTs benefit fishing communities: New directions in fisheries."[1] It aims to provide a reference framework for uses of ICTs in small-scale fisheries, specifically toward achieving the objectives of FAO's (2015) Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (SSF Guidelines)[2] and the UN's SDGs. The objectives set out in the SSF Guidelines provide a useful framework from which to contextualize ICT4SSF in terms of uses, accessibility and inclusive governance, rather than the technologies themselves. It is hoped that this report will be a reference tool for public sector fisheries and development officers and NGO workers in identifying new opportunities to leverage ICTs, but also to guide their design and development to avoid risks and common pitfalls.

Structure and use of this review

The case studies presented in this publication are grouped into three broad categories of ICT uses, framed by the SSF Guidelines, with disaggregated uses within each category (Figure 1). The purpose was to explore how ICTs can support the achievement of the objectives in the SSF Guidelines.

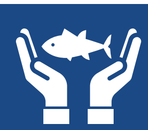
The first of these categories, Management, tenure and ecological sustainability, relates to chapter 5 of the SSF Guidelines and encapsulates the uses of ICTs to record, collate and communicate survey data used in evaluating and monitoring the primary productivity and ecosystems of small-scale fisheries. The second category, Well-being, decent work and gender equality, represents chapters 6, 8 and 9 of the SSF Guidelines and includes cases of safety at sea and where ICTs are improving well-being and gender equality by connecting people and providing information. The final category,

[1] www.fao.org/3/a-a0991e.pdf
[2] www.fao.org/3/a-i4356en.pdf

Value chains, benefit distribution and poverty alleviation, align with chapter 7 of the SSF Guidelines and includes cases of ICTs being used to provide market knowledge or improve product value through traceability.

It is important to remember that there are, of course, numerous overlaps and connections between these broad categories. One case can have elements of two or all three of the classifications. For example, traceability is reliant on monitoring catches and tracking boats, or fair benefit distribution could be strongly associated with gender equality in many contexts. However, these are designed merely to make it easier to navigate and reference the document according to interest in particular subject areas.

Figure 1. Categories of ICTs used in this document based on the SSF Guidelines.



Management, tenure and ecological sustainability
1.1 Catch data, monitoring, analysis and management
1.2 Fisheries effort tracking

Well-being, decent work and gender equality
2.1 Extension and information services, networking and facilities
2.2 Safety at sea, reducing risk, disaster response and preparedness

Value chains, benefit distribution and poverty alleviation
3.1 Value chains, fair benefit distribution and post-harvest preservation
3.2 Traceability

Acknowledgements

This work was developed and undertaken as a partnership between WorldFish and the Food and Agriculture Organization (FAO) of the United Nations. This collaboration contributes to the CGIAR Research Program on Fish Agri-Food Systems (FISH CRP) led by WorldFish and also to FAO's Umbrella Programme for promoting and applying the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication. The FISH CRP is supported by contributors to the CGIAR Trust Fund, and FAO's Umbrella Programme is supported with funding from Norway. This publication has not gone through the standard WorldFish science-review procedure.

Abbreviations and acronyms

AI	artificial intelligence
AIS	automatic identification system
APFIC	Asia-Pacific Fishery Commission
BDT	Bangladeshi Taka
bKash	mobile financial service in Bangladesh
BREW	Binary Runtime Environment for Wireless
BTV	Bangladesh television channel
CC4FISH	Climate Change Adaptation in the Eastern Caribbean Fisheries Sector
CIRP	Caribbean ICT Research Programme
CRFM	Caribbean regional fisheries mechanisms
DGP	National Fisheries Directorate (Timor-Leste Ministry of Agriculture and Fisheries)
eCDT	electronic catch documentation and traceability
ECOFISH	Enhanced Coastal Fisheries in Bangladesh Project
EFMIS	Enhanced Fish Market Information Service
FAO	Food and Agriculture Organization of the United Nations
FFMA	Fisher Friend Mobile App
FEWER	Fisheries Early Warning and Emergency Response
GPS	global positioning system
HBPS	Hathay Bunano Proshikshan Society
ICT4Ag	information and communication technologies for agriculture
ICT4D	information and communication technologies for development
ICT4SSF	information and communication technologies for small-scale fisheries
ICTs	information and communication technologies
INCOIS	Indian National Centre for Ocean Information Services
IOT	internet of things
ISSF	information system on small-scale fisheries
IT	information technology
IUU	illegal, unreported and unregulated
MCI	Meena Communication Initiative

NGO	nongovernmental organization
PDS	Pelagic Data Systems
peskAAS	Fisheries Automated Analytics System
SMS	short message service
SSF	small-scale fisheries
SSF Guidelines	Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication
TBTI	Too Big To Ignore
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
USD	United States Dollar
VDR	voyage data recorder
VHF	very high frequency
VMS	vessel monitoring system

Executive summary

The aim of this report is to present evidence for how information and communication technologies for small-scale fisheries (ICT4SSF) might enable and support the implementation of the Food and Agriculture Organization's (FAO) Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (SSF Guidelines). We present case studies of ICT4SSF initiatives in different use areas to identify key themes and reflect on successes and failures.

This document begins with a review of documented ICT4SSF initiatives, in Chapter 1, and to what extent they interact with the key elements of Part 2 of the SSF Guidelines. The following six case studies then dive into specific examples from around the world to detail their individual development processes and to evaluate the successes, failures and key lessons. Chapter 2 describes the development of a near real-time digital monitoring system for small-scale fisheries in Timor-Leste. Chapter 3 reviews formal and informal use of ICTs and capacity development in South India. Chapter 4 summarizes lessons of how mobile technology in value chains can drive gender equity in the Philippines. Chapter 5 describes the successes and failures of a digital market information service in East Africa. Chapter 6 explores the mechanisms through which fishers can engage with ICTs in the Caribbean toward improved safety at sea. Chapter 7 presents how digital technology and mobile money can enable alternative livelihoods for fishers in remote Bangladesh. In the Discussion and conclusions section, findings from the case studies are mapped back to Part 3 of the SSF Guidelines to provide a more systematic summary of the opportunities, risks and gaps in how information and communication technologies (ICTs) can enable the implementation of the SSF Guidelines.

The guiding principles of the SSF Guidelines are based on international standards of human rights, as well as responsible fisheries and sustainable development practices, with particular attention to vulnerable and marginalized groups. Globally, the most vulnerable and marginalized people tend to be the least represented in digital data because even simple social networks require some level of literacy and a smartphone, which in turn relies on connectivity and power. These prerequisites exclude certain segments of the population in developing countries such as small-scale fishers and fish workers, who often operate in isolated and informal markets where infrastructure is weak. ICTs are often seen as a way for developing countries, including vulnerable and marginalized groups, to hurdle traditional development processes in order to access the new digital economy. However, the investments and policies required to bridge the digital divide (inequalities in access to digital information and services and their associated benefits) are similar to traditional development processes, such as improving education and infrastructure.

There are few baselines against which to compare fisher well-being and access before and after ICT initiatives, and this gap is an important finding in this report. So far, success has only been assessed qualitatively and relatively, in terms of uptake, sustainability and local legitimacy. Still, some ICT4SSF initiatives presented in this document are closely aligned with the Principles for Digital Development and the objectives of the SSF Guidelines. These initiatives highlighted that when ICTs are locally led or developed, or co-designed with end users and marginalized groups, or have strengthened already existing networks and technologies, the potential for positive impact is much higher. However, there is much less evidence of proactive confrontation of inequality through data ownership. Furthermore, there are few examples of developing mechanisms for fishers and fish workers to hold, access or own their data, and few legal mechanisms to recognize their ownership or protect them against misuse or manipulation.

There is little doubt that ICTs hold potential to improve the lives of small-scale fisheries actors. But to bridge the digital divide, ICT4SSF development must be ethical and transparent and be orientated specifically to meeting the needs of the poor and marginalized. For example, in fisheries monitoring systems, co-generated and co-owned data foster transparency and accountability, and they enable small-scale fisheries actors to have an active role in decisions in resource governance. However, given the varying accessibility to information between sexes, individuals, groups, communities or businesses, ICT development must be mindful of how to add value for small-scale fisheries actors. If not, they could merely be contributing to widening the divide between rich and poor or the powerful and the exploited.

From our review, ICT4SSF to date have most commonly been applied in a traditional top-down approach to resource governance (Chapter 2), to monitor who is fishing and when, where and how much they catch. Thus far, ICT4SSF initiatives have followed the tendency for fisheries monitoring (1) to be extractive, with few mechanisms in place for information to flow both ways, (2) to be co-generated, and (3) to have few regulations in place to protect individuals' data privacy. There is great potential for digital technologies to enable transparent and equitable information systems that pave the way for responsible governance of tenure. For example to "establish networks and platforms for the exchange of experiences and information and to facilitate their involvement in policy- and decision-making processes relevant to small-scale fishing communities" (SSF Guidelines 10.6), these systems should include gender-disaggregated "bioecological, social, cultural and economic data relevant for decision-making on sustainable management of small-scale fisheries" (SSF Guidelines 11.1).

There are few examples available of ICT4SSF initiatives that directly target gender equality outcomes, poverty reduction, fisher welfare and equal rights, but these can be meaningfully addressed if ICT development is strategically planned and best practices are followed (Chapter 4). Also, the factors that underpin uptake and sustainability of ICT4SSF initiatives, such as trust, legitimacy, digital literacy and privacy, remain largely unexplored. Without insight into these aspects, stakeholders planning to use ICT4SSF in their activities are vulnerable to unintended and unfavorable outcomes. There is an urgent need to support ICT development with policies that ensure equitable accessibility and distribution of the benefits of digital inclusion.

The SSF Guidelines are for all stakeholders in aquatic systems, from governments and nongovernmental organizations (NGOs) to fishers and fishworkers (SSF Guidelines 2.3). Initial successes of contextualizing "first world" technology into developing world settings have relied on partnerships. Fostering collaboration between data scientists, governments, NGOs and small-scale fisheries actors is more likely to ensure that ICTs are appropriate for the key hardships and constraints unique to each local context (Chapter 2). Unfortunately, many countries view fisheries data as extremely sensitive and are reluctant to trust nongovernment partners with access, even if they lack internal expertise to fully use the data to inform decision-making.

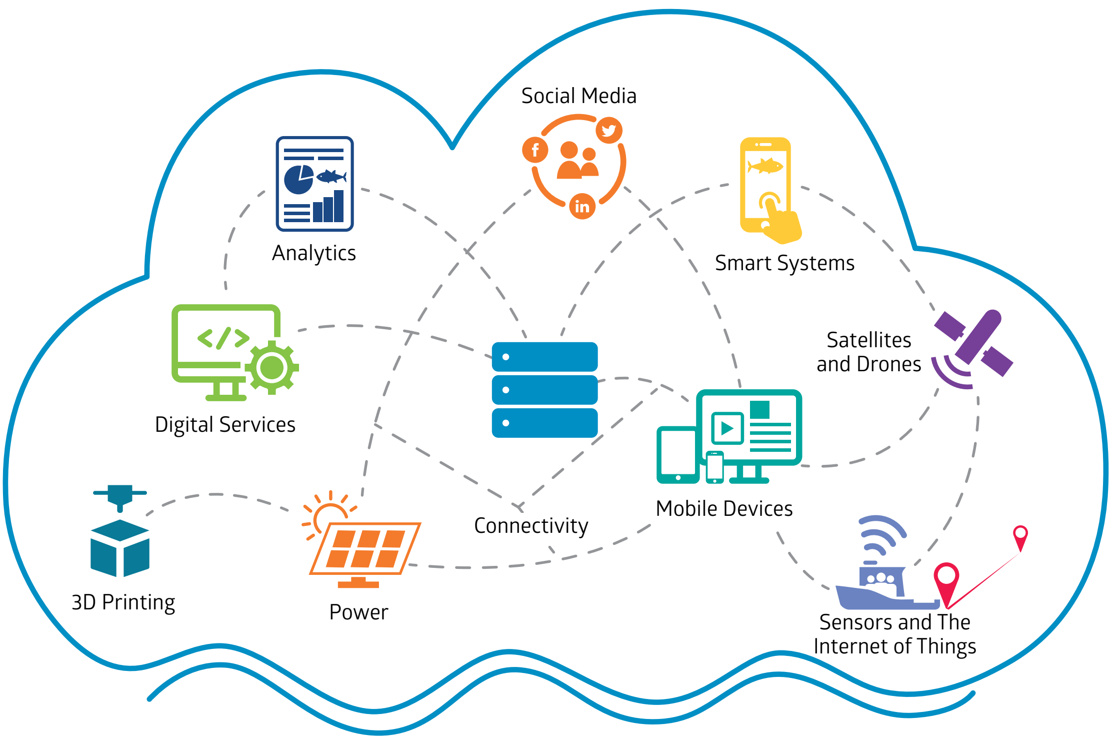
ICTs have shown a great deal of promise in raising awareness and building capacity to drive social behavior change (Box 12). But there is little published evidence of formal investment into innovation or application in this area of small-scale fisheries. This is true for the promotion of the SSF Guidelines themselves with small-scale fisheries actors (SSF Guidelines 13.3), or in terms of recognizing specific knowledge and roles of women in small-scale fisheries (SSF Guidelines 11.6). It is also true of the nutritional benefits of eating fish (SSF Guidelines 11.11) or recording and sharing traditional knowledge and cultural practices (SSF Guidelines 11.7). Evidence from case studies suggests that information exchange between small-scale fisheries actors often emerges organically through social networking, and that building on these existing platforms and capacities could be a way of leapfrogging learning and trust issues associated with new ICTs (Chapter 3). Working with local partners and the small-scale fisheries actors themselves to build from local knowledge, capacity and platforms is the greatest opportunity to leverage and scale technologies to achieve the objectives of the SSF Guidelines.

Introduction

Every digital action produces data, with more than 2.5 quintillion bytes produced by humanity each day (Margetts and Dorobantu, 2019). This data is being harnessed by businesses using artificial intelligence (AI) to add value and reduce the cost of goods and services each year by targeted advertising and predicting people's purchasing behavior. The promise of AI in research and development is the ability to optimize services and interventions at increasing precision to the needs of each community, household or person. In agricultural and fisheries systems, this could help predict and prevent shocks to livelihoods and production systems, such as disease, flooding or drought. All services provided to rural populations could essentially become cheaper and more effective with the increased proliferation and reduced cost of technology.

ICTs are the various tools and processes that enable users to collect, store, access, manipulate and transmit data and information. This categorization has necessarily expanded from technologies like television, telephone and radio to include the plethora of digital technologies, sensors and services that are connected to the internet or the cloud (Figure 2). ICTs can positively influence small-scale fisheries through two primary mechanisms: information provision and financial services. ICTs reduce the time and cost of communicating, which improves the speed and flow of information between actors within formal and informal networks. With the introduction of mobile money, small-scale fisheries actors can access financial services that enable them to lower transaction costs and increase profitability by shortening value chains. However, there is still a substantial "digital divide" separating the banked, literate, affluent smartphone owners from the poor and marginalized groups and communities that are socially, geographically or digitally excluded from these opportunities and benefits.

Figure 2. Types of information and communication technologies.



Note: Connectivity pathways for visualization only; they are not exhaustive.

More than 40 million people worldwide are directly involved in small-scale fisheries for their livelihoods, and they are responsible for approximately 50 percent of the global capture fisheries landings in developing countries (FAO, 2018). Yet it is the remote and dispersed nature of small-scale fisheries that has traditionally made it a difficult sector to fully capture in official statistics, so the contributions of small-scale fisheries to livelihoods and food and nutrition security are largely unknown.

The SSF Guidelines (FAO, 2015) have brought a new focus on small-scale fisheries. They set out broad objectives to support responsible fisheries and sustainable social and economic development of small-scale fishers and fish workers, with particular attention to vulnerable and marginalized groups. The guiding principles of the SSF Guidelines are based on international human rights standards, responsible fisheries practices and sustainable development according to the United Nations Conference on Sustainable Development (Rio+20) outcome document.

As it stands, there is little available information that explores the potential for ICTs to contribute to social outcomes that enable inclusive governance, such as gender equality, accessibility, empowerment, fisher welfare and equal rights. Furthermore, the broader underlying factors that impact the uptake and sustainability of ICT4SSF initiatives, such as digital literacy, cost of technology, local legitimacy and accessibility, remain largely unexplored in small-scale fisheries. The challenge is to ensure that both the risks and opportunities of ICTs, when considered against the principles and aspirations of the SSF Guidelines, are understood and considered as countries move ahead with the implementation.

This report aims to share experiences of successes and failures in the application of ICTs and to synthesize an understanding of how they are and can potentially enable the implementation of the SSF Guidelines. Case studies are presented to provide insight into the challenges and opportunities of using ICTs in small-scale fisheries, and they highlight many of the common uses and intended outcomes. This is not an exhaustive review of the technologies available for use in small-scale fisheries, but rather an exploration into key processes and mechanisms that maximize positive outcomes and sustainability.

Box 1. Lessons from e-agriculture

Gerard Sylvester (Gerard.Sylvester@fao.org)

FAO's definition of agriculture includes crop-based agriculture, forestry, fisheries, aquaculture and livestock. Three-quarters of the world's poor live in rural areas and make their living from agriculture. There are strong, direct relationships between agricultural productivity, hunger, poverty and sustainability. With the increasing challenge of feeding an ever-growing population, the agriculture sector has been continuously reinventing itself, more so in the past decade.

The past ten years have seen phenomenal advancement of ICTs. Agriculture has seen a rapid rise in the use of these emerging technologies and tools (e-agriculture, digital agriculture, information and communication technologies for agriculture (ICT4Ag) to address some of the challenges faced in the sector. At the same time, the farming community has had to deal with a decrease in the amount of arable land, an increase in pests and diseases, and challenges from drastic weather patterns attributed to the effects of climate change, as well as challenges from the industrialization of agriculture. The lack of actionable information makes farming one of the most challenging occupations in the world. Capture fisheries are characterized by unique and even more stochastic challenges related to their "crops" being highly mobile and, to all intents and purposes, invisible. Fisheries livelihoods are increasingly risky, unpredictable and less rewarding in the context of climate variability, deteriorating ocean health and declining fishstocks.

In this context, information and communication tools and technologies that enhance decision-making through accurate, reliable and timely information have an important role to play. For example, digital marketplace applications such as *Esoko* founded in Ghana (Box 9) connect farmers to neutral price information from input sellers and output buyers. Both old and new technologies hold great promise in addressing some of the challenges in agriculture. These include established technologies, such as radio, television, and fixed and mobile telephones, as well as emerging technologies, such as the use of drones, 3D printing, connected networks, the internet of things (IOTs), low-cost high-power sensors, precision agriculture and blockchain (Box 7).

The growth of ICTs in the past decade has exceeded the ability of most governments to keep up with it. Many challenges remain that impede the deployment of appropriate ICTs for agriculture development at a large-scale. For example, the lack of appropriate national strategies, weak collaboration between stakeholders, lack of leadership, weak regulatory frameworks, lack of interoperability and standards, and a lack of clarity about sustainable business models highlight challenges that need to be addressed if we are to achieve the best outcomes from emerging and innovative technologies. Yet even the failures of ICT projects and technologies are vital for learning and adapting the way that ICT initiatives are developed and propagated in specific contexts.

Sustaining such ICT4Ag services and solutions needs a multistakeholder approach, and the key building blocks need to be put in place to sustain such initiatives. FAO, together with the International Telecommunication Union, has been assisting countries in developing national e-agriculture strategies to help rationalize financial and human resources, as well as to holistically address the ICT opportunities and challenges for the agricultural sector in a more efficient manner. The overall aim of an e-agriculture strategy is to generate new revenue streams that improve rural livelihoods in alignment with government plans so that projects and services are not implemented in isolation. Despite the inclusion of fisheries in broad definitions of agriculture, however, small-scale fisheries do not factor in many or indeed any e-agriculture strategies.

With the necessary components (Figure 2) there are a myriad of roles and potential benefits from ICTs in agriculture that might inform similar approaches in small-scale fisheries. These include stimulating investment in ICT infrastructure, reduced waste at various stages from sea to plate, developing value-added services and creating information-sharing networks that help foster preparedness for and response to climate change, natural disasters and other fisheries risks. These information-sharing networks can make a major contribution toward improving relationships between various value chain actors, forging stronger connections based on knowledge and information.

Mainstreaming potential ICT solutions

While the growth and opportunities provided by ICTs have rich potential to promote sustainable fisheries, developing an ICT tool is only part of the solution. The biggest challenge remains in mainstreaming the ICT into a sustainable solution. Emphasis must be placed on making sure the key building blocks or infrastructure needed to sustain these solutions are put in place. This includes buy-in from the main stakeholder, gender considerations, the budget to develop and maintain the solution for a period of time, a business plan to sustain the solution beyond the pilot stage, and the capacity to maintain and update the system. If an in-depth action plan is not put in place, each solution that is developed runs the risk of not moving beyond the pilot stage into the mainstreaming stage.

Figure 3. A stepwise process to identify the necessary e-agriculture components for sustaining ICT4Ag services and solutions.

Source: FAO-ITU.

Chapter 1.
Current and recent uses of ICTs in the small-scale fisheries sector

Chapter 1. Current and recent uses of ICTs in the small-scale fisheries sector

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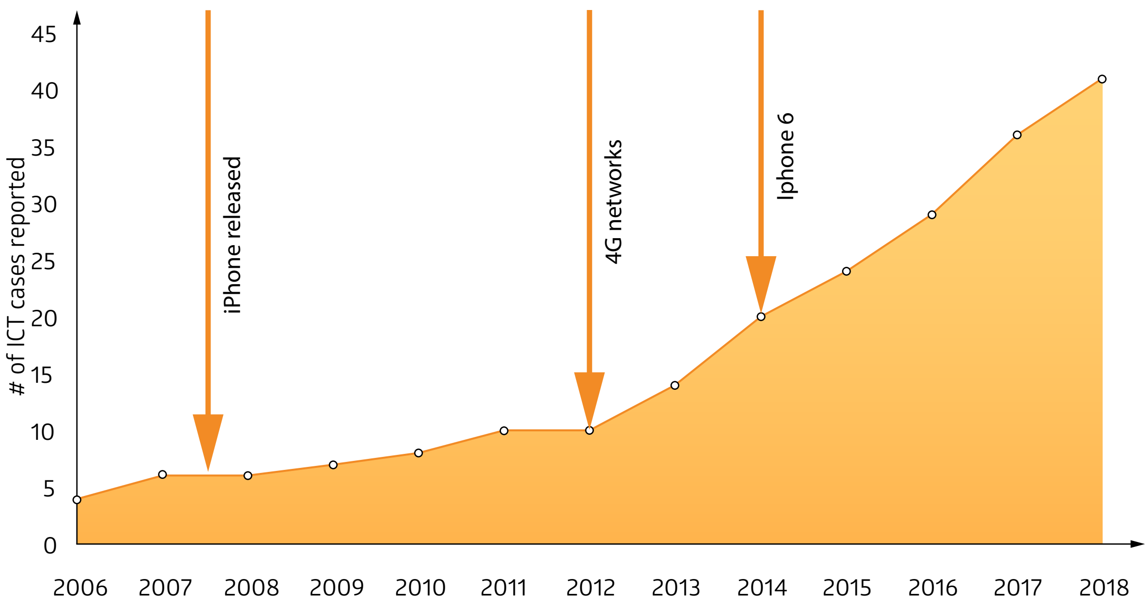
The use of basic mobile phones for agricultural value chain enhancements and interventions has been documented since the early 1990s, but the rapid acceleration of ICT4SSF began at the turn of the millennium. This acceleration of use can be traced to the proliferation of smaller, cheaper smartphones and the development of apps on mobile platforms Android and iOS (Figure 4). However, even now, the diversity of uses in small-scale fisheries is limited, and more than half of the recorded initiatives focused on documenting fish catches and tracing fish through supply chains from sea to table.

There are limited examples of the application of ICT for extension services and the well-being of fishers and fishworkers. This is likely due to an initial focus of ICTs on more straightforward digitization of already structured data, such as numbers and weights of fish. The emergence of other uses for well-being, social protection and marketing, for example, rely on more literacy, digital inclusion, institutional capacity and networked solutions that build on existing infrastructure. For example, the Emergency Position Indicating Radio Beacon is a well-developed and effective technology for sea safety and rescue, but it is still far too costly for most small-scale fishers and relies heavily on a network in place to effectively and rapidly answer a distress signal.

Figure 4. Cumulative frequency of ICT4SSF cases reported through time in literature and on mobile application stores.



Notes: Based on the date of publication and/or project inception if stated. (N=41, See Appendix 1 for details)

Table 1. Different types of technology (n=6) identified during the review.

Technology		Description
Mobile phones	Voice and SMS	Hardware device used for communication through calling or SMS messaging.
	Phone apps	Computer programs and software applications designed to run on mobile phones. Phone applications can have multifunctional uses to integrate aspects of communal data sharing and networking.
GPS hardware devices		A device installed on fishing vessels that uses a radio navigation system to allow users to determine their location, velocity and time.
Video monitoring devices		A device installed on fishing vessels that records video of fishing activities.
Databases		A communal information source of fishery data. Data can be shared or uploaded in real-time (dynamic) or assembled beforehand (storing). Databases are typically accessed via the internet.
Blockchain ledger or ecosystem		A digital ledger is distributed, decentralized, verifiable and irreversible. Typically it is used for tracking fishery supply chains. An ecosystem is a ledger with an associated digital currency.

Note: See Appendix 2 for methods.

ICT uses by geographical distribution

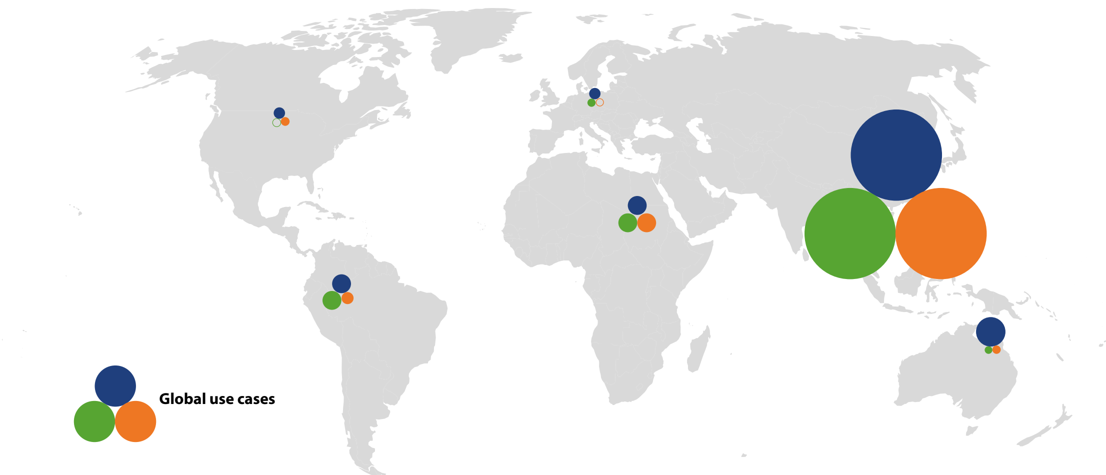
Individual ICTs were categorized into the geographical regions where they had localized outputs. Cases could be tagged to more than one region as well as more than one use category. Those that could be tagged to more than two regions were categorized as global — for example, the Too Big To Ignore (TBTI) information system (Box 4). Overall, catch data analysis and management (44 percent of cases) was the most prevalent use, followed by traceability (41 percent) and safety at sea (39 percent). Asia had the most encountered cases of ICT use, with 18 cases (Figure 5), followed by global (9 cases) and Latin America (6 cases). This was somewhat expected given the dominance of small-scale fisheries in Asia in terms of fleet size and employment (FAO, 2018).

ICT cases in Asia were spread among the three use categories, but safety at sea (category 2) was the most frequent use of ICTs in Asia, with ten individual cases recorded. Following this was value chain and post-harvest (category 3) with seven cases recorded, traceability (category 3) with six cases and effort tracking (category 1) with five. The majority of global ICTs involved components of traceability (seven of the nine cases recorded). With increasingly globalized fish trade supply chains, the prevalence of global scale ICTs for traceability seemed logical.

Africa had a relatively even spread among the use categories. Catch data analysis and management (category 1), extension services (category 2) and value chains and post-harvest all had two cases recorded. Included here is the mobile application suite ABALOBI (Box 9), which had the broadest uses (all three use categories) of all the cases we encountered.

In Latin America, the most common ICT uses were for catch data analysis and management, as well as safety at sea, with three cases recorded for each. One such case that was developed for safety at sea in the Caribbean, mFisheries, is discussed in greater detail in Chapter 6. The two regions with the lowest ICT usage were Europe and North America, with just one case recorded for each. Many uses of ICTs emerged from these regions, but most were developed for commercial fisheries, so they were excluded from our review. For detailed methods of the ICT4SSF review, see Appendix 2. For a full list of identified technologies, see Appendix 3.

Figure 5. Distribution of ICT4SSF by use category and geographic region (Global, Latin America, North America, Africa, Europe, Asia, Oceania). Bubble size is proportional to frequency of use cases within the three broad use categories. Open bubbles represent zero use cases.



Source: SlideGrin LLC/Infograpia.com (2020).

Table 2. Distribution of ICT4SSF by technology type.

	GPS	Video	Blockchain	Databases	Voice/SMS	Phone Apps
	4	1	0	5	0	11
	3	0	0	1	2	2
	0	0	0	1	3	3
	6	0	0	1	3	9
	0	0	0	2	4	4
	2	0	4	6	0	8

= Governance of tenure in small-scale fisheries and resource management
= Social development, employment and decent work, disaster risk and climate
= Value chains, post-harvest and trade.

ICT uses by technology type

Individual ICTs cases could be tagged to more than one technology type as well as more than one use category. Mobile phones and applications made up the majority of cases recorded, with 66 percent (Table 2). Within this, most use cases of mobile phones pertained toward phone apps (49 percent) as opposed to voice and SMS services (17 percent). However, examples of mobile phones being used are particularly hard to quantify, as most are informal in nature and not documented. Even for the use of phone applications, there are many informal and decentralized uses. For example, only through discussions with key practitioners was it learned that WhatsApp messaging groups were formed by fisher groups in Southern India for safety at sea (Chapter 3).

Overall, mobile phone cases engaged with all the different use categories. The most prevalent use for either phone applications or voice and SMS services was for safety at sea (category 2) with 12 individual cases. The next most prevalent technology types recorded were databases (22 percent) and global positioning system (GPS) devices (17 percent). In one instance, these two technology types were from the same case. Pelagic Data Systems (PDS) installs GPS trackers on small-scale fishing vessels that collect a range of data and then feed it into web-based databases (Box 3). These databases can then be accessed to provide advanced data analytics for a range of uses, including catch data analysis and management, effort tracking (category 1) and traceability (category 3). There are also examples of databases linked to phone applications for easy accessibility.

More recently, there have been a few examples of blockchain technology being used in small-scale fisheries, at 10 percent of cases (Box 7). Interestingly, all these cases were explicitly for traceability in supply chains. Although this is an increasingly popular topic in terms of large investments in this sector, there are concerns over its effectiveness to increase the transparency of fishery supply chains. The technology was initially developed for cryptocurrencies and might not be a fit for tangible products or goods trading hands where initial mislabeling of products at the start of the chain is still possible. However, through discussions with key practitioners, early evidence suggests that the greatest promise for blockchain technology comes from its ability to improve trust in cooperative arrangements where transactions are digitized. The least prevalent technology was a video monitoring system, with just 2 percent of cases. This is most likely a result of the high investment costs needed to purchase the hardware devices compared to the relatively low volume and value of small-scale fisheries per vessel catches.

Box 2. Digital and analytical tools make fisheries self-reporting cheaper and more accurate

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Small-scale fisheries are often in isolated areas and are typically characterized by multiple actors, landing sites, fishing gear and species. This makes the routine collection of reliable catch and effort data cumbersome and expensive. In many developing countries, there is a general lack of quantitative fisheries data from most small-scale fisheries (Mills *et al.,* 2011; Kolding *et al.,* 2014), likely constrained by the costs of sampling (Stamatopoulos, 2002).

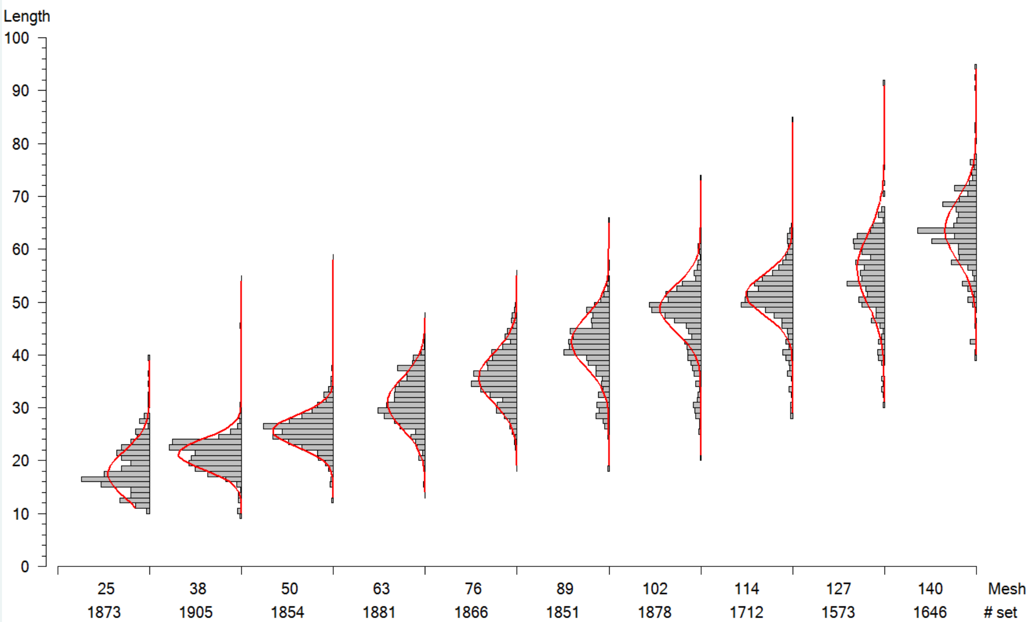
Traditionally, data is collected by government research officers or enumerators, and digitizing this process does not represent a magic solution for quality data collection. Poor data inputs will merely lead to poor evaluation outputs. Ideally, fishers and community members actively participate to collect fisheries information to strengthen co-management, but this adds further logistical and capacity challenges to data checking and quality.

Catch is mostly reported by weight only, as this is the basic standard unit used (Sparre, 2000; Stamatopoulos, 2002). Such data, however, has limited value for scientific stock assessment and typically belongs to what is known as data-limited, or data-poor, fisheries (Pilling *et al.,* 2008). Also, there have traditionally been no ways to evaluate or judge their representativeness, inherent bias or general validity in an effective way. The near real-time analytical potential of digital monitoring systems allows for collecting reliable, high-resolution (i.e. at the level of individual fish) data, which can serve both statistical and stock assessment purposes, but also cost-efficiently verifies data being inputted in remote locations.

An example of this comes from a participatory data collection system that was developed and tested in the remote Bangweulu swamps of Zambia that used fish lengths instead of weights (Ticheler *et al.*, 1998; Kolding *et al.*, 2003). Fish length data was verifiable and could be validated because the accumulated size frequencies could be easily checked for their respective distributions (Figure 6).

Specifically, the expected size distribution of a fish species caught with a particular gear or mesh size is usually known and often close to being normally distributed from gill nets or hooks. At the same time, it is virtually impossible for any individual to construct and record such distributions in random order. As a result, automated analytics can be used to check if the incoming data fits the expected distributions within a confidence interval, as in Figure 6. If not, it can be flagged in the database and the enumerator contacted to investigate the source of the error.

Figure 6. Cumulated size frequencies of African catfish (*Clarias gariepinus*).



Note: The catfish were caught and recorded by six different local fishers using fleets of experimental gill nets during one year in the Bangweulu swamps (Northern Zambia). Superimposed (red lines) are the fitted normal selectivity distributions in each mesh size.

Chapter 2.
PeskAAS: A near real-time monitoring system for small-scale fisheries in Timor-Leste

Chapter 2. PeskAAS: A near real-time monitoring system for small-scale fisheries in Timor-Leste

Alex Tilley, WorldFish, Malaysia (A.tilley@cgiar.org)

Highlight summary

This chapter presents and critiques the evolution of a data collection and monitoring system for small-scale fisheries in Timor-Leste. This system integrates collation and analytics of high-resolution tracking and digital landings collection to feed a decision dashboard for managers. It presents challenges, failures and preliminary successes encountered so far along the journey and explores if, and how, more and better data could contribute toward achieving the objectives of the SSF Guidelines.

Background and context

Poor fisheries management squanders roughly USD 80 billion annually in lost economic potential and 11 percent in catch potential (World Bank, 2017). Every day, around the world, approximately 40 million fishers go out to fish, but we have little idea of where they go or what they catch, not to mention the importance of these catches for income and food and nutrition security. Small-scale fisheries landings contribute to the diets of at least 1 billion people worldwide, but given how little we know about small-scale fisheries in low-income countries, this is likely to be substantially underestimated. A great many small-scale fishers subsist or gain income through informal transactions, which makes them difficult to track and quantify. This, combined with the scale and diversity of small-scale fisheries, has presented major challenges to documenting them in detail to date. However, the size and low cost of emerging technologies could present solutions to this longstanding data gap.

Figure 7. Map of Timor-Leste within the Coral Triangle.

Source: Tilley *et al.,* 2019.

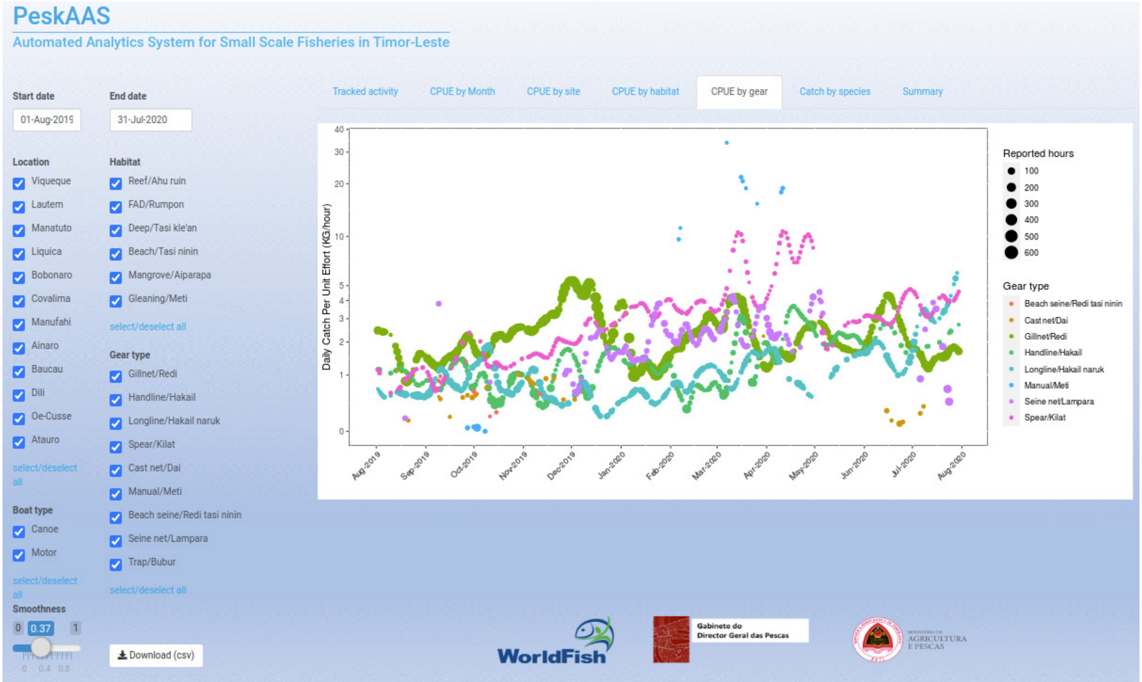
As one of the youngest countries in the world, Timor-Leste (Figure 7) lacks established institutions and historical data to appropriately assess and manage its natural resources. More than 80 percent of its 1.2 million population is reliant on agriculture and fisheries, are not part of the formal economy and much of their livelihood activities are subsistence. Despite being in the relatively fortunate position of having a sovereign wealth fund built from oil exploitation, Timor-Leste still faces significant challenges in combatting poverty and hunger, with one of the world's highest rates of child malnutrition.

Fisheries in Timor-Leste are almost exclusively small-scale, and research suggests that fish and fisheries have the potential to tackle nutritional and livelihood objectives of national and international development goals (Lopez-Angarita *et al.,* 2019; Mills *et al.,* 2013; GOTL, 2011). In 2016, as part of the Norwegian funded Fisheries Sector Support Program, WorldFish began to work with the Fisheries General Directorate (DGP) to design a digital system to understand the current and potential value of small-scale fisheries in Timor-Leste.

The system is called peskAAS — a pseudo acronym that comes from the word for fisheries ("peskas") in the national language of Timor-Leste, Tetum, combined with "Automated Analytics System." It is a data pipeline that starts with data collectors at hired community landing sites around Timor-Leste recording and sending catch data with smartphones and tablets. They record the catch of any fisher they encounter, as well as the ID code of their vessel tracking unit (Tilley *et al*., 2020b). The vessel tracking units are solar-powered, buttonless, archival GPS trackers developed by project partner PDS (Box 3). They also allow for continuous recording of a vessel's position, whether moored or moving. Even if the solar panel is covered, it can continue to record for 1 month. This data is then sorted and added to an online database, run through various statistical analyses using R3 scripts and presented on a dashboard using the Shiny web application framework (Chang *et al*., 2019) (Figure 8).

[3] R is a free, open source language and environment for statistical computing and graphics.

Figure 8. The peskAAS dashboard.



Note: A decision dashboard co-designed with Timor-Leste government partners to visualize and analyze small-scale fisheries data for science-driven decision-making. Data can be viewed on a series of tabs including a map view, CPUE variables and a tabulated summary that can be downloaded. The checkboxes on the left allow the user to filter results by date range, gear, habitat, boat type and municipality. The slider at the bottom left allows for easier visualization of trends by using a cubic spline with an adjustable smoothing parameter.

Process, participation and capacity building

Most applications of ICT4SSF have so far been attempts to field-test new technologies developed externally from the socioecological systems, fisheries and communities they are attempting to help. This is partially true for peskAAS in Timor-Leste too; neither the source of the technology nor the implementing institution is Timorese. However, from the start, it was designed with and in response to feedback and information provided by fishers and fisheries officers. The survey form to collect catch and trip information was designed and deployed iteratively in order to test it with the target users and identify failures rapidly, according to principles of agile or lean development (Ries, 2011).

This project was user-centered from the outset, as it was established in response to the need for usable information about small-scale fisheries, and it involved fishers from the communities and fisheries officers of the DGP that would be gathering the data and acting on it. By involving them in the design, it was hoped that when it came to scaling the data collection, training more staff as data recorders and using the data for management, they would be familiar with the system and its use. However, the reality was dogged by limited capacity. When trying to work backward and frame the system based around the needs of government officers, this proved impossible because of the limited understanding of the information required for responsible fisheries governance, how to interpret the data and how that feeds into making policy decisions. This is through no fault of the Timorese, but rather, to some extent, the situation they inherited following their independence from Indonesia in 1999.

PeskAAS had the objective of improving the information available on small-scale fisheries. Of course, the ideal scenario for two-way information flow to and from fishers would involve fishers themselves recording and reporting catch data. But there are significant barriers to digital inclusion in rural Timor-Leste, such as the cost of technology and data, as well as literacy, leading to low rates of smartphone ownership. In the short term, the decision was made to hire enumerators from the selected landings sites, who would be paid to survey fishers' catches every day on a supplied tablet.

Enumerators required a lot of technical support and frequent feedback on landings data entered, but most were able to ensure continued, good quality recording. Enumerators were connected via a WhatsApp group for technical support, but this forum also proved to be a popular and insightful aspect of the project. It was initially set up to allow collectors to talk to one another, seek assistance or share anecdotes. However, it became a fascinating lens through which we were able to visualize fisheries in Timor-Leste through the eyes of its coastal communities. Collectors and their friends would photograph things of interest and significance to them, related to fish and fisheries but also of cultural events in their villages.

Enumerators were also a valuable resource within communities for collecting local ecological and sociocultural knowledge relevant to fisheries, but also to feed information back to fishers and to facilitate the flow of communication between the government and the communities. Fishers are often assumed to be distrustful of monitoring systems and reluctant to share information about their fishing activities, so fitting vessel trackers was expected to meet with resistance. In Timor-Leste, however, generally this was not the case. More frequent disputes occurred over who was deserving of receiving a tracker, rather than by fishers not wanting to be tracked.

Achievements and failures

The peskAAS system in Timor-Leste has shown early successes and impact in terms of policy outcomes. PeskAAS is now the official national fisheries monitoring system of the Timorese government, and this rapid and nationwide uptake is attributed to the co-design process with fisheries managers (Tilley *et al*., 2020b). By plugging a significant historical data gap, it is already supporting science-based, gender-sensitive policy decisions for governing vital aquatic resources. Furthermore, this previously impossible visualization of fisheries as a key livelihood activity for hundreds of rural communities has brought with it increased momentum and political will to strengthen the sector and decentralize inclusive governance of aquatic foods in Timor-Leste.

With peskAAS, Timor-Leste now has one of the most sophisticated monitoring systems for small-scale fisheries in the world. Where previously fisheries regulations were based on inappropriate and outdated Portuguese legislation, new insights into fishing patterns, production levels and fish-based livelihoods have already had profound effects on the perception of fisheries in the country. Armed with high-resolution data and with assistance from WorldFish, the Government of Timor-Leste has revised its fisheries law and conducted nationwide consultations with fisheries stakeholders at the community level to draft a new national fisheries strategy.

The catch survey questions were improved and updated numerous times based on field testing with enumerators, and records of size, catch, duration or price outside of error boundaries were flagged automatically for further investigation. This process highlighted the crucial need for contextualized question wording and units. For example, units of sale were nonstandard and locally specific in Timor-Leste, so enumerators had great difficulty in converting to standardized units of weight. Testing questions by deploying them and gathering quantitative and anecdotal feedback from enumerators about their success allowed insight into why the question was confusing or nonsensical in a local context. For months, the same species was recorded under two or three different names due to local dialectal differences. While the tools available for translation are improving, the co-design process was critical to achieving both quality data and local legitimacy with enumerators and managers.

A weakness of peskAAS, paradoxically, is contained within the attempt to integrate the existing national fisher registry into the system. A fisher registry set up in 2012 by the Regional Fisher Livelihoods Programme that also trialled initial fisher tracking technology (FAO, 2007) had not been updated since the end of the project, yet the DGP was keen to maintain the registry of vessels. However, in deploying vessel tracking units on boats around the country, it quickly became clear that many of the registered vessels no longer existed, and many more fishers and boats were unregistered, so there was no vessel code to link fish caught with the trip information. Had a complementary registry system been developed from the outset, this would have allowed for much better tracking distributions and easier estimation of national production figures. These problems are not insurmountable, but they present significant delays in providing useful information for management and development interventions.

Broader outcomes and sustainability

Small-scale fishers have access rights to sea space and resources, but the challenge remains how to assist them to assert these rights in the power discourse of the blue economy. Community-based monitoring is one way to do so, by building a detailed and tangible illustration of their fishing behavior and catch rates over space and time. By involving stakeholders in monitoring and recording their own activities, they can learn to speak the management language and provide an entry-point to broader access, acknowledgment and acceptance.

PeskAAS is transparent, open-source and open access, with all stakeholders able to see the data aggregated to the municipal level (Tilley *et al*., 2020b). As a fisher or fisheries manager, all you need is a computer, tablet or smartphone and an internet connection to use peskAAS. However, peskAAS still falls a long way short of empowering individual fishers to improve their own lives. Data generated by peskAAS was used to show how fishing technology could bring improved catch rates and return on investment in Timor-Leste (Tilley *et al.* 2019), which provides meaningful information for developing new government programs and interventions. But peskAAS does not yet put the data into the hands of the fishers. The information does not currently bring new opportunities or benefits to individual fisheries actors other than long-term and relatively intangible assurances of resource sustainability.

The promise of co-management or the potential of data systems to improve the sustainability of shared resources is unlikely to be a sufficient incentive on its own for fishers to engage and participate in data collection. Even in examples of projects that hand out mobile phones to fishers, there is no sustained investment because people whose livelihoods are labor intensive and often subsistent, prioritize other activities over completing lengthy data forms. As a result, they will either stop submitting data or take shortcuts, such as inventing the data later (Ticheler *et al.,* 1998). It was decided from the outset to pay data collectors. This presents long-term financial sustainability concerns in unstable political and economic scenarios common in Timor-Leste and where the record of government spending on agriculture and fisheries is not strong.

High-resolution fisheries data over time and space has the potential to increase efficiency in fisheries supply chains by improving catch rates or reducing fisheries rent, such as fuel costs, but there is no easy way to relay this information to fishers on a broad scale. This data is provided by fishers and should belong to them, but the key constraints to fishers "owning" the data are much larger development challenges, such as illiteracy, poor infrastructure and the cost of technology. Gender inequality, specifically, is an ongoing challenge in Timor-Leste, where still fishers are perceived as "men in boats," but where a large proportion of the nutritious food being provided at the household level comes from women's fisheries (Tilley *et al*., 2020a) and fish trade. One area that peskAAS has so far failed to adequately monitor and quantify is the contribution of "informal" fisheries, such as gleaning[4] by women. Relevant questions were integrated into the catch form, but these questions will only change with substantial alterations in behavior on the part of fishers, data collectors and managers.

Most fishers were willing to install a solar-powered tracker on their boat. If greater restrictions and/or no tangible improvements occur as a result of these interventions, will fishers grow disgruntled and less willing to cooperate? Experience suggests they will, but as of yet there is no cost to them carrying the tracker, neither in effort nor in repercussions. A relatively straightforward method to ensure continued data compliance is merely to regulate license creation or renewal based on contributions. However, research suggests that compliance is higher where fishers feel regulations are legitimized by appropriate processes and inclusion—especially of marginalized groups (Pomeroy *et al.,* 2015). As such, establishing processes to better feed information back to fishers and improve their capacity to both understand and use the information to improve their fish-based livelihoods will be imperative in achieving the objectives of the SSF Guidelines.

The technological aspects of the tracking and catch documentation systems have associated hardware costs (vessel tracking units and the smartphones/tablets), and PDS charges an annual subscription that covers the data costs. Also, ongoing technical support for maintaining peskAAS and adapting it to new needs will be required. At present, the business model of peskAAS is to support the ongoing maintenance and development of the open-access dashboard by charging governments a fee for the solution as a whole, which includes an advanced analytics platform and on-demand reporting. The data at this stage is collected by government staff, so they are not held by fishers but are reported back regularly to fishers.

The government has traditionally attributed little funding to fisheries (approximately 0.06 percent of the national budget). To encourage uptake and improve the financial sustainability of the system under the Fisheries Directorate, a gradual rollout was devised where project funding would support the hiring of a DGP officer for each coastal municipality for the first year. Their salary would be paid by the project, but they would be supervised by, and integrated within, the Ministry of Agriculture's human resources department. These staff members would continue to benefit from extensive support provided by WorldFish according to the existing model of working from within the DGP to provide ongoing support that is not restricted to specific project cycles. This mechanism has shown initial success, and the government has committed to covering the costs of enumerators and vessel tracking going forward, with WorldFish continuing to providing technical support.

Key lessons learned and recommendations

- High-resolution tracking of effort and landings of small-scale fishers provides tangible evidence of tenure rights in the blue economy by showing where they operate and the importance of their activities for livelihoods and food security.
- Small-scale fisheries vessel monitoring systems like peskAAS do not currently have the ability to contribute substantially to enhancing safety at sea in real time. In fact, many off-the-shelf solutions, such as SPOT devices (FAO, 2007), could induce fishers to take greater risks, emboldened by a false sense of security. However, better data on typical use areas, seasonal and diel fishing patterns, and boat ranges builds a knowledge base for maritime safety, improves accident prediction and avoidance, and can improve response effectiveness.
- PeskAAS was designed to collect sex-disaggregated data. However, it is limited as a mechanism to drive greater gender equality and mainstreaming in small-scale fisheries in Timor-Leste because of the male-centric bias inherent in fisheries (Tilley *et al*., 2020a). Specific research

[4] Gleaning is a method of fishing that involves manually collecting aquatic resources from shallow and intertidal habitats.

and development is required to ensure that ICTs are adequately representing and including women to transform gender norms in small-scale fisheries. Androcentric bias is pervasive and a constant challenge in distributed data collection systems. So to ensure equal representation and equitable distribution of benefits in a fisheries context, women must be directly and actively engaged in data collection. This will ensure that marginalized groups and informal fisheries that are notoriously hard to monitor are included in data and then in decision-making.

- PeskAAS presents a valuable solution to efficient and high-resolution catch documentation systems that can drive better management with science-based approaches. This data is gender disaggregated, but the ability for peskAAS to record traditionally underreported women's fisheries, such as gleaning, is still constrained by gender norms at the community level, where fishing is considered to be "men in boats." Furthermore, peskAAS is not yet an effective system to gather traditional, gendered fisheries knowledge from fishers and fishworkers. However, the system has proven useful as an intermediate step, where fishers contribute to knowledge creation that supports more effective government interventions. Fisheries extension officers at the municipal level should combine this scientific knowledge with the nuanced social, ecological and cultural knowledge of the resource users to allow for much more holistic, inclusive and informed management of fisheries systems.
- PeskAAS has begun to raise awareness of the need for communication and information, but there is still much need for broadscale awareness raising.
- The open access dashboard of peskAAS is an important step to ensuring transparency in small-scale fisheries reporting in Timor-Leste. Fishers can already access this data, but there are substantial social and economic barriers to their being able to. To fully engage fishers in generating data, having them own it and using it to empower their voices in decision-making and improve their lives in the process, a newly decentralized governance mechanism will be required that incorporates this system in municipal-level feedback meetings and strategic consultations. At this point, manual reporting back to tracked fishers appears to be sustaining their engagement.

Box 3. Pelagic Data Systems

PDS is an impact-focused technology company that provides vessel tracking solutions designed specifically for small-scale fisheries. The hardware is tiny, durable, completely solar-powered and fully autonomous, and encrypted data is transferred automatically via telecom networks to a secured server. The solution achieves exceptionally high-resolution tracking (up to a data point every second) that allows behaviors occurring at sea to be identified, alerts to be automated (e.g. when boats return to port) and is completely interoperable with any other traceability technology.

From the dataset generated, PDS provides a wide variety of solutions to social, environmental and business challenges. Linking the data gathered with existing supply chain tools enables sea-to-consumer traceability. With increased traceability, access to value-added supply chains (e.g. fair-trade premiums) is possible. Visualizing catch per unit effort as compared to raw fishing effort and catch discards allows management decisions to be based on hard data. Decisions based on this data can help ensure healthy fishstocks and stable revenues for fishers — protecting food security and livelihood welfare. Perhaps most important is the ability to use the information and visualizations generated in partnership with all stakeholders. This allows informed decisions to be made about how a fishery can be best managed to optimize win-win outcomes for industry and the environment, to build trust among stakeholders and to incentivize long-term social, financial and ecological sustainability. Building trust can be a formidable barrier to inclusive and participatory small-scale fisheries management strategies. But with hard data showing that fishers are working within predefined agreements, participatory engagement can be encouraged. In turn, stakeholders would be more amicable to engage in co-management types of activities when they feel more certain no one is cheating.

Currently, PDS works across sectors to partner with governments, communities, NGOs, academia and industry in more than 30 different countries around the globe. It supports the livelihoods of fishing communities and the sustainability of marine resources by advancing data availability, transparency, traceability and accountability. As a private sector company, there are costs involved to purchase the hardware and maintain the data service. But with a mechanism in place to allow fishers to manage their own data, it has the potential to be a catalyst for greater inclusion and participation in small-scale fisheries monitoring and decision-making.

Plate 1. Children and a fisher with a newly installed vessel tracking device on a small boat in Timor-Leste.

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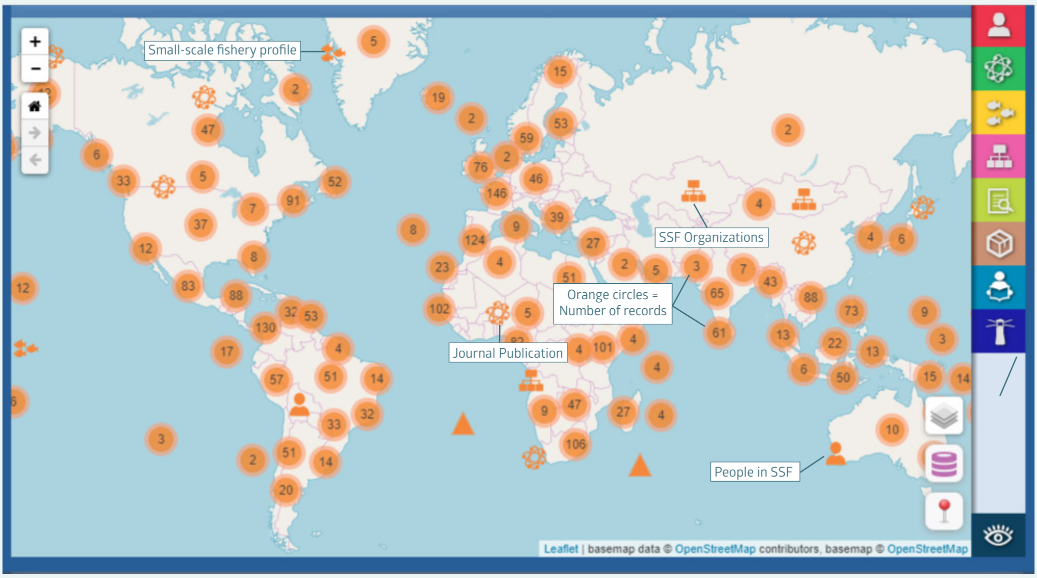
Box 4. Information System on Small-Scale Fisheries (ISSF)

The diverse characteristics of small-scale fisheries present substantial challenges to the complete capture of information by traditional monitoring systems. This often results in a lack of integrated and up-to-date data, which further marginalizes the sector in policymaking and governance. To help rectify the situation, the TBTI project (toobigtoignore.net) developed the Information System on Small-Scale Fisheries (ISSF). The ISSF is an online, interactive, open data platform that collects and visualizes knowledge about small-scale fisheries around the world (Figure 9). Data is crowdsourced, allowing anyone to contribute information and access aggregated data through coordinated online maps and table views. The functions and features of this platform foster collaboration and knowledge exchange among small-scale fisheries stakeholders, as well as forming a collective archive of information on small-scale fisheries.

As of February 2020, the ISSF contains data from 468 contributors in 63 countries. Although about 60 percent of the contributors are from North America and Europe, the majority work in developing country contexts. Information can be explored and extracted by country and thematic distribution (e.g. ecological) of small-scale fisheries research, fishery characteristics and gear, management measures (e.g. marine protected areas), governance modes and key issues (e.g. gender). There is no empirical evidence so far that evaluates the performance of the ISSF in research outcomes, policymaking or advocacy at local, national and international levels.

Figure 9. Information System on Small-Scale Fisheries (ISSF).



Source: https://issfcloud.toobigtoignore.net/. Conforms to Map No. 4170 Rev. 18.1 UNITED NATIONS (February 2020)

Challenges and future

The ISSF was the first extensive set of small-scale fisheries data ever assembled, resulting from significant global consultations with a range of stakeholders, and it represents an important step. Nevertheless, there are significant challenges in the approach of crowdsourcing with web-based technology. The first relates to quality of data, which can be inconsistent. To mitigate this, the ISSF employs a peer-review process and allows any ISSF user to leave a comment on any data record, possibly sharing insights or concerns about the quality of the data. Second, despite integrating the Google Translator plugin, language restriction is acknowledged as creating a bias toward information available in English. Third, the majority of small-scale fishers might not be able to access the ISSF due to inadequate or nonexistent internet connections. To overcome this, several options have been discussed, including developing ISSF into a mobile application. Lastly, sustaining user engagement beyond initial promotional periods is a challenge. Automated data mining approaches could assist in updating data from published papers and other sources. Otherwise, incentives for diverse target groups will need to be considered to encourage participation and contribution by more than the most diligent small-scale fisheries stakeholders. Ultimately, the amount and quality of information in a crowdsourced system like ISSF is subject to the availability of the information, the willingness of the contributors to interact with the system, and ease of access, all of which need to be considered in the future phases of TBTI.

Chapter 3.
Building technology enabled capacity for small-scale fishers in South India

Chapter 3. Building technology enabled capacity for small-scale fishers in South India

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Highlight summary

Internet and digital technologies have influenced most fields of human endeavor today, and small-scale fisheries are no exception. However, the fisheries sector presents formidable barriers to the use of technology, including the lack of availability of internet at sea, limited access to power sources during fishing trips, the harsh operating environment that requires marine-proofing of equipment, the limited budget possessed by fishers, and in some cases a relatively low educational level among users. Despite these limitations, there are several interesting uses of technology by small-scale fishers in the case of South India. This chapter looks at three of these technologies: mobile phone applications, WhatsApp messaging groups and radio communications. In the immediate future, the use of these (and other technologies, such as at-sea satellite internet) could increase, with a positive impact on the fisheries sector, particularly in terms of safety at sea, economics and risk reduction.

Background and context

The fisheries sector is significant in India in various ways. It represents nearly 1 percent of the country's gross domestic product (GDP) (approximately USD 30 billion) and employs approximately 14.5 million people, while contributing to food security and nutrition for many more (GOI, 2018). With some regional variations, it also significantly contributes to women's employment and poverty reduction. In India, the small-scale fisheries sector employs about 35 000 fishers directly and close to 1.5 million people indirectly. The diversity of fishing craft and gear is high in the country, especially in South India. The dominant types of small-scale fishing in the region, simplified for the context of this paper, include the following:

- Single-day coastal fishing (less than 24 hours): Most small-scale fisheries fishing operations fall under this category.
- Multi-day (2–7 days): Single-day fishing has been extended to longer durations through bigger crafts with fish holds, with the primary objective of saving fuel. These crafts also fish largely in coastal waters but can engage in search operations over larger areas.
- Long-distance (up to 45 days): This is a specialized group of fishers from the Thiruvananthapuram-Kanyakumari fishing villages, who traditionally targeted sharks and have now diversified to other species.

As with most other sectors, there have been several efforts to use ICTs in the fisheries sector as well. However, several challenges and barriers exist while trying to leverage ICTs into the small-scale fisheries sector. These include the following:

- A technology-hostile workplace, where the constant exposure to water, wind and salinity can be corrosive to electronic equipment. The constant motion and change of direction of the boats introduce challenges in directional antenna as well as other equipment.
- There is a lack of a reliable electricity sources (to recharge phones), particularly in smaller fishing craft.

- There is a lack of availability of internet connectivity at sea. In places where mobile phone towers are positioned near the coastline and/or located at sufficient height on the coast, cell phones work well up to 15–20 km from the shore. There is no other technology available for internet connectivity at sea for small fishing boats. There are efforts to make satellite phone technology — which currently has severe security restrictions in India — available for fishing craft, with one license granted to an operator, but this is expensive and not yet widely available.
- The available budget is limited for computer/communication equipment from the side of fishers. A complementary issue is the limited budget available to governments for ICT infrastructure as well as search and rescue, though this has improved lately. For instance, the Coast Guard and the Navy worked closely with civil authorities during the Cyclone Ockhi-related search and rescue.
- Among users, educational/technical levels remain relatively low. It is to be noted, however, that fishers, particularly youths, are no different from other communities vis-à-vis their competencies in the use of ICTs. However, the older generation of fishers might not share the dexterity of youngsters with technology, particularly as younger persons from the fishing community seek nonfishing jobs.

Relatively low-tech, VHF radio handsets are simple, self-contained and can be useful in some situations. For instance, in Kollam (formerly Quilon), Kerala, there appears to be a rapid rise in the popularity of cheap VHF handsets among small-scale fishers. The handsets have a short range of 3–5 km in the Simplex Mode[5] and messages are relayed between boats until they reach the target individual(s). This approach appears to be useful particularly for emergencies (at sea or onshore). It is also innovative, as it works even outside the range of repeaters, though currently there are no repeaters meant for fisheries use. The use of VHF handsets could increase further as one of the earlier issues was the tight security restrictions on spectrum use. At present, commercial product vendors appear to be taking care of the regulatory compliance angle.[6]

As mobile phones in general, smartphones in particular, have seen a rapid rise in adoption among most demographic groups in the past decade (including a section of small-scale fishers), NGOs and research institutions have made several efforts to introduce mobile apps that have a broad range of applications for marine fishers. This chapter looks at two of them.

The first is the Fisher Friend Mobile App (FFMA), an app developed by the well-known NGO M.S. Swaminathan Research Foundation in Chennai and supported by Qualcomm and the Indian National Centre for Ocean Information Services (INCOIS). The second is the mKrishi Fisheries app, developed by the Tata Consultancy Services Innovation Lab-Mumbai in collaboration with the Central Marine Fisheries Research Institute and INCOIS. Both have seen a fair degree of adoption and use by fishers. Table 3 compares the features of both apps. Screenshots of both applications are provided in Plate 2. Both are Android apps and are available in the Android App store. During installation, both apps confirm the mobile phone number through a one-time password process for user registration and security reasons. While this practice is generally followed by many other apps

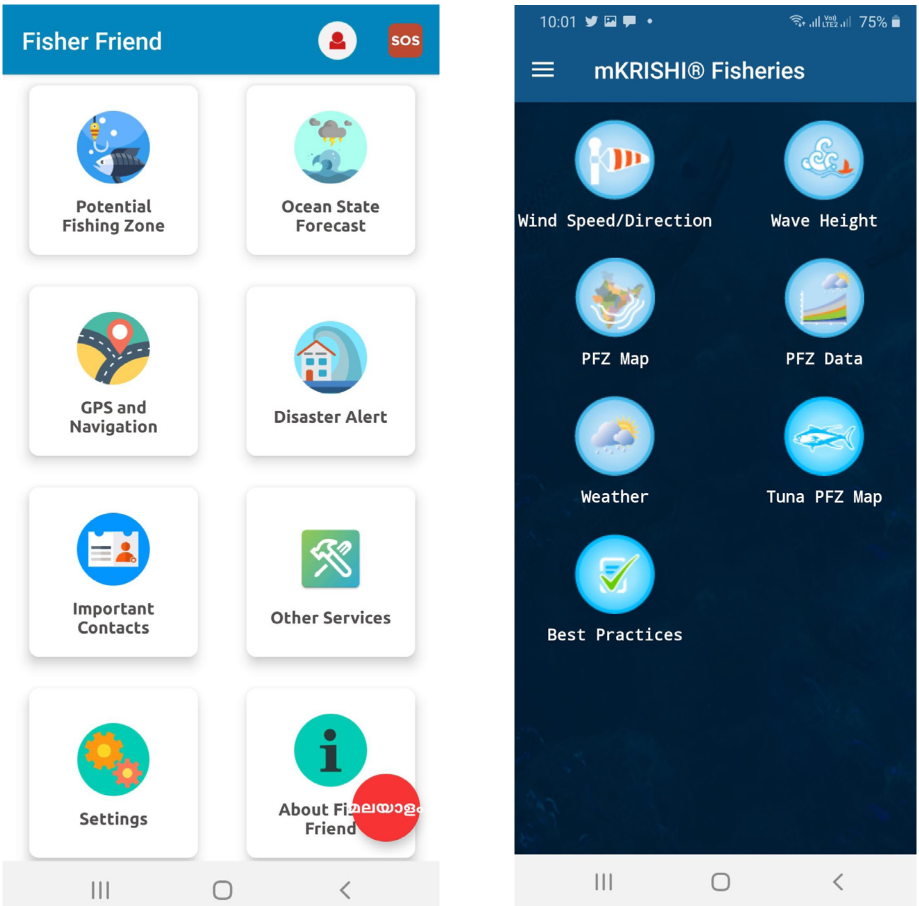
[5] VHF handsets work in both Simplex Mode, which is the handset-to-handset, line-of-sight mode, and the Duplex Mode where the communications flow as handset-repeater-handset. In the Duplex Mode, since repeaters work with two frequencies, the use of frequency is more efficient (in the Simplex Mode, communications by one pair of handset users blocks the frequency for all other users).

[6] From the information available, hand-held units used in Kollam are VHF sets (used by security agencies and radio amateurs among others) which require explicit licensing to be used legally, and not the license-free CB radio (26.957 MHz to 27.283 MHz). Equipment vendors are reportedly selling these handsets after obtaining licenses for fisheries use.

developed in India, when scrutinized closely there are often data protection issues.[7] The features that the apps provide are roughly similar and include five main categories of information: (1) ocean state and weather forecasts, (2) potential fishing zone advisories, (3) distress alerts, (4) navigation and GPS-based services, and (5) informational services. Importantly, this list of features is intended to be illustrative rather than exhaustive, and the apps seem to be integrating new features after consultations with fishers.

The most popular in the category of instant messaging mobile apps are WhatsApp and Telegram. In India, WhatsApp seems to be more popular, and fishers are no exception in using it. Since the app requires continuous access to the internet, it does not work while the boat is fishing beyond the range of mobile phones. However, WhatsApp is useful onshore, as well as during the time the boat is traveling (for fishing or returning from fishing) laterally, parallel to the coast and within mobile range. WhatsApp has been used by the Fisheries Department of the Tamil Nadu Government for creating groups of fishers for distress alerts as well as for other alerts, and it saw some success in Kanyakumari District of Tamil Nadu during Cyclone Ockhi in 2017. There are also reports of family WhatsApp groups for sharing fishing info, such as newly discovered fishing grounds, with friends and family without revealing the information to the public.

Plate 2. Screenshots of the Fisher Friend Mobile App (left) and the mKrishi Fisheries application (right).



7 There is no information available on the policy toward how personal information collected by the app is used, shared or retained (and for how long). The app is likely to collect location information in addition to the mobile number. As General Data Protection Regulation (GDPR)-like data protection legislation in India is still under development, a policy on the use of personal data is not mandatory, but it would be doubtless and desirable.

Table 3. Comparison of mKrishi and Fisher Friend mobile apps for small-scale fisheries.

Item	mKrishi Fisheries	FFMA
Wind speed/direction	Yes	Yes
Wave height	Yes	Yes
Past wind/wave height advisory	Yes	Yes
Potential fishing zone map	Yes	Yes
Potential fishing zone data	Yes	
Weather forecast	Yes	Yes
Tuna potential fishing zone map	Yes	
Best practices	Yes	
GPS-enabled navigation (including IBL alert[8])		Yes
Compass		Yes
Upload danger zones		Yes
Traditional fishing grounds		Yes
Disaster alert	Yes	Yes
SOS (distress messaging)		Yes
Multilingual		Yes
News, schemes, contacts		Yes
Number of languages available	8	8
Calculate distances	Yes	
Real-time wind/water current	Yes	

Process, participation and capacity building

For both apps, an external Indian agency has taken the lead role in developing the app: the M.S. Swaminathan Research Foundation for the FFMA, and an IT company called Tata Consultancy Services for mKrishi Fisheries. There are also back-end collaborators and information suppliers (INCOIS, the Met Department and other government agencies) in both cases that provide the dynamically changing information, particularly potential fishing zones and weather. The role of the lead agency is critical and involves a social intermediation component, given the fact that fishers will use the app along different parts of the Indian coastline.

Both lead agencies for these mobile apps have reportedly followed a consultative approach that involved extensive interactions with fishing communities. In the case of the FFMA, a total of 1 026 fishers across three states (Tamil Nadu, Puducherry and Andhra Pradesh) participated in the pilot phase (Anabel *et al.*, 2018). The app was conceived in 2007 on the BREW[9]/CDMA200 platform. After launching the platform in 2008, the app was ported into Android around 2011. Several versions followed, with field-level volunteers carrying out a social intermediation process with fishing communities at different centers initially in the coastal areas of Tamil Nadu, Kerala and Andhra Pradesh. This process provided training on the app, in some cases by distributing mobile phones with the app installed on a trial basis.

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[8] The International Border Line (IBL) between India and Sri Lanka is an often violated maritime boundary. This feature provides an indication when fishers inadvertently cross the boundary.

[9] Binary Runtime Environment for Wireless™ (BREW) is Qualcomm's proprietary application platform for developing wireless applications, originally launched in the early 2000s.

From interactions with users of the FFMA, it is understood that fishers have generally found the app useful. Ultimately, a section of users (15–20 percent) use most of the features of the app, and quite extensively. These are mostly younger and more innovative fishers. About half the users appear to use the application several times a month as their secondary source of data, with the primary source being their own traditional means. The rest of the users appear to be infrequent users.

While the apps do have visible strengths, continued offtake or scaling up in use is somewhat slow. In the case of the FFMA, a field team from the M.S. Swaminathan Research Foundation trained several thousand fishers in the early years, but it is not clear how many of the initial group continue as users and how many new ones have been added. A total user base of about 50 000 fishers and 4.8 million page views has been mentioned in the media.[10]

Some areas of weakness identified were that the information is not available on a daily basis and, at other times, the information provided by the app (e.g. wind speed and direction) is not intuitively understood by fishers. Furthermore, sometimes information is of inappropriate granularity (e.g. showing data for a district and not a particular village), or it is not directly usable (e.g. a potential fishing zone is located 65 km away when the boats of the village rarely go beyond 10 km).

In contrast, adopting the two other technologies — WhatsApp groups and VHF radios — are essentially processes that originated organically from within fisher communities.[11] Some of the issues faced are perhaps transitional in nature. Specifically, technological adoption in traditional communities is often a nonlinear process, and a few demonstrations of the capabilities of the app (lives and property saved, or high-value fish landed would be two of the most important) would likely be more effective than training or pushing the technology. As the next generation of fishers enters the workforce, there is likely to be easier and more natural adoption of these and other apps.

Digital trust drives the frequency and depth of use and thereby the sustainability of the ICT. As the primary stakeholders of their own livelihoods, fishers pride themselves on their knowledge of the seas, weather and fish stocks. Consequently, they tend to trust their own instincts over new technology. However, increasing variability of climate conditions and safety at sea (Sainsbury *et al.,* 2018) has brought fishers to question their understanding of the behavior of the sea. For example, Cyclone Ockhi in 2017 caused 218 casualties in India, almost all of them fishers at sea.[12] This left many fishers, including veterans, bewildered because they did not expect a cyclonic storm to develop on the west coast during the end of November and so were completely unprepared for it. To build greater trust of new technology, developed applications must build scientific knowledge onto traditional knowledge systems, be adaptive and responsive, and provide guidance based on a holistic view of the information.

Achievements and failures

The use of ICTs appears to have a positive impact in several aspects, including safety at sea, communication at sea or onshore, cost and time efficiency, and fishing capacity (Table 4). Apps can be useful as an information delivery platform as well as a data source from a fisheries management perspective. Assuming fishers consent to it, the location of fishing grounds they visit can easily be mapped, and overexploited grounds identified. If fish catches could be recorded on the app, it would provide rich information to biologists, economists and policymakers. More crucially, it could potentially empower fishers themselves by putting data in their hands to make decisions about their own livelihood activities.

[10] https://timesofindia.indiatimes.com/city/chennai/mssrf-to-conduct-stakeholder-meet-on-fisher-friend-mobile-app/articleshow/68173534.cms
[11] Noting that the adoption of VHF handsets has benefitted from the push by vendors of the equipment.
[12] The west coast of India does not usually see cyclones — in stark contrast to the east coast, where multiple cyclones are an annual feature in the Bay of Bengal.

From a social perspective, diverse and substantial financial, educational and normative barriers restrict the use of ICTs. So far in India, adverse impacts from ICT use have not presented themselves, but the digital divide has huge potential to exacerbate power hierarchies and elites by favoring literate, wealthy, connected actors in the management of specific fisheries over those who cannot access the technology.

Table 4. Potential positive impacts of using FFMA and mKrishi mobile phone applications, WhatsApp messaging groups or VHF handsets.

Impact	Description
Enhanced safety at sea	They provide better information on ocean state and a more reliable prediction of weather. They have also added safety features of extreme weather alerts and the SOS reporting mechanism.
Enhanced communication at sea and onshore	Using the apps or VHF handsets at sea allows for the possibility of being able to quickly search for a particular message recipient by relaying/multicasting the message until it reaches the intended recipient.[13] Also, through WhatsApp there is the ability to pass on the same information to a large group of people or to create groups at will for different purposes while within cellular network range.
Cost and time efficiency	More efficient navigation through GPS allows for fuel savings, time savings and other cost reductions. Fishers can also receive better prices for landings on account of reaching the shore quicker.
Fishing efficiency	The apps and VHF handsets provide better probability of catches through potential fishing zone information. This can also help fishers save money on fuel.

Broader outcomes and sustainability

One characteristic of these applications is the suggested fishing zones predicted for greater yields according to seasonal and climatic conditions. From a sustainability perspective, the use of potential fishing zones is double-edged. On one hand, fishers using this information can enhance catches for fishers who have the app, yet those who do not have the app become disadvantaged. If app predictions do positively affect catch rates, many more fishers are likely to use the predictions, which could result in highly concentrated fishing efforts and an overexploitation of certain resource areas or stocks. More studies might be required to assess the sustainability of using potential fishing zone information over a longer period of time by a nontrivial proportion of the fishing fleet. On the other hand, this also presents opportunities for fisheries management to not only identify ecological information about important stocks, but also to protect key spawning grounds or vulnerable stocks for overall resilience.

ICTs have emerged as an unstoppable force transforming different sectors. In many cases, the mobile phone is the point of entry of these transformational technologies. Looking forward, there is the possibility of getting live internet at sea in the near future,[14] which could significantly alter the nature of the information provided to, and received from, the fishing fleet. Additional services that might become feasible if live internet is available for small-scale fishing fleets at sea could be real-time extreme weather alerts, distress signaling from any fishing craft, voice communications

[13] This is, of course, a manual process where fishers talk on a channel that is being listened to by multiple boats, who then transmit the message again (some get the message multiple times).

[14] SpaceX, the company founded by Elon Musk, plans to put 4 000 satellites into orbit to provide internet to every point on the globe ("http://www.starlink.com/"). There are also other initiatives, such as Google's Loon, attempting to bring the internet to everywhere on earth ("https://loon.com/technology/").

with fishers' families, more effective search-and-rescue operations, fishing craft identification or tracking, better reporting systems for fisheries management, and more effective prevention of collision between ships and fishing boats.

Key lessons learned and recommendations

Given that fishers and fishworkers are using WhatsApp all the time for personal communication, it would be a sensible vehicle through which to develop fisheries focused digital communities to learn, share ideas, ask questions, etc. This could form the platform on which to build a two-way dialogue between government and small-scale actors, as well as educational, capacity building and awareness raising communications. In doing so, big data approaches such as text mining can be leveraged to hone the delivery of services and resources specifically to the needs of small-scale actors.

Given the hazardous nature of fishing operations, ICTs offer important innovations that must be harnessed to improve well-being. Initial evidence suggests that stakeholders are being consulted, but digital trust is often driven by the lack of integration of traditional knowledge. For this to happen in a sustainable, secure[15] and cost-effective manner, it is important to ensure that there is a consultative process that brings together all stakeholders in the design process and throughout its continued development and evolution.

Box 5. Open Data Kit (ODK) for community fisheries monitoring in Lakshadweep, India

Ishaan Khot (ishaan.khot@dakshin.org), Mahaboob Khan and Naveen Namboothri

The Dakshin Foundation is a nonprofit research organization working on the coastal and marine systems of India. Since 2012, Dakshin has been working in the Lakshadweep Islands, a small archipelago off India's west coast, to institute mechanisms for community-based monitoring and management of fisheries. The program involves fishers in voluntary monitoring of day-to-day fishery dynamics. It is envisaged as a two-way knowledge-sharing program aimed at enabling fishers to see patterns in their fishery over time and take knowledge-based decisions for local-level management. The transition from traditional paper logbooks to an ICT-based platform was undertaken to scale up monitoring by reaching a wider section of the community and to increase the rate of feedback to fishers.

Development process

A scoping study was conducted in four project islands in 2016 to gauge the feasibility of ICT-based monitoring and access issues, if any. The study revealed that while older fishers preferred logbooks over phone-based monitoring, each fishing boat had at least one or two younger, tech-savvy individuals who were comfortable using smartphones. When asked to choose between prototypes of an interactive voice response (IVR) platform and a mobile app for fisheries monitoring, most respondents weighed in favor of an app, citing that it was too tedious to go through the long chain of questions that an IVR system would entail.

[15] National security is an important driver of policy, and fishers, especially those who go offshore, are being treated as first-level informants to civil and military authorities.

The Open Data Kit (ODK) platform was chosen to develop the fisheries monitoring forms because it has several inherent advantages: it is open-source, free, easy to modify and offers offline functionality, all of which are important for a geographically isolated place such as Lakshadweep with limited phone signal and internet connectivity. With this in mind, the team worked with an external developer (Mobiatrics LLC) in 2017 to convert the traditional monitoring logbooks to ODK-based forms. At the outset, two main forms for fisheries monitoring were developed: one for the pole-and-line tuna fishery, which is the major fishery practiced in Lakshadweep, and the other for the smaller scale, subsistence octopus fishery. These were then translated into Malayalam, which is the language spoken locally.

Field trials

The form development faced unforeseen delays due to the complexity of translating the long questionnaires from English to Malayalam. Once completed in 2018, the forms were deployed for field testing across four project islands during the 2018–2019 fishing season, with a total of 21 volunteer fisher data recorders. Unfortunately, the response was far from satisfactory, with few entries being submitted to the server. Later feedback from the volunteers indicated that the forms were too long and complex, so they were intimidating for fishers to use. Other potential deterring factors could have been the slightly formal, bland appearance of the ODK user interface, such as the lack of pictures and colors. This might have made it less appealing for fishers to log data on. Internet limitations posed challenges to sharing the app with fishers and uploading completed forms to the server, further affecting uptake.

Reflections

Digitizing the monitoring process certainly illustrated benefits, including enabling the collection of new data types, such as in-app geolocation of fishing locations, which was not previously possible. However, there are crucial design hurdles to overcome before the program can scale up as desired. While the protocols for the larger community-based fisheries monitoring program had been co-created with the community, some elements of co-design of the ODK forms would have proved to be valuable in early development as well. Based on fisher feedback, the next steps for this project would be to conduct co-design sessions with fishers, build shorter and simpler forms and incentivize app uptake by linking it to useful information to create a cost-effective fisheries monitoring tool that can drive evidence-based decision-making for sustainable fisheries management.

Chapter 4. Promoting gender equity through development of e-catch documentation and traceability technology in small-scale fisheries

Chapter 4. Promoting gender equity through development of e-catch documentation and traceability technology in small-scale fisheries

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Highlight summary

This case study presents an example of gender integration into ICT development to guide cutting-edge solutions to small-scale fishery challenges that not only consider conservation objectives but also the priorities and needs of its users — both women and men. The lessons learned from this process have informed a review of the key data elements necessary for integrating gender-sensitive human components in ICT initiatives. Building the capacities of both women and men users in using the traceability tools is critical to empower the users, and capacity building activities should be designed to be accessible, comfortable and valuable for all groups. This means taking into account cultural differences in how women and men learn, contribute to discussions, access information, and in their labor burdens at different times of the day.

Background and context

Women make up half of Southeast Asia's fisheries sector, performing key processing and selling work that enables seafood to reach local and international markets (FAO, 2018). Despite this, women's vital roles and needs have traditionally been overlooked in an industry commonly considered to be male-dominated. To truly advance fisheries management and the human aspects of the industry, it is important to address the needs and interests of both women and men, using an approach that all players can be a part of.

Funded by the United States Agency for International Development (USAID), the Oceans and Fisheries Partnership (USAID Oceans) is a five-year program intended to strengthen regional cooperation to combat illegal, unreported and unregulated (IUU) fishing and promote sustainable fisheries to conserve marine biodiversity in the Asia-Pacific region. The program holds gender integration at the heart of its strategy and efforts. Together with its partners, the Southeast Asian Fisheries Development Center, the Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security, and members of the public and private sectors, USAID Oceans supports the development and implementation of electronic catch documentation and traceability (eCDT) systems. These systems enable data-driven sustainable fisheries management, improve human welfare and livelihoods, increase gender equity and bridge the private and public sectors to create economic opportunity.

To ensure its eCDT solutions acknowledge and advance the needs of both women and men, USAID Oceans conducted extensive supply chain and user experience research, including gender and labor analyses, to identify key human welfare concerns and gender differentials. The program used the research findings to guide eCDT design, such as including key data elements related to gender and human welfare to help monitor labor practices and further gender equity across the supply chain, from point-of-catch to export. Research findings also enabled the program to determine strategies to support gender-responsive policy and other complementary interventions.

Process, participation and capacity building

Before developing or deploying any technological solutions, USAID Oceans worked closely with its partners and stakeholders to assess the experiences, needs and capacities of women and men fishers on catch documentation technology. A fisher was defined as anyone, female or male, who is directly involved in fisheries activities, either offshore or on land, along the nodes of the fisheries value chain. USAID Oceans conducted gender analyses with its local partners in Indonesia and the Philippines to identify gender differentials in fisheries roles and interactions. The analyses integrated USAID's Gender Dimensions Framework and included its Gender-Responsive Value Chain Analysis (Figure 10), as well as key informant interviews, focus group discussions and surveys. The gender analyses provided empirical evidence on gender-related concerns in the supply chain to be considered in the development and implementation plan for eCDT technology.

Figure 10. Gender-responsive value chain analysis framework.

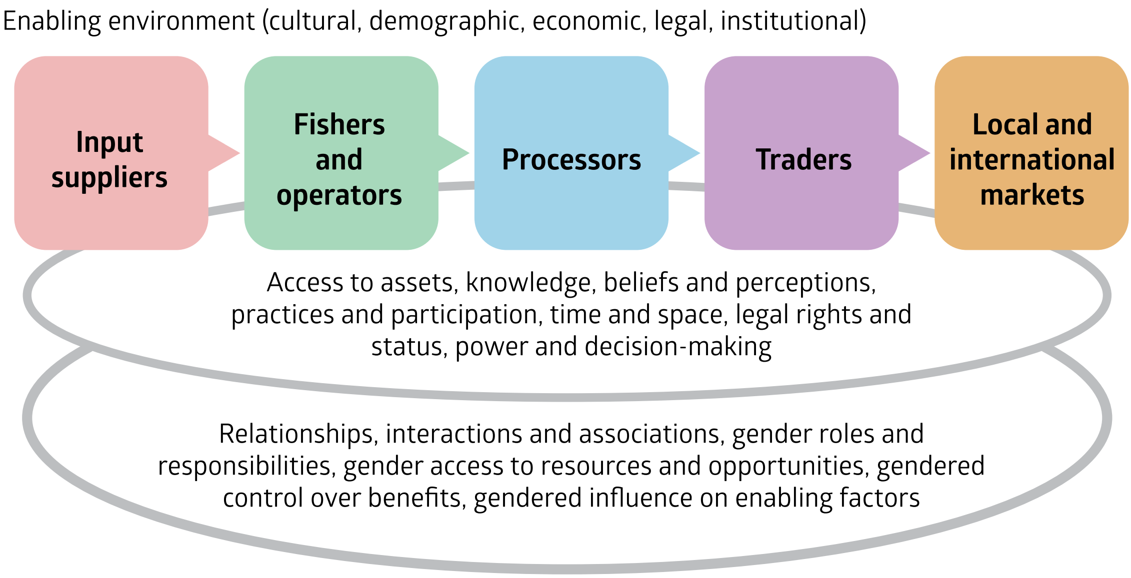

Plate 3. The Trafiz mobile application can be used by middlepersons and suppliers to record transaction data.

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Note: In Indonesia, women are mostly involved in the in-land operations of the seafood supply chain.

While women play important roles through the entire seafood supply chain, the program's gender studies established that women predominantly participate at the point-of-landing stage in the supply chain, where they are responsible for managing seafood purchases, trading and finances. USAID Oceans research identified both women's and men's unique needs and challenges in providing traceability data, given limited access to connectivity, harsh environments and limited personal capacities for digital recordkeeping. As a result, USAID Oceans set out to develop Trafiz, a mobile catch documentation application that enables first buyers and fish suppliers to collect and submit traceability data. Trafiz seeks to ensure full chain traceability by enabling data capture from the point of landing. Given the prevalence of women at the point-of-landing, particularly, USAID Oceans committed to developing a traceability technology solution that acknowledges the needs of both female and male actors at this stage.

Trafiz was designed to be a viable and cost-efficient solution for small-scale fisheries data collection, as data collection at sea is often not possible or feasible due to even more complex environmental factors. Trafiz not only supports catch reporting but offers business functionalities that help suppliers more efficiently manage their businesses through transactional logs, loan management and payment tracking. The app also accommodates offline and online environments by allowing data to be entered without internet connectivity and processed once reconnected.

To kick off the app's development, field trips and workshops were conducted to gather feedback from potential men and women users and other relevant stakeholders. Stakeholders included representatives from the Ministry of Marine Affairs and Fisheries, Yayasan Masyarakat dan Perikanan Indonesia[16] (a local NGO and a USAID Oceans grantee) and USAID Oceans' First Movers,[17] who are industry members that have signed on as early adopter eCDT users. The First Mover companies helped to identify other small- and medium-scale suppliers to be potential users of Trafiz. Once a beta version of the app was developed and launched in August 2018, user acceptance tests were conducted with interested users.

Through this consultation process, USAID Oceans was able to identify additional technology-specific opportunities and user needs from both sexes. While initially the app was only designed to capture catch data and transactional records, women requested functionality in Trafiz to improve their businesses and their confidence in technology use. The major constraints that women suppliers face are financial resources and a lack of market and trade information. Currently, when in need of additional financing, women must take out informal loans from local "loan sharks." Despite their efforts to earn sufficient income and pay off debts from buying and selling fish, the high-interest rates make repayments costly. Through the development of Trafiz, USAID Oceans seeks to empower women fishers by increasing their access to appropriate financial tools for better data management, more informed business decisions and improved agency.

[16] http://mdpi.or.id/

[17] USAID partner businesses that are the first to market with a product or service.

USAID Oceans has been piloting the application since late 2018 and has extended the application's use to additional areas of Indonesia through separate program partner initiatives. As the app is rolled out, capacity building activities for women suppliers to use the Trafiz application will be conducted through training, demonstrations, learning materials and onsite mentoring. Training for trainers will also be conducted to establish designated trainers at landing sites, who will be able to share their knowledge with other users to expand and sustain the use of the application after the final stages of the USAID Oceans program in 2020.

Achievements and failures

USAID Oceans research and development activities were successful in yielding valuable findings to guide the program's development of a gender-inclusive technology solution. The gender analyses highlighted the opportunity to increase the capacity of women actors in all nodes of the fisheries value chain and in ancillary activities supporting the fisheries sector in using traceability tools. Additionally, these tools should include value-added features that support women to better manage their finances and make informed decisions for their businesses. This applies particularly to women fish suppliers and traders at the landing sites or fish ports, in markets and in smallholder processing activities. Furthermore, women in medium- to large-scale fisheries industries who are responsible for ensuring efficient traceability systems might still need further capacity building, both on the use of ICTs and in understanding their rights as workers.

Box 6. Ersita, fish trader, Sulawesi

Ibu Ersita is a fish supplier from the Sangihe Islands in North Sulawesi, Indonesia. She buys fish from small-scale fishers around the island and sells them to a processing and exporting company on the mainland in Bitung. She inherited the business from her mother, who started the business many years ago. Ersita records the large tunas that she buys and sells in a complex system of multiple written record books. While her records are comprehensive, she reports that she would be interested in using an app like Trafiz that would "make it easier to access my data and records, especially to see my loss and profits without having to reference multiple books." Ersita already owns a smartphone and relies on instant messaging apps on her phone to communicate her stock to the processor, which can be cumbersome and prevents either party from being able to manage inventories.

Plate 4. Ibu Ersita, a fisher supplier from the Sangihe Islands, is interested in using an application, such as Trafiz, to record the large tunas she buys and sells to see losses and profits without having to reference multiple books.

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The gender-responsive value chain analysis, undertaken as part of the analysis, was successful in identifying differential gender roles, constraints and opportunities faced by women and men in the fisheries supply chain. Issues relevant to the development of the eCDT technology included a lack of experience from potential users on operating new technologies, challenges in incorporating relevant human welfare and gender elements into eCDT systems, a current lack of technology that provides financial and market information to businesses, and a lack of understanding among small-scale fishers of the benefits of eCDT technology. In response to these findings, USAID Oceans adjusted Trafiz's design and implementation plan accordingly and produced a guide on key data elements[18] to increase knowledge and promote their incorporation into eCDT initiatives.

Looking forward, USAID Oceans is planning to work with an extended range of partners to enhance Trafiz. The expectation is to incorporate additional data collection and business functionalities that address the needs of female buyers and suppliers identified during the gender analysis and observational studies. USAID Oceans will continue to conduct capacity-building activities with men and women to continue building awareness of eCDT technologies, their uses and benefits, as well as capacity building with development practitioners on how gender considerations can be integrated into environmental and resource management. The handbook can be downloaded at the USAID Oceans website for additional information.[19]

Broader outcomes and sustainability

The development of gender-inclusive eCDT tools and end-to-end systems can benefit both the well-being of small-scale fishers and the sustainability of long-term sustainable fisheries management. Traceability data and records provided from inclusive eCDT tools, such as the Trafiz application, can help small-scale suppliers and middlepersons (both women and men) manage and grow their businesses by helping them meet national and international market demands as the credibility of their products is enhanced. In addition, both women and men can have greater — and equal — access to financial information, resources and business opportunities that improve their livelihood and strengthen their agency for informed decision-making. Being gender inclusive in technology development as well as capacity building and training is crucial in providing a level playing field for women and men to participate equally in and access opportunities to advance their well-being.

To further enhance the sustainability of eCDT technology impacts, USAID Oceans recommends that technology initiatives be coupled with activities for advocacy, empowerment and supporting legislation and policy. USAID Oceans, for example, has awarded grants to local organizations to implement targeted activities to advance gender equity and women's empowerment, including through advocacy, capacity building and policy development. USAID Oceans also works with a broad range of local, national and regional partners to ensure continued support in developing and implementing traceability technologies.

18 USAID Oceans' Data Requirements for Catch Documentation and Traceability in Southeast Asia.

19 Gender Research in Fisheries and Aquaculture: A Training Handbook.

Key lessons learned and recommendations

One of the key challenges encountered by USAID Oceans in its development of gender-inclusive technology was a lack of awareness and understanding among external partners of the value and importance of a gender-inclusive design. USAID Oceans learned that considering the following questions was imperative to developing a technology or traceability tool inclusive of all users, including women, men and other marginalized groups:

- Who are the primary users or who has access to the tool's data?
- What are the users' expectations and needs?
- What are the users' primary requirements?
- How will users apply the technology in their established routines?
- What are the user benefits to incentivize and encourage continued use?
- What are the cost implications of deploying and using the technology? Will any groups be excluded?

USAID Oceans highly recommends conducting gender-responsive gaps assessments and a gender analysis preceding any technology development efforts and encourages a strong focus on capacity building following any development efforts. Women's participation should be a principle in all stages of technology development, from design to piloting. Building the capacities of both women and men users in using the traceability tools is critical to empower the users, and capacity building activities should be designed to be accessible, comfortable and valuable for both sexes. This could mean taking into account cultural differentials in how women and men learn, contribute to discussions, access information and are available for day/evening meetings.

Note: *The USAID Oceans program was implemented by Tetra Tech for USAID from May 2015 through June 2020 and, at the time of publication, is now closed. Its website, www.seafdec-oceanspartnership.org, can be accessed for more information and reflects the content and activities completed as of the time of the project's close*.

Box 7. Blockchain applications in the fisheries sector

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One of the most important technologies to emerge from this decade's cryptocurrency "revolution" was blockchain. Although blockchain was introduced as a back end technology for tamper-proof recordkeeping of transactions for Bitcoin, it was soon elevated to the status of an independent technology that had much broader applications than just in cryptocurrencies. Today, blockchain is accepted as a standalone solution for a broad class of problems that require permanent, unalterable storage of digital assets.

For all practical purposes, blockchain provides an immutable data store where the cost of enforcing trust is near-zero (since modifying data written earlier is practically impossible). This makes it an attractive option for storing digital assets that are unchangeable in nature, such as certificates, financial records, land records or personal wills. Since falsification is impossible, new and faster ways of executing tasks are possible with blockchain. Types of blockchains include the public blockchain platforms (such as Bitcoin or Ethereum) that are open and do not impose any entry barriers on users, and permissioned blockchain platforms (such as Ripple, Fabric or Sawtooth) which allow only verified parties to use them. A related term, "digital ledger technology," is an inclusive label for all types of blockchains plus related technologies that are functionally equivalent to blockchain, for instance, directed acyclic graph-based platforms, such as IOTA and Hashgraph.

Blockchain-based technology is rapidly being adopted by different sectors, including banking and finance, supply chain, shipping and logistics, healthcare and government. It promises several-fold acceleration in time for many tasks, including settlement and audit. The global fish trade has several interesting characteristics that make it amenable to the use of blockchain technology:

- It is a high-volume, high-value business.
- The producer and consumer are located in different parts of the country or the world.
- The supply chain has a number of actors who never meet face-to-face (but are forced to trust each other).
- Fish is a complex product that has widely varying prices depending on the size, quality, source, etc. There can be multiple sources for the same species (e.g. culture vs. wild fish) or species that look similar but have significantly different prices or other characteristics. Overall, the chances of mislabeling or product substitution is high.
- Fish trade has complex food safety and other reporting requirements (e.g. fisheries management reporting, hazard analysis and critical control point), some of which, as paper documents, could permit tampering.
- Overall, auditing the entire chain for food safety or other compliance poses formidable challenges.

A number of initiatives in the fisheries sector are exploring blockchain technology to ensure trust and transparency in global fish supply chains for both capture and culture fisheries. For instance, a consumer today might be forced to trust all the information provided about the fish that she is purchasing, which could include the country of origin, type of fishers or fishing gear, certification, and quality or environment-related labels. With blockchain, the consumer can directly verify any part of this information and be confident in the authenticity of the information.

Notable blockchain initiatives in fisheries include IBM's Food Trust, an initiative that attempts to bring in transparency to commodities such as fish, milk, fruits and vegetables. Another initiative is FishCoin, a start-up that attempts to make the fisheries sector more sustainable by incentivizing all reporting through a crypto-token called FishCoin (fishcoin.co). In Australia, the World Wide Fund for Nature Australia is piloting the From Bait to Plate initiative (www.worldwildlife.org/pages/bait-to-plate), which tracks tuna from the Pacific Islands to the final consumer. Every individual fish can be instantly checked on the blockchain to confirm that it is "sustainable, ethical and legal" and not IUU. Earth Twine is a collaborative technology company that uses blockchain to enhance IUU compliance and simplify audits (bit.ly/2ylQZJ7) In Indonesia, the Provenance project (www.provenance.org) ensures that only the catch from local fishers — registered through an SMS as soon as the fish is caught and receiving a unique ID for the fish in return — can be processed, and not fish from poaching vessels from neighboring countries.

It is important to note that the use of blockchain does not eliminate all chances of misreporting or fraud. Since handling of fish (including transport, processing, shipping, repackaging and retailing) are physical, off-chain activities, which take place outside the blockchain), the possibility of misreporting at the point of capture of these transactions on blockchain still exists. However, once captured correctly, the transaction remains as a permanent, immutable record. Increasing automation, for instance by using IOT-enabled equipment, and onsite genetic identification can reduce this risk.

Chapter 5.

The Enhanced Fish Market Information Service: Improving fish markets using ICTs

Chapter 5. The Enhanced Fish Market Information Service: Improving fish markets using ICTs

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Highlight summary

This chapter provides insights into the use of mobile phones to enhance the incomes of fisher communities by improving their access to market information through a convenient, fast and cheap medium. The expected outputs are transparent pricing, improved fish prices for fishers, reduced marketing costs and less post-harvest fish losses. The Enhanced Fish Market Information Service (EFMIS) is a system for generating, packaging and disseminating key market information from fish landing sites and markets around the marine and freshwater systems near major urban areas across Kenya and Uganda. The system has the capability to capture data on four key variables that influence fish marketing decisions: (1) fish prices at landing sites and inland markets, (2) quantities of fish at landing sites and inland markets, (3) number of fish trucks at landing sites, and (4) basic weather information.

Background and context

Fisheries occupy a significant place in the socioeconomic development of most coastal countries (Aura *et al.,* 2019; Njiru *et al.,* 2018; Woodhead *et al.,* 2018). For example, Kenya's fishery sector generally contributes about 4.7 percent to the country's GDP (Mulatu *et al.,* 2018). Total fishery and aquaculture production is about 169 400 tonnes, with 83 percent coming from inland capture fisheries (FAO, 2016). The marine capture fishery is composed of coastal and nearshore artisanal, semi-industrial and offshore industrial fisheries. Coastal communities exploit artisanal and semi-industrial fisheries while foreign fishing companies exploit the industrial fisheries. Uganda's major fishery is from Lake Victoria with 43 percent portion of the entire lake, whereas Kenya has only 6 percent (Njiru *et al.,* 2012). Uganda's total annual production is about 196 900 tonnes valued at USD 72.468 million.[21] Lakes and reservoirs are recognized as important income and employment generators in both nations, because they stimulate the growth of a number of subsidiary industries and are a source of cheap and nutritious food besides being a foreign exchange earner. More importantly, fisheries are a vital source of livelihood for many people in the informal economy in rural and peri-urban communities (Gangadhar, 2011; Njiru *et al.,* 2018).

However, while at sea fishers are unable to observe prices at any of the numerous markets spread out along the coast. This limits their marketing capabilities. Fishers can typically visit only one market per day due to high transportation costs, poor road quality and the limited duration of the market. As a result, fishers sell their catch almost exclusively at their local market. Ultimately, the quantity supplied to a particular market is determined almost entirely by the amount of fish caught near that market, but between markets, there is a great deal of price variation.

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[21] www.fao.org/fi/oldsite/FCP/en/UGA/body.htm

In developed countries, markets function efficiently because the prices of goods and services are known or can be accessed cheaply, widely and readily (Eggleston *et al.,* 2002). On the other hand, rural African markets function inefficiently because information flow on the prices of goods and services is largely difficult and mal-distributed, especially among artisanal fishers and smallholder farmers. This is attributable to a lack of cheap, timely and readily accessible information, inadequate information delivery mechanisms and infrastructure, and a private sector attitude that typically views smallholders as commercially unattractive (Philips, 1988; Eggleston *et al.,* 2002).

A particularly promising aspect of ICTs is in improving fishers' access to markets and information. ICTs can reduce the gap in market inefficiencies through affordable access to this information (Box 8). Mobile phone ownership has boomed throughout sub-Saharan Africa. It accounts for about 12 percent of the 5.2 billion subscriptions worldwide, with Africa and the Asia-Pacific being the main drivers of growth, accounting for 63 percent of projected global net additions by 2025 (GSMA, 2020). Nevertheless, there have been few reliable studies on the social and economic implications of mobile phone use in African countries.

Box 8. The Palliathya initiative

Palliathya uses mobile phones to increase access to information on the part of men and women living in Bangladesh's rural areas, as well as to stimulate economic opportunities for underprivileged women (Bhavnani *et al.,* 2008). The Palliathya initiative deals with (a) preventing exploitation by middlepersons, (b) providing employment opportunities, particularly for rural women, (c) reducing information gaps, (d) saving cost and time, and (e) strengthening access of service providers to rural people. This initiative uses face-to-face contact, together with ICT, to empower women economically, as well as to share community-relevant information on education, emergency situations, markets, weather, etc. The Palliathya case shows that a lack of relevant and timely information is a major bottleneck to rural development. Overall, these cases demonstrate the importance of information for the functioning of markets and that well-functioning markets have a positive impact on welfare.[22]

The EFMIS, an ICT pilot project based on mobile phones, has been operating in Kenya's Lake Victoria fisheries for ten years. The objective of the project is to enhance fish trade and incomes for fisher communities through improved access to market information. Much of the lake region is well covered by mobile phone networks. Fish landing sites with access to a network increased from 82 percent in 2008 to 92 percent in 2012 (LVFO, 2012). Despite this, there were no systematic means of collecting, synthesizing and disseminating information on fish prices, demand and supply at various levels of the market chain in a useful way. This resulted in significant fish price disparities horizontally between markets and vertically up the value chain. Middlepersons took advantage of this to buy fish from fishers at less competitive prices. It also caused considerable inefficiencies in market operations, and when fish landings were high especially during rains, this led to substantial post-harvest losses (Abila and Werimo, 2010).[23]

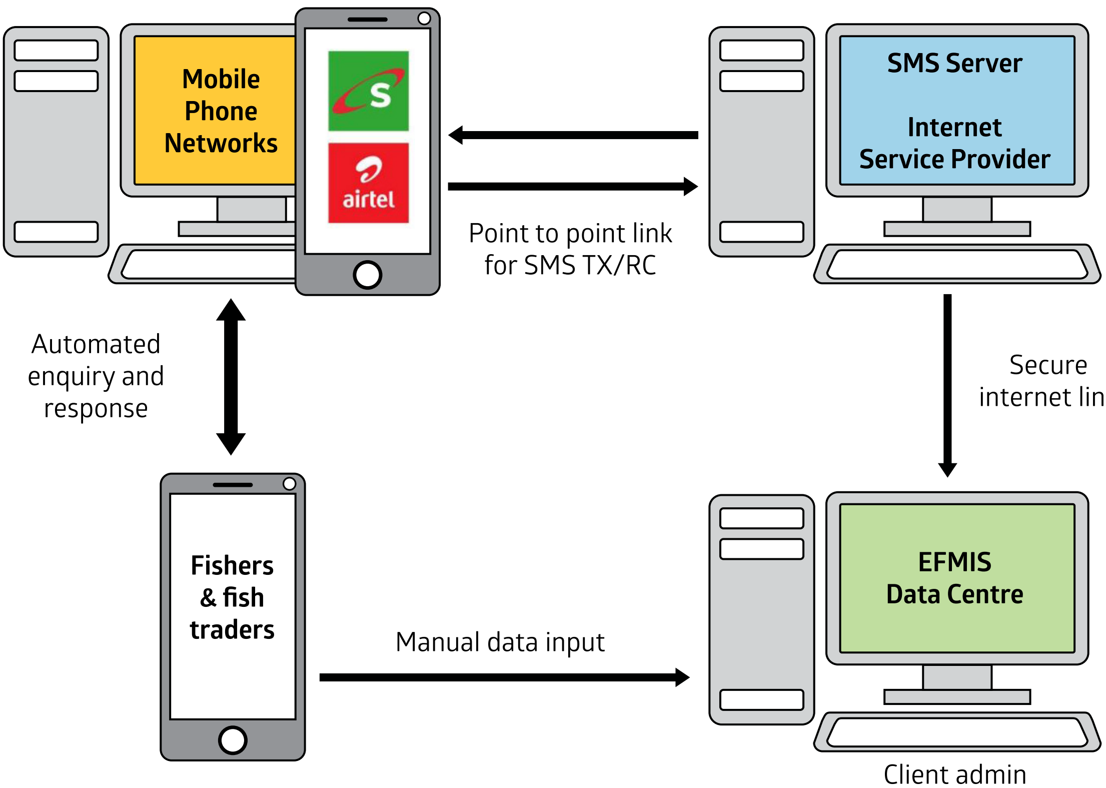
[22] Palliathya was a winner of 2005 Gender and ICT Awards: www.comminit.com/en/node/132155/36
[23] www.growinginclusivemarkets.org/media/cases/Bangladesh_HBPS_2011.pdf

Process, participation and capacity building

The EFMIS system consists of three broad phases: (1) data recording, coding and transmission from landing sites and inland markets to the data center, (2) a central database, and (3) a query and automated response system (Figure 11). In summary, data is recorded once or twice a day at each of the landing sites and inland markets and relayed by phone SMS in a coded format to a data center based at the Kenya Marine and Fisheries Research Institute in Kisumu City. There, it is synthesized into a functional database that users (e.g. fishers, fish traders, cooperatives and other consumers) can access in real time, daily and by the hour, whenever they need it (Aura *et al.,* 2019).

To access the information, users send a query by SMS to the data center from a mobile phone through a dedicated number (shortcode) and get an automatic response usually within ten seconds. The system is active for 24 hours every day and can be accessed from any part of Kenya where there is mobile phone network coverage. The database is updated daily and a summarized information bulletin containing current fish prices and trends is produced every month. The bulletin is circulated to about 1 000 stakeholders worldwide through the internet and is sometimes also featured in Kenya's national newspapers. The EFMIS model offers the potential to be adapted for application in other small-scale fisheries, drawing lessons learned from this pilot (Aura *et al.,* 2019).

Figure 11. EFMIS-Ke system design.



However, convincing fishers to use mobile phones to reduce the cost of travel and bridge the gap caused by traders was challenging. The project had to organize several sensitization workshops for both fishers and traders on the benefits of the system. A training manual was developed, and training was organized at different levels for data collectors and traders. The manual focused on clearly identifying the purpose of training and included modules in data capture and entry in the EFMIS. Specifically, the first section deals with the standard operating procedures in sampling and the selection of data informers. Section two gives the economic importance of fisheries to Kenya, including species of economic importance, and it describes the factors affecting fish pricing in the country. This section also introduces the concept of using mobile phones to transmit data cheaply and explains some of the benefits of using mobile phones, such as faster price identification and reduced bargaining time. Section three explains how the data is recorded and describes the use of data codes, such as specific codes, beach codes and market serial numbers. It also gives some technical background on how data is transferred to data sheets and how query messages are handled. Importantly, to incentivize data collection, the project buys cheap mobile phones and airtime credit to enable collectors to send data to the data center.

Achievements and failures

Among the impacts of the EFMIS, it is assumed that with information beforehand (on prices, fish quantities and the number of fish buyers at various markets), the beneficiaries (fishers, fish traders and cooperatives) will make informed decisions on the most cost-effective markets and avoid unnecessary transport costs. In the same manner, knowledge of comparative fish prices at different landing sites and inland markets will allow fishers to bargain for higher prices. Middlepersons will not easily fix false prices if all players know the true market status (Abila and Werimo, 2010). Furthermore, by having information on the number of buyers and cold storage trucks at a landing site, fishers will avoid taking fish where they are likely to remain unsold and get spoiled. Bargaining time (before fish is on ice) will be reduced if fishers have information on comparative prices in other landing sites, and weather information will enable fishers to make decisions to avoid inaccessible landing sites.

The reduction in price differentials among the landing sites provides evidence of more efficient markets due to better information. Previously, this was difficult to come by, as fish could be sold at one landing or marketing site without any knowledge of prices at other landing sites. These higher fish prices have led to improved incomes for fishers. They might have also led to reductions in marketing costs and post-harvest losses. In 2009, before the introduction of the EFMIS, nutritious Lake Victoria sardines (locally called *dagaa*) were selling at an average price of USD 0.87 per kg from the beaches. After the introduction of the EFMIS in 2016, the price of the same commodity increased threefold to USD 2.89 per kg. Moreover, there has also been a reduction in the number of smoking kilns present at beach landing sites due to more efficient markets, which could indicate that post-harvest losses are less of an issue than they were before (KMFRI, 2009 and 2016).

Despite the EFMIS service being online and functional for some time, it has not been fully used. This could suggest failures in adequately sensitizing users or the pricing structure and magnitude of the user charge fee built into the system. Secondly, the project could not expand as fast as some stakeholders wanted due to limited resources. The project had planned and budgeted to start with 20 markets and gradually increase by adding a similar number per month until it reached its target of 150 markets. However, more markets and fisher organizations wanted to participate in the project faster than was planned and budgeted for, which put a strain on central resources at the data center.

Other challenges included the following:

- Meeting the high expectations of the different stakeholders for market information has been an important challenge. Various stakeholders (fish farmers, traders, fish processors and consumers) have diverse information needs that were sometimes beyond what the project could provide. To address this issue, a second package was attempted that allowed fishers to use mobile phones to find out the availability and costs of fishing nets and other gear in different shops. This, however, has not been fully developed.

- Lack of cooperation by some stakeholders, particularly the fish processing and exporting industry has been another challenge. Most fishers are interested in finding out the prices paid by large fish factories to middlepersons. However, factory owners have been reluctant to declare this piece of information publicly since they regard it as their "business secret." It has been equally difficult to get consistent information on wholesale/retail prices in the export markets, which is of great interest to the fishing community.
- Lack of proper standardization on fish quality and pricing units is an important constraint. For example, fish prices can be reported as low due to poor quality rather than unfavorable market conditions.

Broader outcomes and sustainability

A key issue is the potential of the system to sustain itself beyond donor support. Much of the project's expenditure structure demonstrated that a high proportion of the costs went toward establishing the system, including personnel mobilization and capital equipment, while the operational costs took less than half the budget. For sustainability, effort should be made to reduce further the operational costs and raise revenue from information services. The potential for the system to raise revenue was examined during the pilot by charging users a small premium price above the cost of SMS sent to the data center. A mechanism was put in place to automatically charge a user fee for each SMS query. Based on 20 000 SMS queries, the project raised a total of about USD 2 500 in revenue, which was shared out in a structured way (Table 5). The revenue base is directly related to the number of queries, so greater use of the service would ultimately enhance revenue.

Table 5. Revenue from SMS charges.

Revenue structure	Kenyan Shillings	USD
Number of SMS	25 000	240
Cost of SMS	0.125	0.01
Total generated by project SMS [(a)*(b)]	2 500	24
Cost to mobile phone companies and government tax @ 60.3% of (c)	1 508	14.50
Balance after tax	993	9.50
Payment for code lease and database maintenance services @ 50% of (d)	496	4.50
Revenue available for project activities @ 50% of (d)	496	4.50

Sustainability beyond donor support also comes down to small-scale fishers and traders buying into the system by paying for the services. In the future, the development of a mobile application that will lower the cost of running the system can be developed. Advertisements through radio talk shows, posters and fliers to generate awareness are another way of getting more people to use the system to generate more funds. Additionally, introducing more products into the system to include fish consumers, aquaculture, fish processors and exporters could be explored.

Key lessons learned and recommendations

Modern ICTs have great potential for improving fish trade and incomes in the sector. Yet one cannot expect poor farmers and food insecure residents of rural communities to list computers and digital telecommunication services as high priority items for improving their lives. However, there are various intermediaries that serve these populations. Together with small and medium enterprises in rural areas, these populations can take advantage of these technologies to improve their work and communication capacity, gain efficiencies and reduce telecommunication costs. An integrated approach that fosters horizontal and vertical channels of communication is key to ensuring that such benefits are realized (Woodhead *et al.,* 2018).

This is demonstrated by the EFMIS project, which has improved the level of transparency in the fisheries industry by enhancing access to up-to-date market information for the fisher community. Middlepersons who were taking advantage of an inefficient market were reduced by 50 percent from 2012 to 2016 (KMFRI, 2009 and 2016). The project has managed to disseminate market information to various users using mobile phone SMS services and internet bulletins. There is a good indication that the EFMIS has contributed to improved fish prices and incomes for the fisher community, and potentially a reduction in marketing costs and post-harvest losses (KMFRI, 2006 and 2016). The successful implementation and positive results of the project have attracted a lot of interest, and there are opportunities to replicate its design and software systems for other fisheries in the region. However, as highlighted, this system is reliant on private sector actors revealing their pricing strategies. If they are not compelled to do so, it would threaten the viability of the system.

Despite the outlined challenges in setting and system operation, the EFMIS is a valuable tool for enhancing the competitiveness of trade in small-scale fisheries in developing countries, where real-time information is a big constraint. This model can be adapted appropriately for application in other small-scale fisheries by paying attention to the lessons learned from this pilot, such as taking into account the level of ICT skills available among users and developing mechanisms for project sustainability. Also, the often informal economies of small-scale fisheries imply highly contextualized transactions between actors. Even if fishers identified higher market prices outside of their regular network, they might be unable to access them due to repayment arrangements with creditors or obligations to cooperative associations. The ability for fishers to not only see current prices, but be able to transact with buyers on a digital platform is one way to shorten value chains and enhance revenue for small-scale actors (Box 9).

Box 9. Abalobi: Boosting fisher engagement in co-management through value chain incentives in South Africa

In 2012, the South Africa government adopted and rolled out a new small-scale fisheries policy. This policy allocated fishing rights to fishing cooperatives (instead of individual fishers) to improve fishers' engagement in co-managing fishing resources and to drive local economic development.

Abalobi is a program that developed a suite of apps originally aimed to support the institutional structures of this policy by engaging fishers directly in co-management of their resources through co-generating fisheries data. The Fisher application is a logbook app with a chat platform and personal accounting functions. The Monitor app facilitates monitoring by the community at landing sites and shorelines, and the Manager app is a dashboard for fishery managers. The Co-op tool currently consists of a log where post-harvest fish processors can account for their work and expenses. This function helps highlight the role and value that these workers (predominantly women) add to small-scale fisheries.

Inevitably, there was a need to create a value proposition significant enough to get fishers using the app daily, so marketplace and transactional elements were developed. The aim of the Marketplace app is to allow the posting of catches for sale, transparent prices and trends, cooperative profiles (based on ecological/social criteria), and end-consumer (private persons, restaurants, retail) details and requests. Now, through the Marketplace app, fishers with catch to sell can do so through their newly formed cooperative or to private buyers, such as chefs and restaurants. Selling directly to private buyers can increase fishers' revenue by three to four times more than through the cooperative, so this is a real financial incentive and one that brings with it the opportunity to collect important monitoring and management data.

Once a sale is made to a buyer, a QR tag on the delivery provides buyers with full provenance and traceability, as well as information about the fisher(s) that landed it. Trust is critical in these digital transactions, and this has been improved enormously through technology. An added value from the marketplace has been to actually drive new consumption patterns in the Western Cape. Where previously little of the local catch was served in restaurants, now a greater quantity and diversity of fish are offered in restaurants. There are currently 180 restaurants and 350 fisher households that are registered users of the marketplace app in the Western Cape.

Fishers selling their catch through the co-op or to private buyers can be paid electronically through automated payments. Using this service also opens up a wealth of opportunities for financial mechanisms, such as savings schemes and microcredit.
The initial successes of the Abalobi marketplace platform, and its ability to scale up, are built on a pre-existing familiarity and trust of mobile systems. Initial trials in informal, cash-based economies have been slower going and will also limit the added-value financial services available to registered users. However, Abalobi has the potential to become an important broker of different technologies and services for fisher communities that would otherwise be inaccessible.

Chapter 6. Following the lead of fishers in ICT development in the Caribbean

Chapter 6. Following the lead of fishers in ICT development in the Caribbean

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Highlight summary

The ecological and socioeconomic vulnerabilities that small-scale fishers face from high exposure and sensitivity, as well as modest adaptive capacity, are destabilizing for them and their communities. Yet access to timely information through ICTs, which largely enable resilience in other communities, is a challenge. This chapter shares responsive, context-appropriate policy and programming strategies to leverage ICTs for fishers' resilience. It explores the enabling environment for building ICT capacity among fishers, the beginnings of conversation to incorporate ICTs into Caribbean fisheries policy and management, and lastly the introduction of the ICT stewardship model.

Background and context

Much like Southeast Asia, small-scale fisheries are vital to coastal communities in the Caribbean, where they provide food, nutrition and livelihoods for some of the region's poorest people. They are also the focal point of entrenched cultural dynamics. Yet the lives and livelihoods of small-scale fishers are increasingly at risk on account of a host of weather and climate-related factors that exacerbate pre-existing, physical and socioeconomic vulnerabilities.

Across all sectors, information and communications have been found to be essential to resilience-building—strengthening the ability of systems, individuals and communities to cope with external shocks and trends. ICTs are correspondingly understood to be essential tools for all phases of the disaster risk management cycle: mitigation, preparedness, response and recovery from such shocks. Yet its adoption among small-scale fishers, who figure among the most vulnerable to a host of environmental and social shocks, is modest at best.

A challenge is that effective ICT use requires skills as well as knowledge of device capabilities and limitations, but dedicated training sessions are generally unattractive to fishers. Among other reasons, such training does not often yield a direct impact on profit (but see Chapter 5 and Box 8), so there can be a considerable opportunity cost. Additionally, many fishers are satisfied with their user profiles. Competencies and devices differ considerably among fishers, so dedicated ICT training sessions suffer from attention asymmetries. Fishers have workshop fatigue, and traditional training models are not generally effective for these learners.

In response to the need for a tailored ICT capacity-building approach for small-scale fishers, the Caribbean ICT Research Programme (CIRP) focuses on ICT stewardship. The CIRP is a multidisciplinary team at the University of the West Indies. The team is engaged in information and communications action research with an emphasis on context-appropriate technologies and strategies to support livelihoods and personal safety for disadvantaged communities. Work in the small-scale fisheries sector was prompted by a joint request from a government ministry and the Caribbean Fisheries Training and Development Institute for ICT-based solutions to the challenge of face-to-face training for fishers. The CIRP ICT stewardship initiative was initiated under the Climate

Change Adaptation in the Eastern Caribbean Fisheries Sector (CC4FISH) project funded by FAO with the Global Environment Facility / Special Climate Change Fund as resource partners.

Plate 5. Informal meeting with fishers on a jetty in Tobago.

©Caribbean ICT Research Program

Plate 6. Opportunistic learning through the ICT Stewardship program.

ICT stewardship is the process by which special agents (ICT stewards) opportunistically coach fishers to develop ICT skills. The end goal is to increase productivity, personal safety and resilience to damaging shocks and trends. In this sense, "opportunistically" means that stewards seize any and all opportunities to engage with fishers about their ICT use and also to prompt them to explore additional ways of managing and using ICTs for highest gain. Opportunities are seized at landing sites, after a fishers meeting, during breaks or immediately after workshops, or within a training program on a non-ICT theme.

The region of interest to the CIRP is the set of member countries of the Caribbean Regional Fisheries Mechanism (CRFM): Anguilla, Antigua and Barbuda, Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, St. Kitts and Nevis, Saint Lucia, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago, and Turks and Caicos. The estimated fisher population is 110 818 across these 17 countries, and most always carry a phone to sea. Fishers use a mix of both smartphones and feature phones, though the former are becoming increasingly dominant. In almost every country, there is low to no use of marine band VHF radio despite national and international guidelines strongly urging their use. A significant contributor to low use is the generally poor signal coverage. Small-scale fishers in CRFM countries do not use any other communications capabilities of note. A vessel monitoring system (VMS) service and device provisioning are particularly low. As a result, the primary objective of ICT stewardship for small-scale fishers is functional digital literacy for mobile phones and marine band VHF radio. These represent the most adopted and important devices for emergency communications at sea.

Process, participation and capacity building

Capacity building requires the trust and respect of learners for their coaches. This is very much the case for small-scale fishers, who have been the target recipients of a stream of capacity building activities over the years. As the focus of considerable international attention, they are often called upon for interviews, surveys, and attendance at various sensitization or training sessions. Assistance has occasionally come through projects that have ended unceremoniously, only to be followed by other similar projects with either unnecessary replication or crucial gaps, despite the best efforts of donor agencies.

While fishers have for the most part received assistance willingly, they have become wary of the stream of projects and distrustful of project teams. They have come to expect quick incentives and grow impatient with prolonged engagement. Fishers have work to do, and every disruption from fishing is perceived as money lost. They have understandably met short-term project demands with a fickle response. The fact is that many things take time. Short-term interventions seldom yield long-term impacts. The perpetual problems associated with fishers' limited literacy, both traditional and digital, cannot be solved by short-term training interventions. Nor can their ICT needs be magically solved by mobile applications conceived and designed by remote agents, particularly for applications that restrict their catch and survey their operations.

Recognizing the critical need for trust and also the spectrum of inadequacies of traditional training on the one hand, while recognizing the need for skills and knowledge development on the other, the CIRP has designed an ICT stewardship program of 11 principles (Table 6). The CIRP's ICT stewardship activities draw on a curriculum to develop fit-for-purpose digital literacy. It comprises basic, general and specialized tiers (Figure 12), which collectively cover instrumental, informational, transactional and strategic competencies. Competencies are differentiated by mobile phone and marine band VHF radio and specified in terms of learning outcomes.

Table 6. The 11 principles of the CIRP's ICT stewardship program.

Principle	Description
Coaching	Follow the lead of participants by asking, not telling, and by building on prior knowledge, not depositing prescribed content.
Learner-centered	Respect the diversity of participants, and their considerable local knowledge and expertise, by recognizing their individual learning pathways.
Responsive	Listen and draw out insights to best meet the needs of participants.
Pragmatic	Use ICTs that satisfy the information and communication needs of participants.
Skills-oriented	Challenge participants to successfully execute specific tasks over time.
Exploratory	Prompt participants to explore their own devices.
Device agnostic	Place no preference on phone make, model or operating system, or on marine band VHF radio make or model.
Developmental	Help participants achieve learning outcomes specified in three non-exclusive competency tiers.
Opportunistic	Seize available moments of interaction for learning and reinforcement.
Multimodal	Use a range of context-appropriate delivery channels and associated strategies.
Relationship-centered	Foster relationships between steward and participant that enables both to access opportunities and resources beyond the lifetime of a particular program.

Figure 12. Individual digital literacy pathways to instrumental, informational, transactional and strategic competencies.

Source: Kim Mallalieu.

The ICT stewardship program services individual needs. Participants are guided to assess their own needs and assure themselves that their choices are fit for purpose. Importantly, no particular devices or applications are recommended or treated with priority. Additionally, the delivery of ICT stewardship is multimodal. It uses a variety of informal channels, such as Bring Your Own Device ICT hangouts, ad hoc conversations and custom presentations with accompanying demonstrations that are included in non-ICT training sessions, otherwise scheduled.

Bring Your Own Device ICT hangouts are informal sessions held opportunistically at landing sites and immediately after or alongside otherwise-scheduled meetings and training events for fishers. Hangouts are used for individual and small group interaction. They are not scheduled on their own, nor are any special logistical arrangements made for them. There is no minimum attendance required for ICT hangouts nor is any role taken. Essentially, they are unstructured conversations with the community that are never referred to as "training." Rather, fishers direct the content coverage. Although the ICT stewardship curriculum is not at all evident to fishers at ICT hangouts, the stewards cover a subset of the curriculum as appropriate to the participant, as well as stimulate the interest of fishers in exploring learning pathways for ICTs.

Additionally, opportunities are seized for informal or ad hoc conversations to learn, share and reveal gaps in available ICT applications that could be addressed by the CIRP's software development team or by the stewards themselves. Furthermore, custom presentations and accompanying demonstrations are prepared by the CIRP for training teams to incorporate in non-ICT thematic training sessions. These include the following:

- Get to Know Your Device: mobile phone and marine band VHF radio.
- Is your device working for you?
- Put your device to work for engine repair, safety at sea, asset recording, damage and loss recording, business.

Though the CIRP's ICT stewardship program is targeted at stewards and not directly at fishers, demonstrative sessions are conducted with fishers for the benefit of steward learners. These sessions enable stewards and the CIRP team to together understand the comparative value of different stewardship channels and to characterize baseline use patterns, competencies and pain points.

Building functional digital literacy is a longitudinal undertaking that requires longitudinal commitment, entrenched into the standard operating procedures of stewardship agencies. Stewards are identified by local fisheries authorities, fisheries training organizations and other agencies that have regular contact with fishers in the field. They are selected on the basis of their recent direct engagement in the small-scale fisheries sector, their current circumstances through which they engage regularly with small-scale fishers in the field or in non-ICT related training sessions, and their intrinsic motivation to see ICTs support the livelihoods and adaptive capacities of fishers. Successful stewards build the capacity of fishers to use ICTs for productivity and personal safety gains, as well as to improve their adaptive capacities to reduce the impact of multiple external shocks and trends. Although they are preferably 45 years old or younger, this is not a strict requirement. ICT stewards only require basic ICT knowledge and skills. They are not expected to be ICT experts.

Achievements and failures

Many failures over years of ICT interventions for small-scale fishers have provided valuable insights for future interventions. Chief among the failures are assumptions that fishers' pain points can be translated directly into requirements specifications for ICT solutions. An example of this is the development of a virtual marketplace to eliminate the vendor as the middleperson. This followed insistence among fishers that alongside safety at sea, the parasitic monopoly of vendors was their most pressing challenge. The ICT solution failed because it did not take into consideration the complex interdependence between fisher and vendor.

Another key failure has been the development of mobile applications. These have been conceived and defined by fisheries management and international agencies to solve problems that arise from evident vulnerabilities faced by fishers. Although the problems are legitimate, sustainable solutions best emerge organically and incrementally from existing practices and devices. Despite the CIRP's regular use of co-design in which fishers play an active role in all stages of the design process, external starting points are inevitably evident and have impacted uptake. Where there are disruptive leaps, interventions must be accompanied by an unbroken and conscientious chain of support within the necessary enabling environment. This enabling environment recognizes that expectations of rapid impact from brief interventions for complex problems are a recipe for failure.

The mark of achievement is evidence of attitudinal and behavioral change. Exemplary achievement is characterized by changes in fishers' relationship with ICTs and the role that ICT plays in their lives and livelihoods. It is very much those changes in the perceptions fishers have of their role in their communities and society at large.

At a casual encounter in Trinidad in March 2019, a user of mFisheries (a suite of mobile applications for small-scale fishers) said "All yuh get me to love Motorola," as he pulled out his current Motorola smartphone. He is keen to be an ICT steward. Moreover, a fisher from St. Vincent and the Grenadines said of his experience in the co-design team that developed the Fisheries Early Warning and Emergency Response (FEWER): "I am thankful for the opportunity to be part of the process to shape FEWER, to get an app for my work, to become friends with fishers from other countries and to share with other fishers. I have learned a lot."

Plate 7. Fisher demonstrating how to use his smart phone in Trinidad.

©Kim Mallalieu

Despite the development of several ICT applications for fishers, the CIRP's key achievements fall into three categories. First, mapping the enabling environment, including barriers, bottlenecks and essential roles. The second is initiation of the conversation to integrate telecommunications into Caribbean fisheries policy and management. Last, is the introduction of the ICT stewardship model that draws on extensive fisher engagement and insights.

Examinations into the existing and potential radio range at sea have motivated the CC4FISH project to procure infrastructure to extend coverage and motivated fishers to consider the use of the radio. Radios have been purchased under the project and uptake will be tracked over the coming years. Additionally, there is a great deal of interest in matters such as data storage for photos, videos and contacts. This space continues to represent a safe and neutral focal point for learning, unencumbered by perceptions of ulterior motive for stewardship. Such interaction is essential for trust-building.

As with all social dynamics, there are asymmetries in profiles, perceptions and attitudes. ICT stewardship anticipates this and thrives on the influence of early adopters. The CIRP has noted the initiative and drive of many fishers, for example through unsolicited demonstrations of use. Many fishers have shared tips, asked follow-up questions based on applying tasks introduced in previous interactions, and made queries into strategies to use social media to expand their reach to young customers. Most of all, fishers have shown increased confidence in learning about their phones on their own time and to seek help as necessary. Reflective conversations between the CIRP and stewards is helpful in shaping country localizations of ICT stewardship.

Self-mobilization and taking initiative have not only been noted by fishers but also by stewards. For example, in St. Kitts the lead steward produced a Jeopardy-type game on the ICT stewardship curriculum using the free online tool, called "factile." An initiative such as this is a key steward learning outcome—demonstrating innovative ways of stimulating fishers' interest in ICTs and how they can be applied to increase productivity and resilience.

Broader outcomes and sustainability

ICTs stand to provide small-scale fishers with a great many benefits to their livelihoods, personal safety and broader, more generalized resilience to external shocks. They are also valuable tools in support of sustainable fisheries practice, a key mandate of sector management. Yet their sustained use relies critically on a number of practical factors (Table 7). The question of sustainability can therefore not be limited to consideration of this or that mobile application. It must also be considered in terms of the factors necessary to enable the sustained use of ICTs in general. It must recognize the importance of the mix of ICTs that together constitute an information and communications resilience toolkit. For small-scale fishers today, these include broadcast radio, television, marine band VHF radios, feature phones and smartphones. Tomorrow, they could include satellite communications and the IOT. In all cases, it is necessary to examine whether policy, regulatory and programming interventions are necessary to promote and sustain adoption.

Table 7. Practical factors critical to the sustained use of an ICT.

Factor	Description
Value	If fishers derive no value in using ICTs each day, they are likely to never use them.
Service availability	ICTs are not likely to ever be used in areas where service is unpredictable.
Service cost	Service cost is far more the predictor of sustainability than the device purchase cost.
Operational ease	Ease of use, including device powering, is an important use determinant.
Ruggedness	Devices will only be taken to sea if they can stand up to the marine environment.
Critical mass	ICT adoption relies on a critical mass of users with whom to communicate.
Support	Ongoing support is essential to keep pace with the rapid developments in ICT.
Enabling environment	A carefully developed environment explicitly recognizes information, communications and related technologies within sectoral and institutional policies, and assigns roles for support and monitoring.

High adoption rates of smartphones among fishers in most Caribbean countries compel consideration of this device as an important component in fishers' resilience toolkit. The prevailing limitations of mobile data use at sea do not render these devices inappropriate. The unavailability of low-cost rugged models and the limited coverage at sea suggest that their primary use should be on land and nearshore. Fortunately, the applications that require data service may be used in free WiFi hotspots, and many of the applications are most useful to fishers' support functions that are generally performed on land, such as planning, transactions and recording. Accordingly, the CIRP considers the smartphone a companion to the marine band VHF radio, which it promotes as the first port of call for fishers to use at sea. The feature phone will remain the device of choice for many fishers and, as for all devices, ICT stewardship will explore ways of getting the most out of it.

Key lessons learned and recommendations

There is a lot to be learned from initiatives around the world that can inform ICT capacity building for small-scale fisheries in Asia. The ICT stewardship model and its incumbent institutional policies and standard operating procedures, for example, have emerged from lessons learned in the Caribbean. Years of innovation, intervention, assessments and reflections reveal that developing ICT for small-scale fisheries must follow the lead of fishers. That is to say that it must start and end with them. Recognizing that they often do not have insight into the extent of their own vulnerabilities nor to the opportunities presented by ICTs and information management strategies, it is the role of governments and international agencies to plan and execute interventions that fit between.

ICT stewardship brings fisheries extension services, management, legislation and policy together with key agents in other sectors as necessary to build the resilience of small-scale fishers for the benefit of all. It recognizes the role of all stakeholders in an unbroken chain of action that both yields to the realities of small-scale fishers and delivers context-appropriate services to them.

Plate 8. Small-scale vessel taking on water off St. Vincent and the Grenadines.

©Winsbert Harry

The role of the private sector and regulatory agencies must not be overlooked. Noting, for example, that the cost of mobile data service is far more the predictor of sustainability than the device purchase cost, there are opportunities for providing WiFi hotspots at landing sites funded under the universal service provisions managed by local telecommunications regulatory authorities. Such an intervention would align with a national policy that recognizes the need for underserved geographies and communities at risk to access data services. These policies are in place the world over, including the Caribbean and the Pacific.

The role of fisheries policymakers is to establish the ground rules that recognize small-scale fishers as an underserved community at risk, for whom affordable access to information and communications services (including radio communications coverage) is vital. Fisheries policymakers are well advised to consider advocating for telecommunications policy and regulatory agencies to explore possibilities for a use-based or fee-waived emergency satellite service for small-scale fishers. It is also the role of policymakers to recognize the need and legitimacy of informal, functional literacy, both traditional and digital, for marginalized persons who do not have the opportunity or desire to learn through the formal educational system.

Jurisdictions that see merit in greater adoption and sustained use of ICTs among fishers must engage in cross-sectoral discourse to ensure that the overall enabling environment is in place. This includes infrastructure to ensure adequate coverage of marine band VHF radio and regulatory requirements that encourage rather than discourage acquisition and use of radio communications at sea. They must seize all opportunities for opportunistic learning through the next generation of extension services: stewardship.

Box 10. Thai Union's "worker voice" crew communications pilot: Hi-Chat application

In collaboration with USAID Oceans, Thai Union designed, implemented and piloted a combination of technologies to establish fishing efforts that are legal, regulated and reported, demonstrate fair labor practices, and promote sustainable fisheries in the Asia-Pacific region. One such technology was a smartphone application developed by a local Thai software development firm, Xsense, in cooperation with Thailand's Department of Fisheries. Using the broadband coverage onboard fishing vessels provided by Immersat's Fleet One antennae, Xsense was able to develop a smartphone application called Hi-Chat for the use of the fishing vessel crew, captain and the owner while at sea. The application is a simple chat platform that provides access to registered users to have a group discussion. In addition to the vessel/company-specific chat platform, registered users can have a two-way private account with a contact on land for personal communications. The two-way conversations are private to the other users, while the group chat platform data is something that can be viewed by the vessel owner as well as by Thai Union or anyone else who has registered as a user for the particular vessel/company. This application operates in Thai, Burmese, Cambodian and Lao to enable the crew of different nationalities to use it.

The pilot testing (Thai Union eCDT and a crew communications pilot assessment) confirmed the Hi-Chat application contributes to crew welfare as it is used frequently and enables incidents to be reported to a partner or relative. Vessel crews stated their preference for vessels with Hi-Chat over other vessels, and the internal chat function contributes to improved onboard culture, which is a key aspect of crew retention (when other aspects such as pay and safety are equal). This is especially true for vessels with longer sailing times, as the opportunity to speak to family is attractive.

There were a few exceptions where crew members did not have anyone in Thailand to sign up for the private channel and only used the group chat function. This was due to the difficulty of installing the application, which could not be done without the help of X-sense staff, so relatives and friends back at home could not be reached. This limited the use of Hi-Chat to those friends or relatives within Thailand. Crews who had no contact onshore had nobody personal to talk to during the pilot. However, the crew's preference was to talk to someone onshore in Thailand, as well as back at home. There were also some vessel owners who were nervous of false accusations of crew abuse through Hi-Chat. Many vessel owners considered Hi-Chat as nice to have, but not essential for shorter trips.

Additionally, it appeared that the high volume of traffic on Hi-Chat resulted in the accounts running out of credit quickly. This had a knock-on effect on the other technological uses, such as e-logbooks and two-way communications functionality. It should be considered that business operations and eCDT related information, and their timely and accurate transmission, should remain a priority for the vessel throughout the trip. As a result, limiting the bandwidth use per individual and ensuring sufficient usage for the essential eCDT functions, as well as the two-way communications on each fishing trip, are essential in the next step of the pilot.

Although Hi-Chat was developed primarily for semi-industrial fishing vessels, many low-income nations, such as Bangladesh, use larger boats on long trips that are considered small-scale fishing vessels. Hi-Chat not only represents an opportunity for decent work for these larger vessels, but also for fishers' well-being on smaller vessels more commonly used in small-scale fisheries. Thai Union has extensive plans regarding crew welfare and improving industry standards in terms of transparency of crew conditions, including crew-based auditing of their conditions on board. This work is currently taking place in the context of the Indian Ocean long-line fisheries. The Hi-Chat application links into this whole development, and its successful further development will likely pay dividends in many areas of work in improving the lives of fishing crews. An important consideration, however, is that the advancement of mobile phone networks in coastal areas could provide lower cost competition. As part of government plans for eCDT, human welfare applications like Hi-Chat could be seen as too expensive or only "nice to have" because they are not part of the European Union's yellow card requirements on IUU.

Currently, the information collected, its operational aspects and its compatibility with government systems fall short of what is required for the technology to spread. These shortfalls meant it was not possible with the initial pilot testing to estimate in detail the system efficiencies and related cost-savings. Therefore, the pilot did not demonstrate its ability to save time, improve business transactions and operations and more easily meet regulatory requirements.

Chapter 7.
ICTs instrumental in scaling women's employment model in fishing communities

Chapter 7. ICTs instrumental in scaling women's employment model in fishing communities

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Highlight summary

In fisher communities of coastal Bangladesh, fishing for hilsa shad (*Tenualosa ilisha*) is a key livelihood activity. Recent management measures have closed the fishery for three months a year, so women from these communities are engaged in various enterprise development and income-generating activities to build their livelihood resilience during hilsa ban periods. In collaboration with a social business enterprise, one such activity is making hand-knitted/crocheted toys and clothes for export markets under the branded name Pebbles. ICTs played an important role in bridging the communication gap between the participating women living in remote areas and the social enterprise operating from the country's capital. Mobile video technology allowed women to access new designs and attain better prices. The project also tapped into an existing mobile banking service called bKash, which works to financially include the unbanked people of Bangladesh. With the help of mobile phone banking technology, women gained financial inclusion and control of their money.

Plate 9. Reshma with her "Pebbles" in the village of Adarsha, Bangladesh.

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Background and context

Hilsa is not only a symbol of national and cultural pride for Bangladesh, but millions of people are also directly or indirectly involved in hilsa fisheries for their livelihoods. Often, however, women's role with small-scale fisheries is unrecognized and limited (Kleiber *et al.,* 2017; Mills *et al.,* 2011). Consequently, women in these coastal fishing communities are one of the most vulnerable groups. They have limited decision-making power and access or control over resources, with 80–90 percent belonging to households that earn USD 1.25 or less per day. To meet their financial burdens, most of the women resort to borrowing from different money lending institutions, both formal (microcredit organizations) and informal (high-interest local moneylenders called *dadon*). Repaying these loans can be difficult, especially during the hilsa ban. To reduce this financial pressure, especially during the ban period, different income-generating activities were promoted by WorldFish and Bangladesh's Department of Fisheries under the Enhanced Coastal Fisheries in Bangladesh (ECOFISH) project funded by USAID (Nahiduzzaman *et al.,* 2018). ECOFISH aims to support coastal fishing communities and other fisheries value chain stakeholders to improve the resilience of the Meghna River ecosystem and the communities reliant on coastal (hilsa) fisheries. Among these activities, WorldFish collaborated with the Hathay Bunano Proshikshan Society (HBPS),[23] which translates as "Hand Knitting Training Association." This social business enterprise provides work-from-home employment opportunities to rural women from fishing communities. Specifically, the HBPS provides women in rural areas with low technology, low-cost and labor-intensive employment opportunities through making crotched and hand-knitted toys for children under seven years old, targeted for export. Importantly, these employment opportunities provide training, fair wages and links to an already established export market. However, when ECOFISH approached the HBPS to scale into the region of Barisal, the lack of production centers and costs around setting up infrastructure were highlighted as major concerns. Nevertheless, working with the fishing communities in this region meant the HBPS needed to expand its working area and change its model of working (Box 11).

Box 11. The Hathay Bunano Proshikshan Society (HBPS) model

The HBPS has production centers in local areas where approximately 50 women gather at a time to produce toys. Each production center has supervisors (one each for crochet, embroidery and knitting), who are selected in a participatory manner and are often the best trainees in the community. These supervisors also play the role of community coordinators in their respective village groups and are paid a monthly salary apart from the piece rate wage they receive. Specific responsibilities include recordkeeping, distributing raw material and payments, coordinating local training for new samples, controlling product quality, maintaining contact with the organization's head office and being the collection point for the final product.

Master trainers from Dhaka are sent to train the women initially. Childcare facilities are also provided on a need basis at these centers. When a new design comes in, the supervisors go to Dhaka for two days to learn and carry forward what they have learned to the rest of the trainees. The supervisors are also provided with training on accounts and administrative tasks as needed.

Orders are received from foreign buyers at the Dhaka office of the HBPS along with designs and specifications. The required raw materials are then sent to the rural production centers. From the centers, the supervisors drop off the raw materials so the women can work from their respective homes. When the product is finished, the supervisors also pick it up. Local courier services and buses are used for delivering and transporting raw materials and final products.

The HBPS emphasizes the quality aspect of their products. The first line of quality control is done at the production center by the supervisors.

To save time, costs and labor, WorldFish designed a new model that tapped into ICT solutions. One such solution was bKash mobile banking, which allows women to receive their payments efficiently and on time, without needing a bank account. bKash[24] is one of the leading providers of mobile financial services in the world. It was founded as a joint venture between BRAC Bank Ltd, Bangladesh and Money in Motion (LLC, USA). Subsequently, the International Finance Corporation joined as an equity partner and the Bill and Melinda Gates Foundation as an investor.

In Bangladesh, less than 15 percent of people are linked to the formal banking system, whereas more than 68 percent have mobile phones. bKash tapped into this potential, starting as a money transfer platform and has since expanded into services around remittance, airtime top-up, merchant payments, etc. Now, over 30 000 merchants accept bKash payments, providing financial services to people both linked and not linked to the formal banking system, mostly through the various “mom and pop” shops across the country. Among the 16 mobile banking service providers in Bangladesh, bKash is the largest, capturing 99 percent of the market along with Rocket (another provider). Its registered customers are more than 24 million. bKash was ranked 23rd among the top 50 companies listed by Fortune Magazine to change the world based on social issues in 2017.

Process, participation and capacity building

Under the new HBPS model, training is provided to women participants in Barisal and Bhola. Since the organization did not have production centers near Barisal, ICT solutions were built in to combat some of the issues that its absence raised. Most of these women do not have bank accounts, and the HBPS needed a way to pay them on time. In response, the project took advantage of the existence and popularity of bKash, which even the rural women were familiar with given the rapid growth in its popularity and use since its launch in 2011. Each coordinator received a bKash account that they could monitor on their phones and the organization could easily send them money to.

The HBPS also needed to frequently train women on new designs and products, so the use of both live and pre-recorded video was proposed. The videos are usually dispatched by the coordinator in three ways. One, the coordinator gathers the women in her house to watch a live video on her mobile phone of the master trainer making the product. This allows the women to learn, imitate and ask questions virtually, in real time. Since the mobile screen is small, another way it is done is the coordinator receives a one-on-one lesson virtually from the master trainers from Dhaka, which she then uses to train the rest of the women. The final way is that HBPS master trainers pre-record videos of them making the new product and then these are shared with the coordinators to dispatch to the rest of the women.

[24] https://globalpaymentsummit.com/bkash-bangladesh-24-million-customers-using-mobile-money/

Before beginning initial training activities, the HBPS conducted a small feasibility assessment by talking to the women in these areas to gauge their interest. Most were interested in being able to make money from home and by doing something that is stereotypically associated with women. The first training session was provided in the village of Adarsha, Barisal Division, in January 2016. In the beginning, trained women lost interest quickly because of the low amount of money they made. For example, 15 women together could only earn BDT 4 500 from 150 toys, amounting to only BDT 30 (USD 0.35) per toy. However, their interest picked up as new designs and higher value products were introduced via videos. (For example, a bunny costs BDT 60 or USD 0.71 per piece.) The women also became more efficient and were able to produce more toys within the same time period. The steady and timely flow of income also incentivized them to continue and contribute to their family income.

Achievements and failures

Initially, 728 women from 19 villages in the districts of Barisal (eight villages) and Bhola (11 villages) in Barisal Division were trained in making toys for export alone. Among these 19 villages, only four were successful in terms of production and producer retention: Kalia, Kauartek and Shitakunda from Bhola District, along with Adarsha in Barisal District. This was mainly due to their location and facilities. Currently, 130 women remain employed in Pebbles production. From April 2016 to September 2018, total income from Pebbles production was BDT 1 611 095 (USD 19 294).

The village of Adarsha has good road infrastructure because it is home to the district headquarters. It also contains various bKash service-providing mom and pop shops and has good cellular network and internet coverage. Similarly, the three successful villages in Bhola have well-developed water transport systems that also provide easy, convenient and safe travel options for women. These conducive transport systems gave women access to bKash service providers that are not as available in the island villages of Bhola.

The 15 unsuccessful villages could not keep pace due to their remoteness, which made it difficult to coordinate and make payments despite the ICT solutions. Supplying raw material to these places was difficult and often delayed due to underdeveloped water transport systems. Internet connectivity issues inhibited the women from receiving regular orders and watching the training videos that would have given them access to higher-value designs. Furthermore, even though bKash services are available via 180 000 agents across rural and urban areas of Bangladesh, women coordinators in the remote villages still had to travel far (often in unfavorable water transport systems) to cash out their mobile payments. Most of the bKash service providing shops are available mainland.

Broader outcomes and sustainability

Overall, the ECOFISH project collaborated with the HBPS to expand its working area into the Barisal Division. The HBPS did not have the production centers set up in Barisal that they have in their original working areas. As a result, to make the HBPS model work without proper infrastructure, ECOFISH sought to leverage the pre-existing network of bKash users and providers to bridge geographical gaps in the value chain. Essentially, the HBPS no longer had to distribute cash in person. It could make payments to the local woman coordinator directly via an ICT mobile banking service all the way from Dhaka.

The use of ICTs aided the HBPS to expand and benefit a larger number of rural women with employment and income. ICTs also helped combat the mobility issues women face by enabling training and payments from home, which they could cash out when needed. Moreover, understanding the mobile banking system has built the agency and strengthened the trust of these women. Mobile banking allows women to monitor the amount of money flowing, store the information for future referral and match with the records that the coordinator keeps. This helped women independently engage in their livelihood, have access and control over the income they earned and be able to fulfill their unpaid care work while earning an income. Monitoring results have shown that women use this money for feeding their families and to meet household expenses, especially during low-income periods, like when hilsa fishing is banned.

Key lessons learned and recommendations

ICTs can help scale innovations and ideas. But when they are tied to a direct economic incentive, the potential of ICT adoption increases, and it can be instrumental in the success of the innovation. The ECOFISH project also realized the importance of tapping into and linking women with existing successful digital initiates rather than trying to reinvent the wheel. However, our results show that it is crucial that projects evaluate site-specific vulnerabilities and challenges, especially in working with ICTs that are reliant on connectivity in remote areas.

The project took an accommodative gender approach where it tried to conform to existing prevailing norms in designing its interventions, such as gender-stereotyped knitting activity from home, and choosing ICTs that are instrumental in adoption. In the future, it will be important to take up gender-transformative strategies that will enable women and their families to critically examine the harmful norms that obstruct women from pursuing any livelihood they desire, even beyond the home (Kantor *et al.,* 2015; Behailu *et al.,* 2018). Unless the stereotypes and norms are challenged, women will continue to remain within the sphere of the homestead with limited opportunities. ICTs can be powerful tools to disseminate such messaging that critiques stereotypes and harmful norms. The Meena Communication Initiative[25] (Box 12) by the United Nations Children Fund (UNICEF) is one such example that had a substantial impact in Bangladesh.

Box 12. Gender-transformative action through the Meena Communication Initiative (MCI)

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The Meena Communication Initiative (MCI) started as a human rights campaign back in 1991 by UNICEF in four countries: Bangladesh, India, Pakistan and Nepal. Its perceived intention was to transform the status and rights of young girls. It used a multimedia education approach to convey entertaining stories and messages that aim to provoke critical reflection about harmful social norms, leading to attitudinal and behavioral changes among its audiences. In doing so, the initiative mainly made use of a popular ICT entertainment source: television. It later expanded to radio, school curriculum, billboards and theater as well.

The stories followed Meena, an animated nine-year-old South Asian girl and her adventures as she confronts the various gender relations surrounding her, starting from her brother Raju to the members of her family and her village community, in establishing her rights. Her pet parrot, Mithu, is also a key character in the story. Meena is portrayed as a strong, spirited role model who teaches her family and community members the importance of providing the girl child with her rights. She fosters positive social change with various lessons and messages around equity in girls' education, health, and freedom from exploitation.

[25] www.unicef.org/french/evaldatabase/files/ROSA_2004_800_Meena_Comm_Initiative.pdf

Implementation of the MCI in Bangladesh began in December 1992 via television. This was later scaled and lived on beyond the 1992–1996 development period through partnerships with the government, NGOs, mass media and the private sector as part of a mass mobilization strategy. Meena videos were screened repeatedly on the national Bangladesh Television (BTV) channel. UNICEF and BTV also collaborated on two documentaries about the MCI. Bangladesh Biman Airlines included Meena videos in its in-flight entertainment system between 1993 and 1994. To reach large audiences who do not have access to television, the Department of Mass Communication used mobile film units to showcase Meena cartoon episodes on large screens in various rural and urban areas. By doing so, they reached an estimated audience of over 3 million people. UNICEF and the British Broadcasting Corporation collaborated to produce the first Meena radio series in 1994. Manuals, posters, comics, films and billboards were also created. Meena videos were also incorporated in teacher training courses via the IDEAL project. More episodes are still coming out, and in 2016 UNICEF even developed a mobile app called the Meena Game (available on Google Play Store), which provides an interactive platform for children to learn about their well-being. According to UNICEF, about 97 percent of urban and 81 percent of rural children and adolescents recognize Meena in Bangladesh.

The Meena Initiative also affected fishing communities in Bangladesh. In small, informal discussions conducted recently with three fishing groups in coastal Bangladesh, most participants recalled watching Meena, while others have heard of her. A group of participants recalled how she solved various social problems with determination. All communities responded that key messages they received from Meena and which impacted their communities were to provide equal education for female children and for parents not to get their daughters married at a young age.

Box 13. Fisheries data privacy trade-offs in small-scale fisheries of Taiwan Province of China

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Taiwan has a large fishing industry with a total estimated annual revenue of USD 2.9 billion (Fisheries Agency, 2017). The national fleet comprises 12 381 motorized fishing vessels and 10 109 non motorized fishing rafts or sampans (Plate 10). Two tracking systems are used to track large cargo, passenger and foreign fishing vessels: a VMS and an automatic identification system (AIS). However, most of the national offshore and coastal fleet has not been required to carry tracking systems until recently. To fill this gap in data for the largest number of boats of the national fleet, the voyage data recorder (VDR) device was developed in 2006.

The VDR is a simple GPS tracker. Although similar in purpose to a VMS, a VDR records a vessel's location and bearing every 3 minutes compared to 30 minutes to 6 hours for a VMS. A VDR does not have the ability to relay data back to the base station via satellite or telecom networks, but rather stores the data internally until it is downloaded manually from the vessel once returned to port. Despite not being communicated and analysed in real time, VDR data is still used in combination with landings reports and auction records to regularly compute the distribution of efforts by site, fish catches and fishing gear use in regions of interest (Chapter 2).

In 2007, the Taiwan Fisheries Agency mandated that all coastal and offshore fishing vessels in Taiwan must be equipped with a VDR device. Some fishers initially resisted the mandatory VDR installation, citing violation of their privacy, fear of prosecution or disclosure of their fishing grounds, and the additional labor burden of uploading data. To mitigate these concerns, the government gave assurances that the data would be kept private unless ordered by a court, and instigated fuel subsidies as an incentive. The fuel subsidy is obtained through one of two methods: by computing the total effort using VDR records or by giving a fixed quota subsidy without using VDR records. Small boats that do not travel far choose the fixed quota subsidy because it will be higher. As a result, these vessels will not submit their VDR data and records will be lost.

Currently, more than 8 000 coastal and offshore fishing vessels, as well as a few overseas vessels, are equipped with a VDR. Approximately 5 000 of them have uploaded their trajectories to the servers. Despite the law requiring fishing vessels to have the VDR system installed, submitting VDR records to the authorities is currently not mandatory as the debate on freedom from surveillance is still going on.

Interestingly, however, this data can also be of crucial use to small-scale fishers in providing quantifiable evidence of the value of their livelihood activities in the blue economy. One illustrative example of this potential came in March 2016 when the 15 487 gt container ship TS Taipei ran aground in the north of the island and split in two, spilling oil along a 2 km stretch of coastline used by approximately 10 000 fishers.[26] By matching registry and landings data with effort from VDR vessel tracking data, it was possible to estimate the loss in earnings from fisheries due to the oil spill and calculate the value of reparations the fishers association should request in negotiations with the shipping company.

There are clear trade-offs in providing data from small-scale fishers. On the one hand, fishers are skeptical of being tracked and reluctant to spend additional time and effort submitting data. Yet in the evaluation of the data and the insight it provides into fisheries livelihoods and food security, there are also opportunities. Data from VDRs has become an important basis for fishery policymaking and research to understand national fishing activities and their impact on marine resources. Clearly, however, there are also opportunities to use them to raise the socioeconomic well-being of fishers and fishworkers and to move toward responsible governance of tenure by including fishers in decision-making and securing their access to small-scale fisheries areas (SSF Guidelines).

Plate 10. A sampan (left) is generally used for small or family-scale fisheries. A Styrofoam boat (right) can be equipped with an outboard motor and is dangerous if the weather conditions become rough.

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[26] www.taipeitimes.com/News/taiwan/archives/2018/02/06/2003687161.

Discussion and conclusions

Discussion and conclusions

The diversity and isolation of many small-scale fisheries are responsible for their resilience and perseverance in providing food and income in informal contexts. But they also represent the most substantial obstacles to their emancipation from poverty. One of the most significant challenges to implementing ICT4SSF is insufficient understanding of the social, economic and cultural barriers to digital inclusion. Differences in data needs, digital literacies and network and power infrastructures contribute to these challenges. In sum, small-scale fisheries communities, groups and individuals are not equally capable of accessing or exploiting digital tools. As ICTs continue to spread, there will be inherent advantages for the wealthy and digitally literate. To bridge the digital, divide specific attention must be paid to ensure that these services and solutions reach vulnerable and marginalized communities.

We must encourage the design of ICTs that are socially relevant to remote communities (whether geographically or socially), and that improve lives, even if they do not directly improve economic productivity (Steyn, 2011). Many applications of ICT4SSF have been attempts to field-test technologies that were developed externally. They are often the result of proposal driven projects, and as such the program objectives and methods are mostly preordained before the local context and problems are understood. Evidence from this report suggests that unless an ICT is designed or developed locally, it will not be successful beyond the scope of donor project timelines due to either a lack of local applicability, unsustainable finances or an insufficient knowledge foundation. A participatory approach that co-designs the application of the ICT can minimize the risks of it being disconnected from the on-the-ground reality, and can ultimately save money and time (Chapter 2 and Chapter 4). More important, however, is building on the opportunity for the ICT to be a vehicle for larger socioeconomic and environmental gains, such as gender equality, inclusive governance and improved well-being.

Policy coherence, institutional coordination and collaboration

ICTs have potential to contribute to combating poverty by allowing poor countries to leapfrog traditional stages of development to access the digital economy. To facilitate this shift, however, governments need to promote policies that target digital inclusion (Mori, 2011). They must also narrow the gaps between individuals based on gender, religion, economic class, etc., that can access and benefit from ICTs. This implies improving telecommunication and electricity infrastructure and access to education, as well as supporting the private sector to engage with the global economy (Clarke, 2011).

The regulatory environment, particularly in the least developed country context, can significantly influence the availability and adoption of ICTs. Kenya is an example of where this approach has had tremendous impact. Direct financial and political investments into ICTs in Kenya, such as mobile banking and digital services, are seen as key drivers of financial inclusion, jumping from 27 percent in 2006 to 83 percent in 2019 with marked reduction in disparities between rich and poor, men and women, and rural and urban areas (Finaccess, 2019). Some benefits of early prioritization of digital inclusion are illustrated in Chapter 5 by trialing market information systems. This would not be possible in other areas where network penetration and phone ownership are much lower.

The inclusive growth of small-scale fisheries relies on socially and geographically isolated individuals accessing and using digital services for a better life. The core benefits of ICTs are to create equal opportunities for fishers to access and benefit from information and services. This may be information about current market prices or buyers looking to trade; for training materials or video tutorials; or for financial services such as microcredit. ICTs should also contribute to the vertical and horizontal flow of information guiding equitable governance of shared resources in the blue economy. Yet these benefits are hard to illustrate to individuals.

In Taiwan Province of China, the value in having good information on fisheries livelihoods proved essential in negotiating reparations to small-scale fisheries from environmental damage to fishing grounds (Box 13). These examples are extremely valuable in highlighting the need for top-down investment in policies and initiatives that promote digital inclusion, and bottom-up awareness raising of the need to participate and collaborate to achieve mutually recognized goals (SSF Guidelines 10.6). Governments must build on positive examples to raise awareness of the benefits of inclusion, while investing in extension and capacity building to enable them to choose.

Welfare and well-being

ICTs in development have traditionally been biased toward economic activity (Sreekumar, 2011), but research conducted in India suggested that fisheries actors seldom define welfare in economics terms, but rather more to safety, such as risk avoidance and emergencies (Srinivan and Burrell, 2013). Phones were more important for keeping in touch with family and friends, and for safety (Srinivasan and Burrell, 2013; Steyn and Das, 2015). This is certainly supported by the self-organization into chat groups via WhatsApp messaging (Chapter 3). It also highlights an important lesson in identifying the needs and aspirations of small-scale fishers in ICT initiatives. To improve well-being, then, we must encourage the design of ICTs that are socially relevant to remote communities (whether geographically or socially) and that improve lives, even if they do not directly improve economic productivity (Steyn, 2011) (Box 11) (SSF Guidelines 6.12).

Fishers need to understand how to use a technology (literacy) and also how they could benefit from using it. Ensuring equitable access to ICT4SSF can be done through capacity building activities and strategies that give marginalized groups an opportunity to learn outside of formal education systems. In the Caribbean, a variety of informal methods, such as ICT hangout sessions and one-on-one training sessions, showed results in creating an inclusive, flexible and multimodal environment for capacity building with higher user uptake and more sustainability (Chapter 6).

This also illustrates the value of building on and linking with existing capacities and technologies that people are already familiar with to achieve development outcomes, rather than developing ICTs to solve every problem. Social networks increase the speed of information flow between people, which improves the response to shocks and increases social learning and technology uptake (Aker and Mbiti, 2010). Consumption of video content on mobile devices is growing remarkably quickly for both men and women, by as much as 50 percent over 2 years in some countries (Rowntree *et al.,* 2020). This reflects the growing popularity of applications, such as YouTube and TikTok, that facilitate sharing of user-generated video content and could be instrumental in both informal learning and more formal capacity building initiatives.

Using existing or integrated platforms to take advantage of data links (i.e. interoperability) could also pose significant opportunities to improve well-being in its broadest sense of agency and capability (Sen, 1986). Examples of this are being effectively used in agriculture to automatically generate data on the needs and priorities of actors and by gamifying learning or using chat bots in social media platforms.[27] Another example of this is where simple integrations and adaptability built into ICTs, such as allowing fishers to add information of departure time and expected time of arrival or generating SMS alerts when fishers return to port, can bring substantial gains in fisher safety as well as monitoring efficiency (Box 3).

[27] www.farm.ink

Gender

Globally, women play a significant, yet undervalued, role in small-scale fisheries. The pursuit of digital solutions to contemporary issues must be cognizant of gender-digital divides and use inclusive strategies to transform gender norms. Women across low- and middle-income countries are 8 percent less likely than men to own a mobile phone, but 20 percent less likely than men to own a smartphone (Rowntree *et al.,* 2020). Evidence suggests that enabling ICT use by women represents an opportunity to fight longstanding inequalities in developing countries, including access to employment, income, education and health services (Hilbert, 2011). This is the core objective represented in sections 8.1–8.4 of the SSF Guidelines and also represents the key to kickstarting inclusive economic growth in small-scale fisheries. This is consistent with the findings in Chapter 7, where financial inclusion, specifically the easy access to mobile money tools, was the deciding factor in an alternative income-generating scheme linked to mobile money.

Addressing the digital gender gap requires not only substantial investment in women's education, but also the proactive development of their capacity and confidence to effectively participate in decision-making processes (Mutimukuru-Maravanyika *et al.,* 2017). These investments have been shown to bring about direct household nutritional gains (Miller *et al.,* 2017) and resource sustainability improvements (Tindall and Holvoet, 2008). Following the lead of initiatives such as in Chapter 4, work must be undertaken to better understand women's needs and barriers to mobile ownership and use in the market, and interventions must be designed to address these barriers. Women must be consulted and involved in ICT product/service design and implementation, including testing and piloting, and in proactively tailoring marketing and distribution approaches to their needs (Rowntree *et al.,* 2020) (SSF Guidelines 8.4).

The need for gender-disaggregated data in official statistics at a minimum is becoming more appreciated. But it is still not the norm, and greater research focus is needed to identify the constraints to collecting disaggregated data (SSF Guidelines 11.1). The contribution of women fishers and fishworkers in small-scale fisheries is substantial (Harper, 2020), and their omission from statistics and decision-making impacts our ability to manage resources effectively (Tilley *et al*., 2020a).

Transparency and trust

Trust shapes the way people choose to interact with others and with technology. Digital trust is determined by the ICT properties and is a representation of trust in the designers, creators and operators of that technology. Communities have become the testing grounds for technologies developed far away, and they have little control over how the data is used, managed and analyzed. Many initiatives are extractive and lack the transparent, two-way information flow between small-scale fisheries actors that incentivizes cooperation toward common goals of food security and sustainability. Future ICT4SSF initiatives should seek to better understand the information and complementary system failures in a given context to better understand if the lack of information is a binding constraint. Aker *et al.,* (2016) suggest that information services should be of high quality and from a trusted source and that such services should be "delivered via platforms that build upon local ICT access and usage, paying particular attention to the gender digital divide."

The ICT needs of fishers and fish workers will not be solved by applications conceived and designed by external agencies, because they are not locally legitimate. This is especially true of initiatives they perceive to be aimed at restricting their catch by surveying their activities, which is by far the most frequent application of ICT4SSF (Chapter 1). Furthermore, these applications are generally limited to vessel locations and catch records. To a far lesser extent, they are used for and by small-scale fisheries actors to build a record of gendered social, cultural and economic data relevant for transparent decision-making (SSF Guidelines 11.1).

There is great potential for transparent and equitable information systems paving the way for responsible governance of tenure — for example, to "establish networks and platforms for the exchange of experiences and information and to facilitate their involvement in policy- and decision-making processes relevant to small-scale fishing communities" (SSF Guidelines 10.6). These systems should include gender-disaggregated "bioecological, social, cultural and economic data relevant for decision-making on sustainable management of small-scale fisheries" (SSF Guidelines 11.1). However, the tendency is for fisheries monitoring to be extractive. There are few mechanisms in place for information to flow both ways, to be co-generated, and few regulations in place to protect an individual's data privacy and ownership. So far, these have been poorly addressed in the small-scale fisheries sector.

Value chains and markets

Small-scale fisheries continue to generate and distribute food and income in contexts where formal markets and global supply chains function poorly (Cohen *et al.,* 2019). That said, traditionally rural fishers have been at the mercy of middlepersons due to limited market information on current prices. Since the onset of mobile phone use in rural markets, it has been theorized that they will bring about increased supply chain efficiency and increased welfare of actors by driving reduced price dispersion. Robert Jensen's (2007) paper "The Digital Provide" is commonly cited as evidence for mobile phones having the potential to determine market prices by fishers selling at the best market. Theoretically, with everyone accessing and aware of the same information, the price stabilizes across the whole market, ensuring equal opportunities and benefits for small-scale actors. However, these claims have since been found as lacking in empirical evidence and characterized as overly generalistic (Steyn, 2016; Srinivasan and Burrell, 2013). Fishers and traders operate within social networks, where business transactions are determined by trust and are built up over time and through experience. Often fishers are obliged to land their catches at a particular market due to credit arrangements, or agreements with buyers or fuel subsidies. To operate outside of these and attempt to exploit price differences across spatially distributed markets adds significant risk and potential costs that their digital trust of an information service might not justify. Inevitably, as shown in Chapter 5, these systems could still be at the mercy of preexisting elites or power hierarchies within markets where, particularly price information, represents the power of one actor over another, and it is not something they are prepared to relinquish.

However, there is certainly evidence from across the sector that mobile connectivity can stabilize prices and bring especially large impacts in geographically isolated markets (Aker, 2008), which often characterizes the small-scale fisheries sector. In African market settings, ICTs have reduced price dispersion, with stronger effects seen when the distance from the producer to the market is greater and the roads are poorer (Aker, 2010). Furthermore, an even greater effect size is seen for perishable goods over storable goods, presumably due to the cost savings accrued from less wastage. This is consistent with preliminary findings in a small-scale fisheries context, where Jensen (2007) and Abraham (2007) found improved welfare and less wastage following mobile phone adoption in Kerala, South India.

Increasing numbers of small-scale fisheries actors look for ways to shorten value chains and sell directly to consumers (Brinson *et al.,* 2011). Stoll *et al.,* (2015) suggest that the ability to market directly combined with the resulting economic incentives drives social-ecological resilience in small-scale fisheries communities through better cooperation, communication and information flow. Furthermore, the evaluation of the Abalobi suite of apps in South Africa (Box 9) found that ICT4SSF have the potential to bring about large improvements to economic welfare and can potentially trigger socioeconomic welfare improvements, so long as they can access the digital services (Nthane *et al.,* 2019).

COVID-19

The coronavirus pandemic (COVID-19) has brought massive global economic and food security shocks, with devastating and lasting impacts on the world's poor and vulnerable. The emergency measures restricting movements and forcing millions of people to return to rural areas from cities has brought new and rapid awareness of the enormous value of small-scale fisheries for food security, both for full-time fishers but also as a buffer for temporary migrants. The pandemic has also highlighted the urgent need for digital inclusion of these vulnerable groups to ensure that everyone has the opportunity to learn from home with digital technology, to send money to relatives easily and instantaneously, and to access online services. This should be the *new normal* we strive for.

In some locations, movement control orders to restrict the spread of the virus have taken a terrible toll on artisanal fishers and traders. The worst affected are those who are not allowed to fish at all, such as seen in Uganda,[28] where fishers have been forced to move away from water bodies to search for alternative ways to feed their families. However, other small-scale fisheries are faring better than commercial fisheries precisely because they require less port services, can venture out in small numbers, and the market connections are often local and familiar rather than relying on high value export markets that rely on functioning transport systems over large distances. Those fishers and traders who are digitally connected have been able to continue to trade and even innovate to create new enterprises and business opportunities in the process. COVID-19 might offer countries an opportunity for a new normal. This could come in the form of a shift from subsidies that enhance the capacity of industrial fleets in favor of more support for responsible small-scale fishers, as well as measures that encourage sustainable stock management and improve fishing traceability.

On top of this, FAO has compiled numerous examples of initiatives in support of small-scale fisheries during the COVID-19 crisis to facilitate information and experience sharing.[29] One illustration of the adaptive capacity that digital systems provide is from Abalobi (Box 9). In response to COVID-19, it pivoted to enact a type of community-supported fishery, where consumers can buy a share in weekly local catch for home delivery. This ensures fishers' earnings during a risky time and allows them to retain fish for food security to sell locally to community members at a highly discounted price.[30]

[28] www.independent.co.ug/over-1000-starving-fishermen-vacate-lake-albert/
[29] http://www.fao.org/3/ca8959en/ca8959en.pdf
[30] www.dailymaverick.co.za/article/2020-04-09-go-fish-the-covid-19-edition/

Next steps

Next steps

Small-scale fishing communities in developing countries are often representative of some of the most geographically and socially marginalized individuals and groups in the world. As such, the biggest barriers to using ICTs to achieve the inclusivity and well-being elements of the SSF Guidelines are naturally the broader development challenges themselves, such as poverty, literacy, gender inequality and services infrastructure.

To develop an ICT4SSF strategy, governments and agencies should first assess the underlying social, cultural and normative barriers to digital inclusion. For example, what percentage of the country has internet connectivity? How many women and men have mobile phones and/or smartphones? What is the most popular messaging platform? This should categorize communities and/or areas according to their digital inclusion and receptiveness to new initiatives.

The Principles for Digital Development[31] is a useful starting point in guiding ICT4SSF with best practices (blue italics added by editors for greater clarity):

- Design with the user *but with all stakeholders in mind*.
- Understand the existing ecosystem.
- Design for scale, *but be prepared to scale gradually and through partnerships*.
- Build for sustainability *and adaptability*.
- Be data-driven *by building capacity to understand and use the data*.
- Use open standards, open data, open source and open innovation.
- Reuse and improve.
- Address privacy and security.
- Be collaborative.

Establishing baselines to evaluate impact

Development is best seen in terms of an expansion of people's basic freedoms or capabilities, and the growth of GDP serves as an important means to achieve this (Dreze and Sen, 2015). Yet a general lack of clear pathways from ICT adoption to improved well-being limits government motivation for investment in the sector.

Many ICT4SSF initiatives are not documented openly, and somewhat paradoxically there are few data or scientific studies reporting their performance and efficacy at achieving fisheries or development outcomes. The effects of ICT interventions are not being measured despite valuable insight being embedded into the details of not only what worked, but more importantly what did not work in different contexts. This is largely due to the problem of omitted variable bias and the lack of randomized controlled trials to test the effects of ICT adoption on development indicators.

Of the research that does exist on the impact of ICT for development (ICT4D) more broadly, Chipidza and Leidner (2019) argue that the lack of evidence is due to the varying definitions of development, including increased freedom, inclusion, economic productivity and well-being. ICT4D is said to be overly focused on economic growth instead of broader more holistic definitions of well-being (Sreekumar, 2011), defined as the freedoms, agency and capability to make choices and act effectively (Sen, 1986).

Without empirical evidence examining the ecological, social and economic impacts of ICT4SSF initiatives, there is a critical gap in our understanding of how these initiatives are affecting target users and communities. Consequently, there is real risk in establishing or perpetuating harmful

[31] https://digitalprinciples.org/principles/

practices that can exacerbate digital divides and erode well-being. To distill best practice methods for implementing ICT4SSF, evaluations are needed that examine the performance and efficacy of initiatives at achieving their intended outcomes.

The impact of technology on achieving the objectives of the SSF Guidelines, such as inclusive governance of resources or improved well-being of small-scale fisheries actors, is not yet possible to effectively measure. But as more ICT initiatives emerge, big data approaches could provide new insights.

Big data and AI

Big data (the aggregation and analysis of large and unstructured datasets) is increasingly valuable in driving learning by identifying new insights and trends that are not possible to ascertain with sample-based research. The insights gained from analysis of aggregated data must be of demonstrable value to those contributing the data, or else the process is merely extractive and unethical and so there is no incentive for them to collaborate. However, a user-centered design process in ICT4SSF allows for the specific development of technologies that respond to the needs of fishers and stakeholders, place them as the owners of their own data and empower them through data.

The application of big data approaches in small-scale fisheries is in its infancy, with relatively exploratory research, such as automated identification of fishing types and behavior by vessel speed and tortuosity (O'Farrell *et al.,* 2019). Precision and digital approaches to fisheries remain predominantly in the industrial sector, aiming to optimize efficiency of species or gear-specific fisheries (Bradley *et al.,* 2019), minimizing by-catch (Hazen *et al.,* 2018) or predicting fruitful fishing grounds.[32] Yet even in the industrial sector, it has been suggested that innovation is stagnating due to issues of trust and cooperation with fishers and managers (Bradley *et al.,* 2019). This implies the need to continue to calibrate and sound out research on the ground and in consultation with the actors involved.

All services provided to rural populations could essentially become cheaper and more effective with the increased proliferation and reduced cost of technology. In agriculture, for example, index insurance providers are increasingly using AI to evaluate loan eligibility (Margetts and Dorobantu, 2019). The promise of AI in research and development is the ability to optimize services and interventions at increasing precision to the needs of each community, household or person. In agricultural and fisheries systems, this could help predict and prevent shocks to livelihoods and production systems, such as disease, flooding or drought. However, concerns are already being raised regarding the potential for technology to be used in ways that do not necessarily benefit small-scale fisheries actors and communities, particularly in countries where social institutions are weak and semi-authoritarian regimes are more common. Also, when people are aware of the fact that their personal data is being used to make decisions about benefit distribution, such as who is eligible for aid or a loan, they are inevitably incentivized to "game the system" (Marr, 2015).

Corruption is strongly associated with centralization and misuse of power and the hiding and distortion of transactions and results (Aliyev and Safarov, 2019). The legislation in Europe and the US, for example, that is designed to limit government and corporate abuse of data privacy is often not in place in developing countries or is flouted. Blockchain provides a decentralized mechanism for transparent and immutable transactions in public services and governance. As a result, it might have the potential to drive transparency and accountability to eliminate corruption in small-scale fisheries, such as in financial transactions in cooperative arrangements (Box 7). However, the applicability of blockchain has been criticized in the traceability of aquatic foods in supply chains, because of the physical (as opposed to solely digital) commodity involved in the transaction.

[32] www.japantimes.co.jp/news/2020/05/11/business/ai-japan-fishing-training/#.Xrzf7mgzbGi

Risk

As with any agricultural livelihood at the mercy of environmental effects, fisheries are defined by large uncertainty and risk, and they are risky in terms of personal safety and economic well-being. Fishing at sea is commonly regarded as one of the world's most dangerous occupations (Zytoon and Basahel, 2017). If a fisher is killed or injured, it often results in significant shocks to household and community food security and well-being. Even under normal circumstances, the uncertainty of fisheries catches and increasingly scarce resources present small-scale fisheries actors with economic risks.

Diversification can be a way to spread risk, either by fishing different species or areas, or conducting a non-fish-based livelihood (Kasperski and Holland, 2013; Kotschy *et al.,* 2015). But these are not without their own risks and potential efficiency costs (Thompson and Wilson, 1994; Cohen *et al.,* 2016). To raise funds for housing or children's education, or to overcome shocks and setbacks, small-scale fisheries actors need access to insurance, savings mechanisms or loans. They seldom have bank accounts, and as such do not normally qualify for access to formal institutional credit schemes. Insurance schemes in small-scale fisheries are extremely rare for numerous reasons (Tietze and van Anrooy, 2019), and credit schemes are predominantly limited to private lenders at high interest rates. In Ghana, a recent study found that credit-constrained small-scale fisheries actors were significantly worse off than those with access to credit, and the primary constraints to credit were cumbersome application processes and the lag time for funds disbursement (Twumasi *et al.,* 2020). This is an area of opportunity for ICT4SSF to have significant impact if combined with direct support and investment from governments into capacity and awareness raising for digital inclusion.

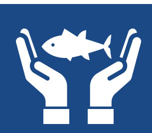
Microcredit

Microfinance institutions have emerged over the past 30 years as a way to provide financial services to the poor, who were excluded from formal credit sources (Tietze and Villareal, 2003). They initially started out by providing microcredit, but have now broadened their services to include other financial products. The digital revolution and ICTs have enabled the rapid diversification of services and tools and their uptake by accessing millions of previously unbanked rural poor. The research is limited on mechanisms through which small-scale fisheries actors benefit from microfinance, and it is highly concentrated in South Asia (Vipinkumar *et al.,* 2013; Gopal *et al.,* 2012; Karmakar *et al.,* 2011). This is an area where ICTs and digital financial services can be leveraged for significant impact by providing rapid digital money transfers based on information provided through a smartphone application (Chapter 7).

Extending these services to isolated communities and marginalized individuals will be essential to closing the digital divide and enabling conditions under which the SSF Guidelines can be enacted. Financial services provide a pathway to improved economic well-being, so governments must invest in the infrastructure and awareness raising necessary to reach the most isolated groups. In doing so, this can also be a driver of inclusivity and improve governance by incentivizing data sharing from these isolated and so far often invisible fisheries. This provides a mechanism for building personal evidence bases for livelihood activities to ensure small-scale fisheries actors have a voice in the growing clamor of the blue economy that is increasingly focused on attributing quantifiable economic value to aquatic activities and resources.

Guiding questions

The following guiding questions are proposed for governments, development workers and ICT4SSF practitioners to frame the evaluation, design and development of ICT4SSF initiatives as a platform that enables broader human-rights objectives of the SSF Guidelines according to the three categories of use:



Management, tenure and ecological sustainability
1.1 Catch data, monitoring, analysis and management
1.2 Fisheries effort tracking

- Who is providing/generating the data? Who owns it? Who holds it?
- Does the data include gendered traditional knowledge?
- Will users trust the source of the data? Is there a way to use technology to amplify local efforts?
- How will data be checked and validated to ensure accuracy?
- Can the technology be used to both share and collect information?
- How can the technology increase insights and trust from fishers and be used to set targets, create strategies and track progress on improving well-being and governance?
- Are initial and ongoing costs of the technology and data sustainable for small-scale fisheries actors?
- Is it using a platform that stakeholders use or are already familiar with?
- What are the user benefits to incentivize and encourage continued use?
- Are there issues of literacy or awareness that could influence understanding, uptake and benefit sharing?
- How will the data be used for decision-making? Is the process transparent and inclusive?
- Is the technology a shared and multipurpose platform, or can it interact with them?

Well-being, decent work and gender equality
2.1 Extension and Information services, networking and facilitation
2.2 Safety at sea, reducing risk, disaster response and preparedness

- Who are the users? What are their expectations and needs?
- What are the priorities and aspirations of women and men users for their own social, economic and environmental well-being?
- Are there issues of literacy or awareness that could influence understanding, uptake and benefit sharing? Will any groups be excluded or disadvantaged?
- Are initial and ongoing costs of the technology sustainable for small-scale fisheries actors? Is it using a platform that stakeholders use or are already familiar with?
- Does the technology build on local systems and infrastructure or use a platform that stakeholders are already familiar with and trust?
- Will users trust the information provider? Is there a way to use the technology to amplify local efforts to build trust and legitimacy?
- Is the technology a shared and multipurpose platform, or can it interact with them?

Value chains, benefit distribution and poverty alleviation
3.1 Value chains, fair benefit distribution and post-harvest preservation
3.2 Traceability

- Who are the users? What are their expectations and needs?
- Does the technology facilitate pathways for financial inclusion?
- How will users apply the technology in their established networks transactions?
- Does the system secure rights to data privacy and protection?
- Are payment mechanisms selected for recipient empowerment?
- Are there any requirements of information held by private sector companies or individuals?
- What are the user benefits to incentivize and encourage continued use?
- Are initial and ongoing costs of technology and communication sustainable for small-scale fisheries actors? Will these costs exclude any groups?
- Are there issues of literacy or awareness that could influence understanding, uptake and benefit sharing? Will any groups be excluded or disadvantaged?
- Does the technology build on local systems and infrastructure or use a platform that stakeholders are already familiar with?
- Is the technology a shared and multipurpose platform, or can it interact with them?

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Appendix 1. Guidance for case study structure

To guide case studies, key elements and themes were refined during two processes:

- a survey of priorities and key challenges with representatives from member states that attended the Seventh APFIC[33] Regional Consultative Forum Meeting in the Philippines in May 2018
- an expert consultation convened in Penang, Malaysia, in November 2018.

Experts were from academia, NGOs and the private sector, and they were identified through the snowballing process[34] presented in Chapter 1. Case study authors were asked to reflect on failures and successes, but most cases are framed as successes with some initial and persistent challenges.

Process, participation and capacity building

The use entry point of this review aims to tease apart the role that ICTs can play in achieving social, ecological and economic impacts in small-scale fisheries. However, it also highlights areas where ICTs might actually worsen inequalities in information access, such as limiting access to only those with smartphones.

The key elements of failure or success highlighted in the expert consultation were **trust, uptake and sustainability**. These were points to talk about when considering achievements and failures. Case study authors were asked to consider the following questions to guide their presentation of the cases:

- What were the ICT project experiences with trust?
- Did the particular ICT case strengthen or reduce trust among participants and/or facilitators?
- How did you set out to build trust initially?
- How can ICTs contribute to this?
- How do they make it more difficult?
- Which direct or indirect incentives were used to encourage initial participation?
- Were these same incentives sufficient to sustain use and engagement long term?

Broader outcomes and sustainability

Case study authors were asked to explore the financial, social and institutional outcomes and sustainability of the initiative or technology in their study context. They were guided by the following questions:

- How will ICT continue to benefit the stakeholders after the project cycle?
- If it is a technology, how would it continue to be paid for or replaced?
- Is there sufficient human capacity to maintain the system and transfer knowledge of its use?
- What social impacts does your case study present? That is, what were there outcomes for poverty alleviation or gender equity?
- How does the use of ICTs in your case contribute to objectives like these?
- How will these benefits scale and influence national/regional policy?

Key lessons learned and recommendations

Authors were asked to conclude by reflecting on what recommendations they would give to project implementing actors or policymakers to strengthen trust, uptake and sustainability toward achieving the ecological and social objectives of the SSF Guidelines.

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33 Asia-Pacific Fisheries Commission

34 Snowballing is a procedure by which respondents are found and interviewed by means of informal contact between them.

Appendix 2. ICT4SSF review methods

A desktop review was conducted to better understand current and recent uses of ICTs in the small-scale fisheries sector. The objective of this review was to provide an up-to-date assessment of the uses of ICT in small-scale fisheries. The aim was not to detail all the current technologies in use, but rather for what purpose they are being applied in a small-scale fisheries context. However, due to the tendency to frame projects and reporting around the technology, the initial step in this process was to conduct an electronic search for existing published and grey literature of ICTs in practice. There is little published literature on the use of ICT in small-scale fisheries, so this was informal in nature and methodology. We supplemented this search through expert elicitation, relying on snowballing from one person to another, or where projects were identified through discussion with key practitioners. In total, we recorded 41 individual ICTs (Appendix 3).

Each unique ICT discussed in a particular source was considered its own case. If a source discussed multiple technologies (e.g. a service provider that distributes both video monitoring devices for traceability and an unrelated phone application for fishers social networking) they were each considered their own case. Individual ICTs were organized into use categories based on the SSF Guidelines. These uses are broad, and overlaps do exist. Many technologies were relevant for more than one use category. In these cases, all relevant uses were recorded, meaning a unique case could be counted in more than one use category. In addition to the different thematic areas of ICTs, the types of technology were divided into five different categories (Table 1). Mobile phones were then separated into two different categories to disaggregate rudimentary from modern uses, bringing the total categories to six. Similar to the use categories, overlaps also exist with the different technologies — specifically between phone applications and databases. In a few instances, a specific case could be tagged to more than one technology.

For each observed case, several other information elements were extracted. If data was available, the regional geographic focus of each ICT was captured, as well as information pertaining to funding and implementing partners, risks and limitations, training, benefit distribution and availability, policy implications, key wins and lessons learned. For the majority of the cases, however, this information was not available. For example, approximately only 30 percent of the cases covering mobile phone applications provided comments about training users on how to use the technology. One case study cited the lack of training for users to operate new technologies as a major issue for the continued development of e-technologies (Chapter 4). Yet dedicated training sessions for fishers have proven to be difficult for several reasons (Chapter 6). Furthermore, there was not much data that empirically evaluated or reported the performance of ICTs at achieving their intended outcomes. Rather, information for many of the ICTs was obtained via promotional or marketing material.

The data that was included regarding reflections of key wins or lessons learned was often in the form of broad qualitative conclusions that were not well-supported or generalizations for the potential of the technology to achieve its intended outcomes at a larger scale than it is currently operating on. So far, little importance has been placed on understanding the socioeconomic impacts of implemented technologies in beneficiary communities. As such, it was not possible to collect much contextual information besides basic uses, technology types and geographic distributions of the technologies from this review.

Appendix 3. Identified technologies, uses and geographies in ICT4SSF review

Table 8. Specific ICT cases found in the review.

ID#	Technology name	Source	Technology type	Catch data, analysis and management	Effort tracking	Extension and info services	Safety at sea	Value chain and post-harvest	Traceability	Africa	Asia	Europe	North America	Latin America	Oceania	Global
1	Community-based monitoring app	1	Phone App	1		1	1							1		
2	mKRISHI	2	Phone App			1	1				1					
3	Automatic catchable stock index algorithm	3	GPS / Database / Phone app	1							1					
4	Mobile phones (Indonesia)	4	Voice and SMS			1	1	1			1					
5	Mobile advisories in South India	5	Voice and SMS		1		1				1					
6	Sistema de Localización y Seguimiento de Embarcaciones Pesqueras Andaluzas (SLSEPA)	6	GPS	1			1					1				
7	GPS/sonar devices in Malaysia	7	GPS		1		1				1					
8	Mobile phones in Kerala, India	8	Voice and SMS			1	1				1					
9	Mobile phones in India	9	Voice and SMS		1			1			1					
10	Mobile phones in South India	10	Voice and SMS					1			1					
11	Mobile phones in Nigeria	11	Voice and SMS			1				1						
12	EFMIS	12	Voice and SMS / Database					1		1						
13	eCDT system	13	Database / Phone App	1					1		1					
14	mFisheries	14	Phone App				1							1		
15	NETFISH	15	Phone App	1						1						
16	OurFish	16	Phone App	1				1			1			1		
17	FishFace	17	Phone App	1					1		1					
18	eCatch	18	Phone App	1												1
19	FishTraX	19 , 20	Database	1					1				1			
20	mFish	21, 22	Phone App					1	1		1					1

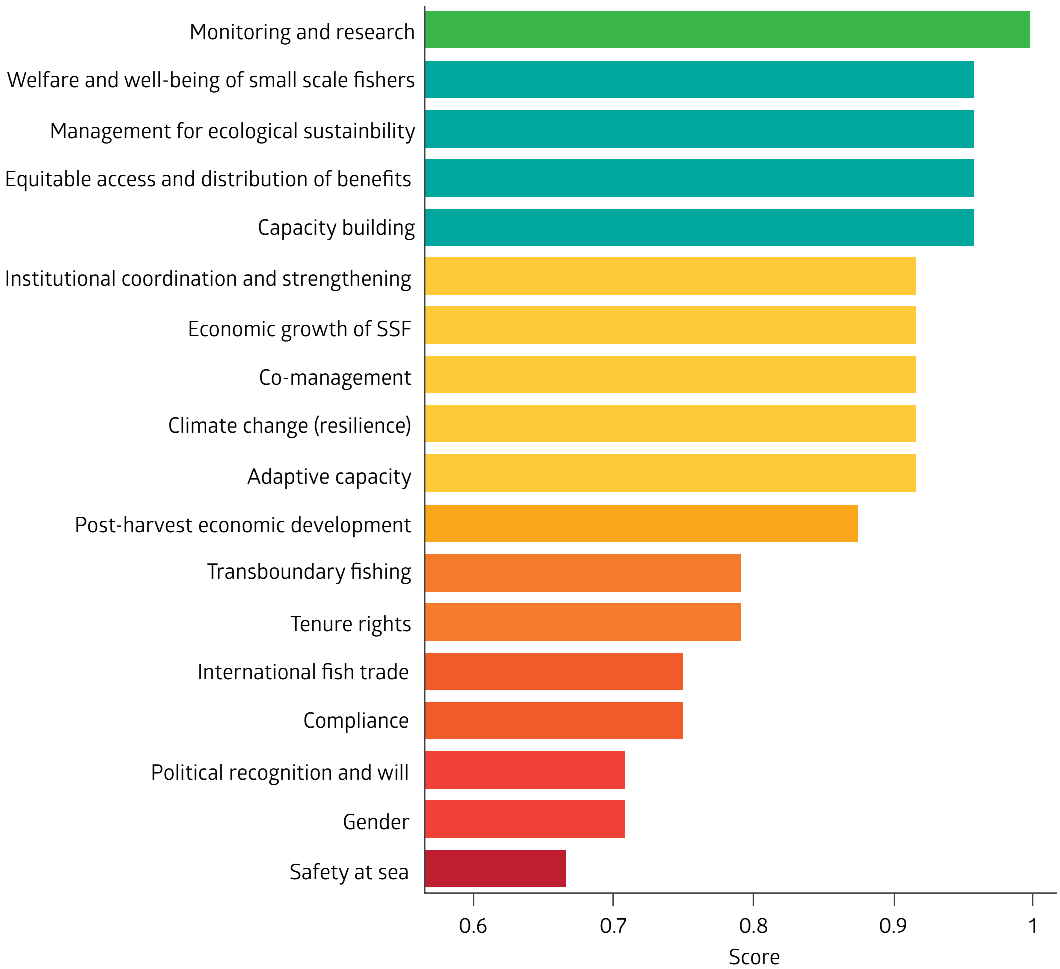
ID#	Technology name	Source	Technology type	Catch data, analysis and management	Effort tracking	Extension and info services	Safety at sea	Value chain and post-harvest	Traceability	Africa	Asia	Europe	North America	Latin America	Oceania	Global
21	Trace Register	23	Database						1							1
22	ShellCatch: Video Monitoring Hardware	24	Video	1										1		
23	ShellCatch: Mobile Phone Application Suite	24	Phone App						1					1		
24	ThisFish	25	Database / Phone App						1							1
25	FisheriesApp and KnowYourFish	26	Phone App	1					1							1
26	Happy Fish, Happy People	27, 28, 29	Phone App	1											1	
27	Tuna Supply Chain System	30, 31, 32	Blockchain						1						1	
28	The Fishcoin Ecosystem	33, 34	Blockchain						1							1
29	Tracking Tuna	35	Blockchain						1		1					
30	Personal Locator Beacon	36	GPS	1			1								1	
31	TraceVerified	37	Database					1	1		1					
32	ABALOBI	38	Phone App	1		1	1	1	1	1						
33	PDS	39	GPS / database	1	1				1							1
34	Odaku	40	GPS / Phone App		1		1		1		1					
35	Fisher Friend	41	Phone App		1		1	1			1					
36	Portable Fisheries Assistant System	42	GPS				1				1					
37	Tails	43	Phone App	1											1	
38	ISDApp	44, 45	Phone App				1				1					
39	TBTI information system	46	Database	1		1										1
40	FEWER	47	Phone App				1							1		
41	Earth Twine	48, 49	Blockchain						1							1

Appendix 4. APFIC representative survey results

Country government delegates attending the APFIC meeting in May 2018 were asked to rank in order of importance their information needs regarding ICTs for small-scale fisheries in their home countries. The primary need identified was for information about how ICTs can be applied to monitoring and research. Interestingly, aspects of how ICTs can contribute to better fisher welfare, equitable benefit access and distribution, and capacity building were of great interest, while interest in how ICTs can contribute to safety at sea was of the least interest (Figure 13).

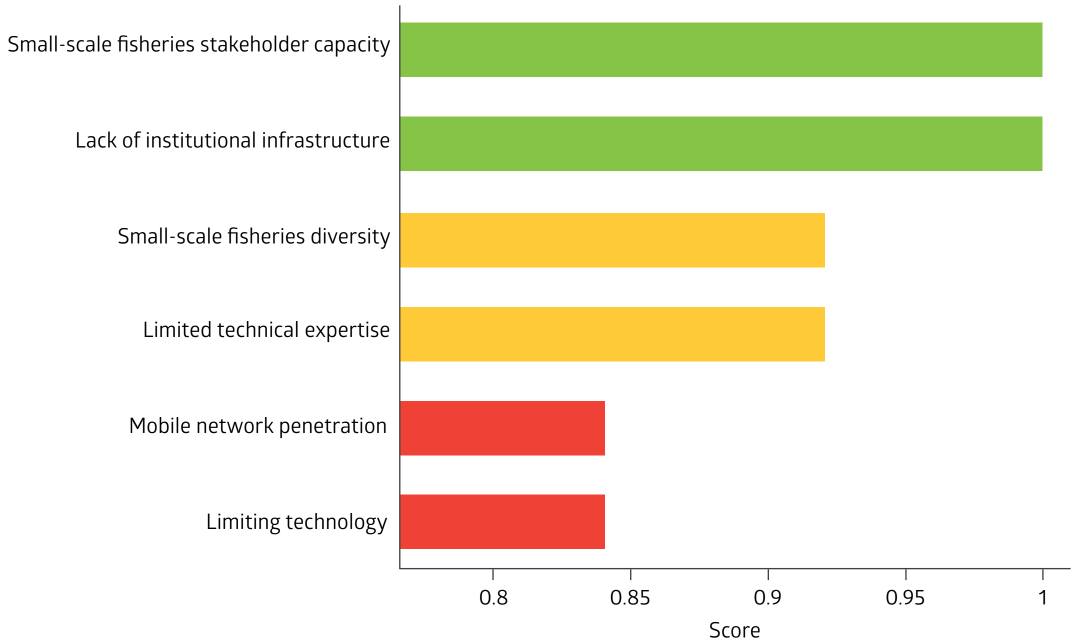
The survey also asked informants to rank in order of importance the most important constraints to ICT use for small-scale fisheries in their countries. The most important were institutional infrastructure and stakeholder capacity (Figure 14). Initial survey results also suggest that the technological arena and infrastructures necessary for ICT usage are not important constraints in the represented APFIC countries.

Figure 13. Primary needs for information on ICT for small-scale fisheries ranked by APFIC informants in order of perceived priority for their respective countries.



Note: Color gradient used for visualization only.

Figure 14. Constraints to ICT usage in small-scale fisheries ranked by APFIC informants in order of perceived priorities for their respective countries.



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