CTA
Working Paper
15/03

Rejuvenating ACP Small-scale Fisheries using ICTs

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Series: ICTs for agriculture

CTA Working Paper 15/03 | July 2015

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CTA operates under the framework of the Cotonou Agreement and is funded by the EU.

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Please address comments on this Working Paper to Benjamin K. Addom (addom@cta.int), Programme Coordinator, ICT, at CTA.

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Acknowledgements

This Working Paper is a product of work conducted under the direction of Benjamin Kwasi Addom, Programme Coordinator, ICT, as part of CTA Master Project 'Promoting the application of ICTs for value chains development and ARD policy and strategy processes', subproject 'Promoting the Enabling Environments and Uptake of ICT Solutions'.

The author acknowledges the kind assistance of Ms Rishma Hansil with her assistance with the desk research on ICT applications in ACP states.

Executive summary

Capture fisheries and post-harvest value-added trade account for nearly 1% of global gross domestic product (GDP), with half of all global fish exports originating in developing countries. In these countries, the small-scale fisheries sector predominates and its management presents vexing challenges at the intersection of competing biological, economic and social priorities. As a result, in many countries, relations between different agents in the sector are strained and the progress of product 'from hook to cook' has languished. This report posits that for resilience, this traditional value chain cannot be divorced from the complex system of policy, legislation and practice within which fish is legitimately harvested, handled, processed and sold.

As the basis for rejuvenating small-scale fisheries in ACP countries, this report maps the pathway from fisher to the system of policy, legislation and practice that constrain his operation. It identifies information and communications technologies (ICTs) as key enablers of linkage along the way; it classifies the progressive categories of intervention according to instrumental, informational, transactional, organisational and ultimately ecosystems strategic tiers. It introduces the notion of the vertical value chain, which describes the use of information and communications in progressively more complex tasks. These tasks add tangible value to the operations of the small-scale fisher while ultimately enabling him to engage with all agents who govern various aspects and contexts of his livelihood.

The report reviews the existing use of ICTs in the small-scale fisheries value chain in ACP countries and finds that there is no strategic or operational framework within which these technologies are applied. The report closes by identifying nine key reasons for the failure of the small-scale fisheries sector in using ICTs for transformative gain. The shallow penetration into the vertical value chain and the lack of embedding ICTs and complementary disciplines in the development cycle at an early stage and consistently, features strongly among the shortcomings. Recommendations and cautions are offered to rejuvenate the small-scale fisheries sector within the context of its complex interdependencies and rich ecosystem.

1. Introduction

In aggregate, capture fisheries along with post-harvest value-added trade, accounts for nearly 1% of global GDP (World Bank *et al.,* 2010). There is also growing interest and activity in fish farming or aquaculture, with estimates that in the next decade, worldwide capture fisheries and aquaculture yield will outstrip that of beef, pork or poultry (FAO, 2012). Half of all global fish exports originate in developing countries, but in these countries, the economic importance of small-scale fisheries to total catch has generally been underestimated. In African, Caribbean and Pacific (ACP) countries, for example, Zeller, *et al.* (2007) have reported that the GDP contributions in the Pacific have been underestimated by more than five times by official sources; Zeller and Harper (2009) report that the contribution in the Cayman Islands in the Caribbean has been underestimated by a factor of three.

Policies that seek to maximise the economic rent of the fishery are favourable for large-scale commercial fishing but are far less so for small-scale fisheries, which predominate in many ACP states. The associated wealth-based fisheries management model successfully used in Iceland, New Zealand, Norway and other countries has come under attack by Béné (2011) and other authors (Béné *et al.,* 2010) for its applicability to small-scale fisheries. Béné estimates that in Africa, the wealth created through increased efficiency of this type of sector reform would be insufficient to compensate those fishers and fish farmers forced to leave the fisheries sector and concludes that the social and economic impacts are simply too great in developing countries. The complex interdependencies between the livelihoods of small-scale fishers and the host environment of their catch have motivated an interest in policies, broader than the wealth-based tradition, which promote holistic ecosystem stewardship. At the same time, the critical vulnerabilities of fishers to environmental and market conditions over which they have little or no control, in addition to a host of other ground realities, call for increased resilience of the small-scale fisheries sector through its management and operations.

Improvements in management and operational efficiencies throughout the value chain are broadly accepted as key to the rejuvenation of the multiply challenged small-scale fisheries industry. Designed in congruence with holistic sustainable development policies, the strategic use of information and communication technologies (ICTs) in the value chain appears to be a promising starting point. This paper establishes the context in which key value chain interventions and ICT solutions may be used to rejuvenate small-scale fisheries in ACP states.

2. Small-scale fisheries value chain

A value chain refers to a linked set of activities that maps the development and/or movement of a primary product from its source all the way to the consumer. Value chain analysis (VCA) has been widely applied to derive important determinants of global income distribution and insights into the costs and bottlenecks associated with each sequenced activity associated with harvesting, handling, production/processing distribution and sales. It has been used as the basis of recommendations for maximising the economic rent of the fishery through efficient use of scarce resources, processing, value addition, marketing and distribution. Using typical business models and taking account of different harvesting methods used by small-scale fishers, market-driven VCA assesses performance in terms of catch potential, capacity with respect to stock and estimated maximum sustainable yield

of marine resources. Used in this way, it provides inputs into policies that align with national priorities on competitiveness, productivity and marine resource sustainability (Russel and Hanoomanjee, 2012). Findings reveal the critical importance of market access, market focus, partnering, collaboration and information sharing, and innovation (Webber and Labaste, 2007).

Several VCAs have been conducted for the fisheries sector over the past decade with each adapted for the jurisdiction under study (Hempel, 2010; Da Silva, 2011; Sweenarain, 2012a, 2012b). These assessments reveal that the constitution of the value chain differs significantly according to species and the ground realities of the market. The constitution of the value chain also differs according to scope, i.e. whether it is domestic, regional or international (World Bank, 2010).

Of particular relevance to the small-scale sector is the broader application of the fisheries value chain that considers social, cultural, political and institutional issues. Appropriately formulated, VCA may inform policies which mitigate inequities that flow from globalisation (Kaplinsky and Morris, 2002) and align well with the ecosystems approach to fisheries (EAF). EAF has gained the interest of development and policy agencies as described by FAO (2009a; 2009b); it is a "people-centred perspective" on small-scale fisheries value chains (McConney and Charles, 2010) that acknowledges the linkages between ecosystem health and the well-being of human communities. These broader perspectives on the value chain call for increased stakeholder engagement and participatory governance as a way of improving the resilience of the multi-stakeholder ecosystem and its various constituents.

The horizontal value chain

In his seminal work, Porter (1985) elaborates on a value chain in the context of a company. In this context, the chain comprises primary activities (design, production, marketing, delivery and product support) that are supported by a variety of other activities (infrastructure, human resource management, technology development and procurement). Although the specific chained and supporting activities in small-scale fisheries are somewhat different, the fundamental principles that apply are the same. There are primary chained activities that move the product from source to consumer, and enablers, which can be linked directly or indirectly to tangible aspects of value and provide necessary support along the way.

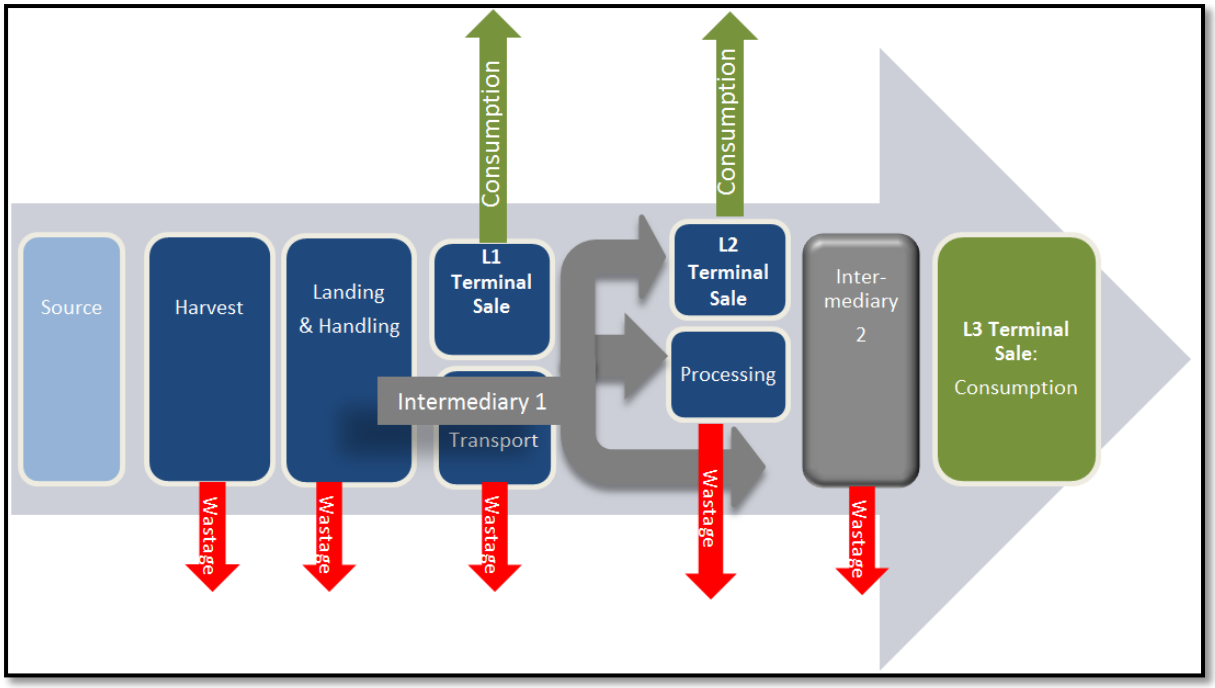

Figure 1: Generic model of fisheries value chain

This paper uses a generic model that considers the propagation of harvested fish through a number of levels of sale, value addition and loss, as shown in Figure 1. The value chain originates in the marine or aquaculture environment and terminates in the zone of consumption. In the figure, *Consumption* depicts the end-point use of the fish or fish product by any consumer – a human, animal or agricultural system. The consumed product may be fresh, preserved or processed, depending on the point of consumption in the value chain. Fish product may also be wasted at any point along the chain (as depicted in red in Figure 1). Intermediary 2 depicts any type of additional intermediary process or agent including transportation, secondary/tertiary food processing, packaging, retail, distribution, wholesale, export etc.

Figure 1 illustrates several possible value chain instantiations such as:

1) Harvest ⇨ Landing and Handling ⇨ Sale at landing site to consumer (via Level 1 Terminal Sale)
2) Harvest ⇨ Landing and Handling ⇨ Sale at landing site to vendor ("Intermediary 1") who transports and sells to:

    a) A consumer (via Level 2 Terminal Sale)
    b) A processor
    c) Some other agent, Intermediary 2

3) Harvest ⇨ Landing and Handling ⇨ Sale at landing site to vendor ("Intermediary 1") who transports and sells to ⇨ Intermediary 2 ⇨ consumer (via Level 3 Terminal Sale)
4) Harvest ⇨ Landing and Handling ⇨ Transport ⇨ Sale to consumer (via Level 2 Terminal Sale)
5) Harvest ⇨ Landing and Handling ⇨ Transport ⇨ Sale to fixed vendor/retailer/wholesalers etc (Intermediary 2)

Small-scale fisheries value chains do not only differ by species, jurisdiction and scale but also vary and "adapt", according to various sociological conditions. A comparative breakdown of the percentages of catch moved to different agents at each stage of the value chain is provided by Mahon *et al.* (2007) for 12 distinct and aggregated "other" species in Barbados. The adaptive nature of small-scale fisheries value chains is described by McConney (2012), who cites the example of Grenada where its form is dependent on fishers' social networks. The depth of the chain may be greater than that depicted in Figure 1 (due to variances in the instantiation of different value chains) in which case any intermediary step is, or intermediary steps are repeated as appropriate. The form of the value chain may differ from fisher to fisher in the same jurisdiction as they are dynamic in nature.

Despite the varied nature of the small-scale fisheries value chain, horizontal progression from left to right is associated with the addition of value at each stage. This value may be tangible (e.g. processing) or it may be intangible (e.g. a more convenient access means or location). Each activity in the horizontal chain in Figure 1 draws on nested tangible and intangible enablers for execution. For example, the activity of harvesting presupposes the existence of fish; this requires a means by which fish can be caught and the knowledge to use these means to catch the fish. The means by which fish may be caught, in turn, may require a boat, an engine and fishing gear. The efficiency with which fish is caught may depend on knowledge of migration patterns of target fish species, appropriate gear and the abundance of fish. Not only is each activity in the value chain associated with a number of enablers, but it is also exposed to a variety of risks. Risks include, for example, the exposure of fishers to natural hazards and piracy and the availability of a purchaser for landed fish.

The vertical value chain

Our scope of interest in this paper is the extent of the fisheries value chain that most relates to, and impacts, the small-scale fisher. We are therefore most concerned with the activities closest to the source. Figure 2 illustrates a representative segment of the horizontal value chain for marine fisheries, although aquaculture could also represent the case with the omission of landing, depending on the scale. The figure shows a representative vertical value chain comprising five orders: physical/ instrumental, informational, process/transactional, organisational and strategic. As value is added to *harvested fish* with each activity in the horizontal value chain from left to right, so too is value added to each *activity* with each order that is engaged in the vertical value chain from bottom to top. This value may represent a resource (time, effort etc.) saving, risk reduction (personal safety etc.), or some short- or long-term profit (increased revenue, market expansion, market sustainability etc.), or other positive impact (marine resource sustainability etc.).

To illustrate the value introduced with each order in the vertical value chain, we may consider the harvest activity. At the minimum, the conduct of this activity requires fishing gear, a vessel, gas, ice, storage etc. These artefacts represent first-order enablers in the vertical value chain. Informational inputs into the harvest activity are not physically necessary to catch fish but they add value. They are thus classified as second-order value enablers. For example, information about impending weather or fish migratory patterns is not required to fish but it enables fishers to plan their trips in such a way as to increase the chances of a successful catch. At the same time, accurate catch and effort data enables fisheries managers to execute their roles with greater integrity.

	Biodiversity/Conservation | Responsible Fisheries | Poverty Alleviation | Equity & Inclusion | Profitability etc. National, regional & global policy; Legislation; Standards; Comparable performance metrics & evaluation methodologies; Research etc				
Vertical Value Chain	1. Knowledge Management systems 2. Relationships 3. Communications 4. Appropriate literacy & skills	1. National standards for all landing sites, e.g.: a. Acceptable post-harvest practices b. Infrastructure & services	1. Industry standards & practice: a. Quality standards b. Inspection c. Compliance 2. Communications & skills	1. National market infrastructure & services: a. Physical markets b. Cooperatives etc. 2. Info & communications	**Fourth Order**: Organisational
	1. Processes relating to: a. Fisheries/coastal manag't b. Harvesting & safety 2. Communications 3. Appropriate literacy and implementation skills	1. Processes relating to: a. Landing & personal safety b. Handling & fish quality 2. Communications 3. Appropriate literacy and application skills	1. Process Stream: a. Resource planning b. Grading/batching etc c. Process and quality monitoring & control 2. Communications & skills	1. Market assessment 2. Marketing 3. Order processing & sales 4. Logistics 5. Communications 6. Literacy and skills	**Third Order**: Process/ Transactional
	1. Information about: a. Weather, seismic activity b. Catch & effort data etc 2. Registers of licensed fishers 3. Access to information 4. Appropriate literacy skills	1. Information about: a. Locations of landings b. Landing conditions c. Availability of ice etc 2. Access to information 3. Skills to interpret information	1. Current process data 2. Quality reference data 3. Applicable standards 4. Traceability data 5. Access to information 6. Skills to interpret info	1. Market prices 2. Identification, availability & contact info for potential sellers/ buyers 3. Access to information 4. Skills to interpret info	**Second Order**: Informational
	1. Operations & Facilities: a. Fishing gear b. Vessel and gas c. Ice and storage 2. Communications for safety 3. Appropriate skills	1. Operations & Facilities: a. Landing facilities b. Infrastructure c. Icing & disposal facilities 2. Communications 3. Appropriate skills	1. Operations & Facilities: a. Freezing, salting etc. b. Trimming, slicing etc. c. Weighing, labelling etc 2. Communications 3. Appropriate skills	1. Market & Sale Facilities a. Purchaser/s b. Measurement means c. Payment means etc. 2. Communications 3. Appropriate skills	**First Order**: Physical/ Instrumental
	Harvest	Landing & Handling	Processing	Terminal Sale	

Horizontal Value Chain

Figure 2: Sample small-scale fisheries value chain

Additional value may be added through the introduction of efficient process artefacts. For example, an efficient process for procuring ice and bait for each trip for the fisher, and a process for trending catch and effort data over time, species and landing for the fisheries manager. These processes are not necessary for the consumption of information or the aggregation of data, but add tremendous value in terms of increased efficiency and/or are the basis for effective planning. They are considered third-order enablers in the vertical value chain. Fourth-order enablers are those that provide linkages, coordinate, integrate or otherwise organise different local activities across an institutional, community or sectoral space. Information and knowledge management systems are examples of fourth-order enablers. Fifth-order enablers provide similar functions across disparate institutional, community or sectoral spaces and represent overarching integration, coordination and management. They are thus in the realm of local, national and global strategy.

A sample of typical artefacts is included for each order in Figure 2. The figure does not aim to model the complex interdependencies intrinsic to small-scale fisheries and linked ecosystems, but it uses a basic deconstruction of the value chain to reveal key opportunities for ICT intervention in a structured manner. The rich interconnectedness of the ecosystem will be taken into account in due course.

3. Challenges in the small-scale fisheries value chain

Perceptions of the challenges in the small-scale fisheries value chain vary according to economic, biological or social priority. From an economic perspective, the key challenges in the fisheries value chain are typically reported as relating to illegal fishing, open access, use of non-selective gear, obsolete infrastructure and the lack of quality assurance in handling, processing and marketing. One of the high economic priorities is the curtailing of illegal fishing that for example amounts to US$1 billion per year in sub-Saharan Africa (Béné, 2011). Surveillance and monitoring are also a high priority from a biological perspective as the marine resource is under threat. Regulations to limit harvest and enforce gear selectivity are necessary for long-term sustainability and to reduce by-catch and other forms of wastage.

From a social perspective, small-scale fishers generally feel that large-scale commercial fisheries challenge their livelihood. Marine fishers are particularly vulnerable to piracy and fish stocks that are dwindling due to a host of environmental changes; all fishers are vulnerable to environmental threats and natural hazards. They additionally cite challenges relating to market and operational inefficiencies, personal safety, limited financial and banking capacity and inadequate or inconvenient access to training (Mallalieu and Sankarsingh, 2012). If the sector is to be regulated, an equitable means of sector management is a high priority. Participatory governance, as espoused by the EAF has attracted a great deal of attention as a reasonable strategy, even amidst the many tensions.

FAO (2012) cites among the key sector challenges: poor governance, weak fisheries management, conflicts over the use of natural resources, poor fishery and aquaculture practices, neglect for the priorities and rights of small-scale fishing communities, and injustices due to gender discrimination and child labour. There also exists a compelling body of evidence on the critical need for broad and rich stakeholder engagement in the small-scale fisheries sector. Such engagement is broadly recognised as a prerequisite, though not a sufficient condition, for harmonious and sustainable sector development within the context of competing interests in the shared marine resource. It is

generally understood to constitute best practice in policy development and sector management as well as in regular operations.

Apart from the thematic challenges in the small-scale fisheries value chain, there are broader issues that distinguish it from large-scale commercial value chains. In particular, activities along the chain are typically handed over from independent agent to independent agent, outside of a single, overarching institutional enabling environment. Each small-scale agent often manages a disparate set of activities such as gear procurement, maintenance, fishing and sales. There is thus little room for specialisation and the efficiencies that accrue therein for larger scale enterprises (Porter, 2002). An additional consequence is that the penetration into the vertical value chain for small-scale fishers is generally shallow so that unbroken threads from each activity up to fifth-order, strategic, enablers do not generally exist. Strategic interventions therefore generally require the onerous establishment of intermediary organisational, process and information systems before they can take root. Interventions that do not recognise this, or adequately plan for it, are at risk of failure.

4. Information and communication technologies (ICTs)

ICT foundations

The term ICTs generally refers to all technologies which use electronic means to capture or generate, store, process, retrieve, analyse, display and interact with information, as well as electrical or electromagnetic means to communicate information. “Electronic means” generally refers to the use of systems which use electrical circuitry and semiconductor components with relatively low voltages and currents, in contrast to those that use high voltages and currents associated, for example, with the transmission and distribution of electrical power. “Electrical means” of communication generally refers to the use of electrically conducting cabling or waveguides to transmit signals; whereas “electromagnetic means” of communication generally refers to the transmission of radio or optical signals over wireless or non-conducting (optical fibre) channels.

The computer and computing industries are the foundation of information technology that relates to the hardware and software platforms and utilities that facilitate the processing and manipulation of data derived from input information and are presented as output information. The facilitation of communications between computers, dubbed “data communications” gave rise to computer networks and the emergence of the term ICT that recognises the natural synergy between the manipulation of information and its communication. The term ICTs refers variously to manufacturing and service industries and to associated products in the form of hardware, software or a mix of both. According to the Organisation for Economic Cooperation and Development (OECD, 2003) ICT products and services are classified as follows:

For manufacturing industries, the products of a candidate industry:

- must be intended to fulfil the function of information processing and communication, including transmission and display
- must use electronic processing to detect, measure and/or record physical phenomena or to control a physical process

For services industries, the products of a candidate industry:

- must be intended to enable the function of information processing and communication by electronic means"

In contrast, communications technology has its roots in the telecommunications industry. Unlike traditional data networks, which sought to achieve a very low error rate, with less emphasis on real-time communications, traditional voice networks prioritised real-time communications over data integrity. Traditional video networks prioritised streaming media to ensure unbroken transmissions, with less emphasis on its real-time transmission or the assurance of a very low error rate. The three sets of technologies and networks, optimised for different performance criteria, were quite different and served separate industry and service segments. Over the years, however, phenomenal technical advances across all sectors have facilitated the convergence of the respective networks, services and sectors. The term "ICTs" has come to refer to traditional information and communications technologies and the expanded range of technologies associated with this convergence.

Dismantling ICTs

For the purposes of this work, ICTs may be categorised according to the generic flow of information from an ICT end point at the source to an end point at the destination, as shown in Figure 3 below.

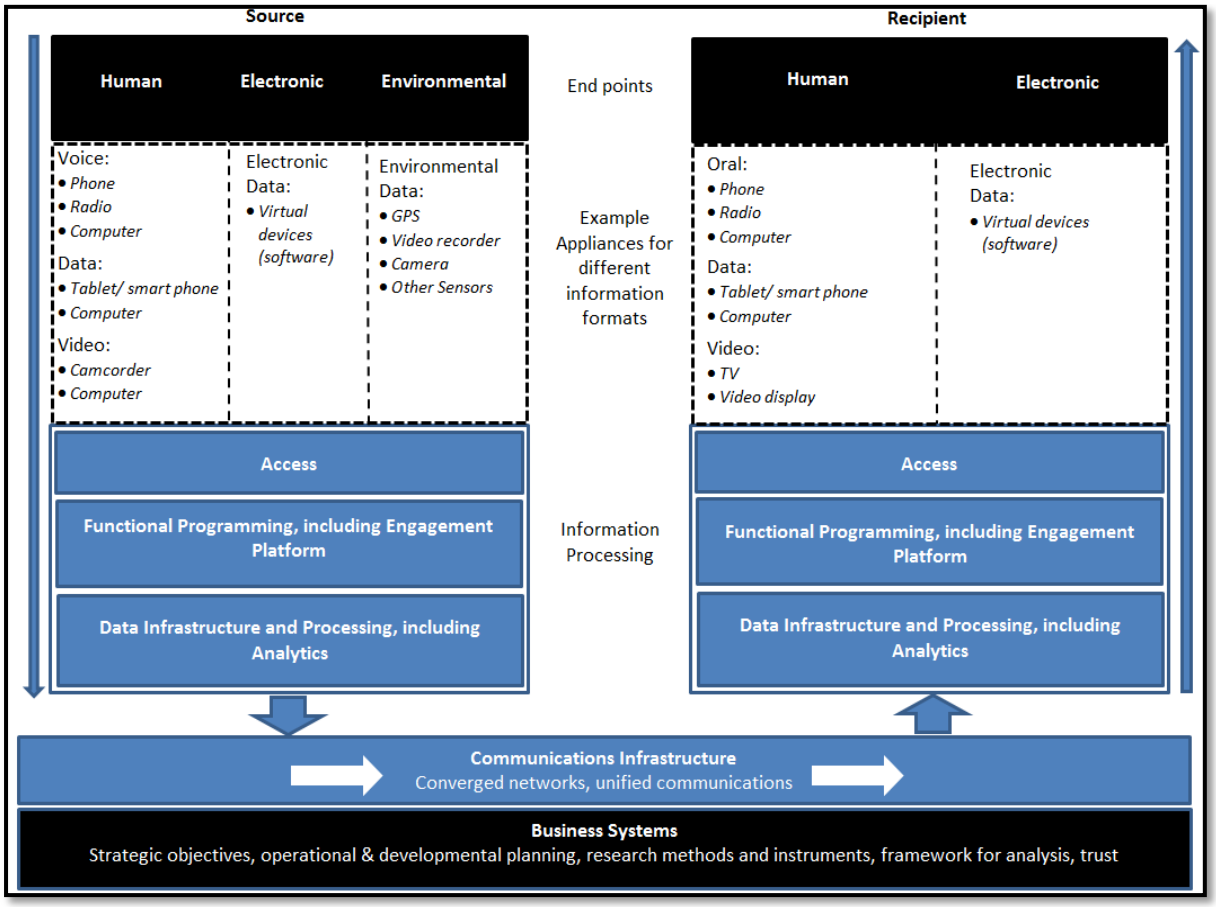

Figure 3: Dismantling ICTs according to basic information flow: Source to destination

An information source may be human, electronic or environmental (Figure 3). An example of electronic source information is catch and effort data stored in a database; while examples of environmental source information are ocean altimetry and geo-location. Generally, information recipients are either human or electronic, though actuators are often used to effect some changes in the environment, for example in irrigation control.

ICTs use a variety of hardware end-user devices to capture data in various formats from an information source and convey it to a software application for processing. Hardware devices include phones, computers, radios and sensors such as GPS devices. Each device accepts input information in a given format, for example audio or video, and generates an electronic output that is processed in hardware or software. The processing, which may be simple or complex, satisfies functional and performance requirements. Capabilities include a variety of accessibility solutions, which enable users to interact with the device using text, touch screen, voice, video or gestures. These user inputs can be simply conveyed over a communications channel, as in the case of voice communications, or cause actions to be performed, as in the case of web or mobile applications. Underlying these front-line user options is often an engagement platform – such as is the case for social networks or learning management systems. User devices may also feature software that enables deeper levels of processing capabilities such as data analytics.

The output of the originating end-user device may be communicated to a single remote user or multiple users via a receiving end-user device over a communications channel. The communications channel may be infrastructure-based, e.g. a cellular network; or peer-to-peer, e.g. walkie-talkie radios. The communications channel may be implemented over some wired medium, such as copper cabling or optical fibre, or it may be wireless. In the case of wireless communications, a licence is required for use of the shared spectrum resource for transmissions falling outside of prescribed licence-free bands, such as those used in Wi-Fi.

Different communications technologies are designed to operate using specific communications protocols and network resources and typically cannot inter-operate. For example, marine radios typically use frequency modulation on the VHF band of frequencies (156.0–162.025 MHz) while LTE (long-term evolution), a fourth-generation cellular technology, uses other bands and modulation schemes; therefore the two technologies cannot inter-operate. Different technologies meet different functional and performance criteria. For example, marine radios have extended coverage at sea but limited data-carrying capability, while cellular coverage is far lower but the technology can support very high capacity data transmission. The selection of communications technology for a particular application is based on a variety of end-user requirements and constraints.

Many ICT systems comprise a server-based component that performs data storage and processing capabilities. In such cases, the processing requirements on user devices are reduced and a hardware server, outfitted with server-side software, acts as an intermediary between communicating end-user devices or provides services to a single end-user device. Some business system often underpins the use of ICTs and defines the strategic objectives for its application; operational and developmental planning; and often some framework for performance analysis. The ICTs are not expected to yield desired outcomes unless these are well articulated and drive the ICT design and implementation strategy.

Existing and emerging trends in ICTs

In contrast to its early beginnings as a means of processing and exchanging data between networked computers, ICT has increasingly become user-focused. A great deal of emphasis is now placed on engaging the human user with a deliberate awareness of the user context and appropriate interaction modalities. For example, graphical user interfaces are standard in most ICT systems while others are available without oral, visual or textual inputs to facilitate interaction by users who, are deaf, blind or have low literacy ratings, respectively. Other ICT applications use oral input and output for those with visual impairments and many use social networking to appeal to younger users who are comfortable engaging with each other in contemporary conversational ways through the mobile channel.

Not only have there been transformational developments in the so-called "front-end" technologies with which ICT users directly interact, but astonishing developments have impacted all stages of information flow between end-point users. Existing and emerging trends, categorised according to the associated stage in Figure 3, include:

1) Access
    - to environment:
        - Hardware interfaces including location-based sensing, image and other sensing
    - to/from data:
        - Programmatic data access, including open data
    - to/from human users:
        - Presentation: audio, visual, tactile
        - Display: Flexible displays, high resolution displays
        - Visualisation: Graphical, media, simulated, augmented reality
        - Input: multi-modal natural user interfaces using, for example, touch screen, voice and gesture
2) Functional programming including engagement platforms
    - Semantic web
    - Responsive apps
    - Simulation
    - Open data
    - Crowd-sourced data
    - Data mining
    - Co-creation platforms
    - Collaboration platforms
    - X-management systems (e.g. learning management systems, knowledge management systems etc.)
    - Gaming
    - Social networking

3) Data Infrastructure and processing, including analytics

   - Cloud storage
   - Big data
   - Distributed processing
   - Cloud computing
   - Virtualisation
   - Business intelligence
   - Business analytics
   - Service-based data management
   - OLAP (online analytical processing)
   - Predictive analytics
   - Artificial intelligence
   - Machine learning
   - Game theory

4) Communications infrastructure

   - 4G, 5G wireless communication technologies
   - Universal broadband
   - The internet of things.

The combination of powerful, mobile end-user devices with location and broadband services, together with ambient intelligence and massively parallel core computing capabilities which facilitate interaction with vast quantities of content anytime, anywhere and from any device has strong appeal for advanced personal users and corporate enterprises. However, quite apart from emerging technological trends which most impact sophisticated users and commercial entities, a number of ICT trends have had and promise to have pervasive impacts across a wide range of demographics. Perhaps most significantly is that the market for smart handheld devices continues to grow apace and, at the same time, mobile broadband service is more affordable than fixed broadband service (ITU, 2013a). Additionally, for 20 countries around the world, broadband and/or internet access is either a basic legal right, a citizen's right or a constitutional right (ITU, 2013b); with 69% of world countries having a National Broadband Plan in place and 6% of countries around the world with a plan in train. A total of 82% of plans include provisions for governance and citizen participation, 66% include provisions for the adoption of public applications and services and another 31% of plans include provisions for poverty reduction and food security (ITU, 2013). The power of smartphones, together with physically and economically accessible broadband service; supported by advances in data processing algorithms which facilitate multi-modal interaction; as well as wireless charging capabilities, represents a promising proposition for an integrated tool of the trade for many low-literacy, low-income earners.

5. ICT as an intervention tool in fisheries

An historical perspective

A review of ICT in the European fishing industry (EFILWC, 2003) in the period 1990–2002, revealed that ICTs played a significant role in sector modernisation, which was necessary to combat the threats of dwindling marine resources and increased competition. The review categorised ICTs in the fishing industry according to the scope of application as follows:

> **Macroscopic:** support the monitoring, measuring and policing of fisheries and fishing fleets as well as providing support to fishing vessels on catch location and indirectly health and safety.
>
> **Microscopic on-board:** manage the vessel and support the fisher in all aspects of the fishing activity.
>
> **Microscopic on-shore:** manage the supply chain and increasingly the commercial/marketing side of the industry.

The 2003 review, which focused on commercial fisheries, found that ICT was involved at every stage of the fisheries value chain "from catch to counter", and identified the technologies adapted to the fishing industry, along with relevant applications and associated implications, as shown in Tables 1–3.

Table 1: Fishing industry: Technology adaptation, example applications and implications – macroscopic

Technology	Application	Implication – Supports/Contributes to:
Satellite: Positioning	• Pinpoint ship's position • Monitoring fishing vessels • Policing protected zones	• Sustainable fisheries management • Transparency – meeting regulation • Increases fishing efficiency
Satellite: Remote sensing	• Locating/monitoring fishing grounds and proxies e.g. water temperature	• Sustainable fisheries management • Efficiency of catch finding
Satellite: Communication	• Transmission of catch data to shore • Vessel location in emergencies • Emergency & other communications	• Health and safety • Supply chain efficiency

Source: EFILWC (2003)

Table 2: Fishing industry: Technology adaptation, example applications and implications – micro on-board

Technology	Application	Implication – Supports/Contributes to:
Electronics: Echo-sounder and sonar	• Sea bed depth sensor • Species & fish density sensors	• Fishing efforts & increases catch efficiency • Fisheries sustainable management through, e.g., the identification of mature fish
Electronics: Sensors and fishing gear	• Manage catch • Optimise selectivity & minimise discards • Optimise catch quantity	• Sustainable fisheries management • Catch quality
IT systems	• Data management and communication (including e-logbooks)	• Health and safety • Supply chain efficiency • Facilitates remote social contact • On-board training • Sustainable management: data direct to regulator
IT systems	• Vessel management: on-board systems data integration	• Seamless vessel operation • Fewer crew required • Catch efficiency and cost reduction

Source: EFILWC (2003)

Table 3: Fishing industry: Technology adaptation, example applications and implications – micro on-shore

Technology	Application	Implication – Supports/Contributes to:
IT systems	Computer aided design (CAD): vessel, engine and fishing gear design and manufacture	• Operational efficiency • On-board safety • Reduced construction and operational costs • Increased productivity
IT systems	eCommerce (including eTraceability, eAuction, mobile telephony, etc.)	• Marketing efficiency, reach and expansion • Increased industry transparency • Increased traceability • Sustainable fisheries management

Source: EFILWC (2003)

The macroscopic ICTs, Table 1, identified by the European Foundation for the Improvement of Living and Working Conditions (EFILWC, 2003) penetrate the vertical small-scale fisheries value chain, illustrated in Figure 2, to the fourth order. That is to say that they employ physical, informational, process and organisational enablers. The microscopic on-board and on-shore technologies, Tables 2 and 3, penetrate the vertical value chain to the third order, employing physical, informational and process enablers. All applications have a strong focus on efficiency and productivity, with notional potential to feed into sustainable management, with a strong focus on short and long-term yield.

In the developing world, particularly in small-scale fisheries, ICTs have generally not been involved at every stage of the fisheries value chain “from catch to counter”. The iconic reference to the use of ICTs in small-scale fisheries is the case of Kerala, India, which comprises hundreds of fishing villages and over a million fishers, as reported comprehensively by Jensen (2007). Prior to the introduction of the mobile phone in 1997, catch was primarily sold via face-to-face auctions at the beach landings, about 10 km apart. By 2001, the mobile phone had become an established channel to access fish pricing information and for marketing.

The need for and application of ICT interventions in small-scale fisheries is linked to overarching objectives and ground realities, which are not consistent across different agents in the ecosystem. Table 4 provides an example of the intervention tools and strategies for improved fisheries management, according to the primary objectives: biological, economic and social. The strategies and tools documented in the figure are drawn from Satia and Gardiner (2004). For each tool and strategy, there is an indication of the aspects of the vertical value chain that are primarily invoked. For Satia’s and Gardiner’s (2004) representative set of tools and strategies, those with a biological objective are generally evenly spread across the entire vertical value chain, i.e. that they generally require the engagement of physical, informational, process, organisational and ecosystems strategic enablers. Tools and strategies used with an economic objective are generally bunched up in the process/transaction and organisational orders of the vertical value chain, reflecting the heavy focus on commerce and productivity. This table shows that tools and strategies used with a social objective have strong requirements for organisational and ecosystems strategic enablers.

Table 4: Example intervention tools and strategies for improved fisheries management by objective

Objective	Related tools/strategies & ideals	Physical/ instrumental	Informational	Process/ transaction	Organisational	Ecosystems strategic
Biological	Provision of access rights		✓	✓	✓	✓
	Appropriate data collection	✓	✓	✓	✓	✓
	Ecosystem management	✓	✓	✓	✓	✓
	Compliance with international conventions	✓	✓	✓	✓	✓
	Effective monitoring, control and surveillance (MCS)	✓	✓	✓	✓	
Economic	Increased export earnings			✓	✓	
	Improved marketing/processing and value addition		✓	✓	✓	
	Technological provision and modernisation	✓	✓	✓	✓	
	Credit provision and modernisation			✓	✓	
	Credit provision and saving schemes			✓	✓	
	Collection of resource rent/licensing, royalties		✓	✓	✓	
	Economic diversification			✓	✓	✓
Social	Maximising employment					✓
	Ensuring food security					✓
	Participation of stakeholders			✓	✓	✓
	Support for fisher and fish worker organisations	✓	✓	✓	✓	✓
	Human capacity development				✓	✓
	Alleviating poverty				✓	✓
	Provision of safety nets				✓	✓
	Access rights				✓	✓
	Support for customary rights				✓	✓
	Utilisation of by-catch			✓		
	Gender issues				✓	✓

Source: Satia and Gardiner (2004)

Opportunities for ICTs in small-scale fisheries

An important opportunity for leveraging contemporary ICT capabilities in small-scale fisheries is the application of the technologies to build unbroken links up the vertical value chain for each activity in the horizontal value chain, as shown in Figure 4. In this way:

1) Value is added to each activity in the horizontal value chain in such a way as to optimise the respective operations through the use of instrumentation, information, process and organisation, consistent with a strategic intent (fifth order in the vertical value chain) that is itself sensitive to the priorities of all stakeholders that comprise the complex interdependent ecosystem of small-scale fisheries
2) Strategic initiatives at the level of the complex interdependent ecosystem can be coordinated and managed on the basis of their respective underlying linked knowledge management systems.

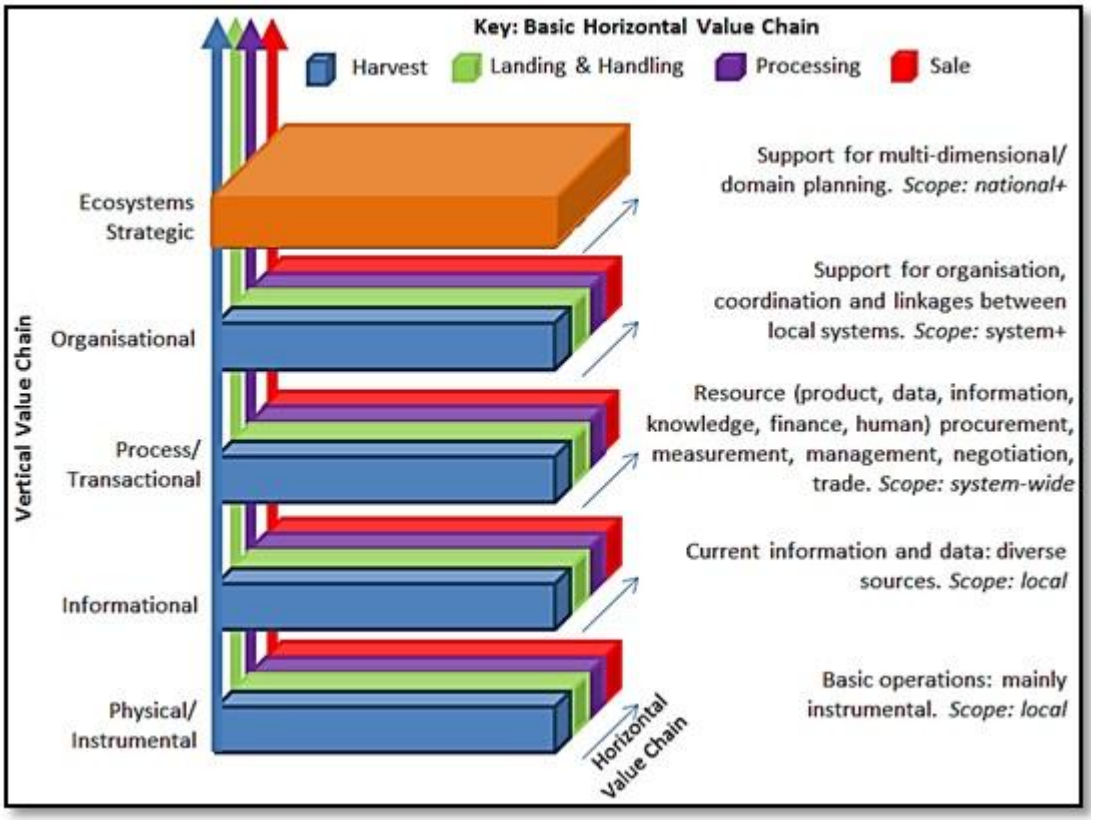

Figure 4: Key focal points for ICT interventions in small-scale fisheries vertical value chain

Figure 4 provides key focal points for ICT interventions at each order in the small-scale fisheries vertical value chain, illustrated in Figure 2. At the most basic level, physical or instrumental support is provided to support an activity. Value is added through the provision of information. Further value is added through the provision of efficient and effective processes which link and/or integrate several component sub-activities. Yet more value is added through the organisation, coordination

and linkage between similar activities performed by disparate agents in the value chain. At the height of the value chain is the value added to the entire ecosystem through specific strategic interventions within different vertical chains. The scope of impact of value inputs increases progressively from local, (in the case of the physical and informational inputs (orders 1 and 2)); system-wide in the case of process/transactional inputs (order 3); greater than system-wide scope (in the case of organisational value inputs (order 4)); and greater than national scope (in the case of ecosystem strategic inputs (order 5)).

6. ICTs in ACP small-scale fisheries

There is growing interest in and use of ICTs in fisheries. The technologies have mostly been produced in the developed world for use in commercial and game fisheries, though some are available for use in ACP countries. For example, Bist LLC produces a range of commercially available nautical charting and navigational applications for Android, iPhone and Blackberry devices[1]; with maps available for several ACP countries. Imray produces a free Chart Navigator[2] for Apple devices, with maps for a number of countries, including ACP states, for purchase. Imray also offers a range of other applications that provide marine rules and signals, chart symbols, tide planner and boat instruments. SIS Software produces *Fishing Calendar*[3] that "predicts the probability of successful fishing"; displays moon phases; and stores and shares catches. Fishing Calendar, which is primarily targeted at game fishers, is available for Apple and Android devices, and claims to operate worldwide.

A number of popular weather applications are available for a range of ICT devices and with coverage, which includes ACP countries. One such is Weather 4D[4] developed by Olivier Bouyssou of France. The application provides up to date data on cloud cover, precipitation for both rain and snow; wind speeds 10 m above sea level; temperature 2 m above mean sea level; and wave height, direction and period. It is available for a one-time purchase of the web or mobile application and is available in French and English. The simple and intuitive interface allows users to watch weather data in a 4-dimensional space. Applications which display tide information are also useful for harvesters in the small-scale fisheries sector. Some of these are available for use in ACP countries. For example, TXT Vault[5] from Australia has developed such applications specifically for the Caribbean and Pacific islands.

The Pacific Disaster Center (PDC)[6], has produced a range of early warning tools that capture data from all over the globe and may therefore be used in ACP countries. For example, *DisasterAWARE*

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[1] Nautical charting and navigational applications by Bist LLC: http://www.appszoom.com/iphone-developer/bist-llc_dzsrr.html

[2] Chart Navigator: http://www.imray.com/apps/

[3] Fishing Calendar by SIS Software: http://www.sis.si/fishing-calendar

[4] Weather 4D: http://www.weather4d.com/en/

[5] TXT Vault Tide Times: http://brightpurplefrog.com/ and https://play.google.com/store/apps/details?id=com.txtvault.android.tidetimesuscar&hl=en

[6] PDC free apps and tools: http://www.pdc.org/solutions/tools/

("*Disaster All-hazard Warning Analysis and Risk Evaluation*"), developed in Hawaii, provides comprehensive, integrated situational awareness, decision support, and information exchange capabilities to disaster management decision makers around the world to support assistance for disaster management and risk reduction. Though targeted at disaster management decision makers and not at the fisheries sector, the full functionality of this application may be used by registered organisations within the sector agents. In this way, it is accessible to fisheries sector management, which plays an overarching role in the small-scale fisheries value chain. PDC has also produced *Disaster Alert*, which provides mobile access to near real-time data on active and potential hazards to people, property or assets from the DisasterWare platform, in a form that is easy to understand. Though not targeted at the fisheries sector, this free Android and Apple application may be used by all agents in the fisheries value chain, particularly harvesters who are the most vulnerable to natural disasters.

IHS Global has developed Sea-web,[7] a web application which provides marine shipping data for ship vetting, to evaluate chartering risks relating to tonnage, used by engine manufacturers and marine equipment companies for risk assessment and historical shipping data. Target users are commercial marine fishers, ship owners, oil ports, maritime agencies and fisher organisations. The Vessel Monitoring Systems (VMS)[8] has been developed in the UK to aid in safety navigation, search and rescue for all seafarers; and for catch reporting for fisheries management. Crafts are required to be outfitted with GPS, computing and communications facilities, to link with a flag centre. The application is used to monitor and track fishing vessels for commercial fishing. Target users are commercial fishermen, fisheries management, safety organisations and research analysts. VMS deployments began in 1997 and the application remains operational with periodic updates incorporating new radio and mobile communications technologies. Although not developed for ACP states, all boats nominated to Commonwealth fishing concessions are required to maintain an operational VMS on-board at all times.

The Norwegian Institute of Food Fisheries and Aquaculture Research (NOFIMA) has developed the *How Fresh is Your Fish*[9] iPhone app that supports quality assurance by helping different agents in the fisheries value chain evaluate the freshness of catch for packaging and storage. Target users are fish harvesters, consumers, educators and other agents in the fishing industry. The application is customisable for some ACP countries, with support for more than ten languages. It is free and available on the App Store and on the NOFIMA website for the iPhone and iPad. Several other ICT solutions have been developed outside of ACP states and for sectors other than fisheries but that are transferable to ACP fisheries value chains. These include Reef ID's AquariApps,[10] which provides

[7] Sea Web app: http://www.sea-web.com/seaweb_welcome.aspx

[8] VMS: http://ec.europa.eu/fisheries/cfp/control/technologies/vms/index_en.htm

[9] How fresh is your fish: https://itunes.apple.com/us/app/how-fresh-is-your-fish/id431891732?mt=8

[10] AquariApps: http://www.reefid.org/Brochure_AquariApp_Trifold1.2_12.pdf

information about marine artefacts, primarily for tourists. An important one is Ecofund,[11] a peer-to-peer crowd funding platform for eco-projects, and an Apps4Africa winner.

A number of applications have been developed in ACP countries for demonstrative purposes and in programming competitions. For example, in 2011 Pascal Katana, a student of the Department of Electrical and Information Engineering at the University of Nairobi, Kenya, developed *Fish Call The Fisherman*[12] to automate fishing and increase fish catch. Several mobile applications were developed at the First Ever Caribbean Open Data Code Sprint in 2012. Eric Mutta of Problem Solved Ltd. developed *Minishop*[13] for Kenya and Tanzania as part of the AppsforAfrica competition in Demo Africa 2012, and won the second round of the SME Finance Innovation Challenge Fund Competition organised by the Tanzania's Financial Sector Deepening Trust (FSDT). *Minishop* provides electronic record-keeping solutions to manage and access finances for small- and medium-sised enterprises. While not specifically for the small-scale fisheries sector, *Minishop* is applicable to small-scale business owners in the sector. Several other ICT applications have been developed in ACP countries for other sectors but it may be extended to fisheries. These are primarily targeted at the provision of market information and linking different agents in the value chain, such as Esoko[14] Ghana and citizen engagement, such as Trac FM[15].

ICT applications have also been produced specifically by or for small-scale fisheries in ACP countries. Table 5 provides a sample of these with details, where available, about the objectives, target user, developer, key dates, current status, type of funding source, component in the value chain, outreach mechanisms used, constraints to dissemination and adoption, terms of use, intended and actual impact, and lessons learned.

[11] Ecofund: http://www.ecofund.net.au/

[12] Fish Call the Fisherman: http://www.afrigadget.com/2009/07/21/fish-call-the-fisherman/

[13] Minishop: http://www.humanipo.com/news/30408/tanzanias-minishop-now-in-kenya/

[14] Esoko: http://www.esoko.com/

[15] TracFM: http://www.tracfm.org/

Table 5: Further details on sample ICT applications made in or for small-scale fisheries in ACP states

Navigation		
App/country	*Key information*	*Further particulars*
mFisheries Navigation Component within mobile Fisheries At-Sea Toolkit Developed in Trinidad & Tobago Applicable to all countries	**OBJECTIVES**: To provide everyday support for sea- and large-riverine farers to assist with navigation; planning, viewing and notifications of trips; communicating with at-sea social networks and logging location-based data. **TARGET USER**: Small-scale fishers**,** but applicable to all seafarers **DEVELOPER:** Caribbean ICT Research Programme **DATES**: Preliminary appraisal: 2009; first cycle development: 2010; field trial: 2011; deployment: 2012; second cycle development: 2013. **FUNDING**: Primary donor (IDRC) for research support; with provision of in-kind support from local agencies and financial contributions from private sector	1. Component of value chain: Harvesting 2. Outreach mechanisms: About app: Caribbean ICT Research website, media channels, regular meetings with small-scale fishers, ad hoc meetings with other members of fisheries sector, local field trial, conferences, community outreach, academic papers, use cases and role playing to demonstrate application. In App: Trip and incident sharing capabilities, and social networking. 3. Constraints to dissemination: Cost of face-to-face, print and other dissemination channels; scheduled face-to-face meetings not convenient for all target fishers. 4. Terms of use: Free open-source application downloaded from the CIRP website. Requires Android device running OS version 4.0 Ice-cream Sandwich with internal memory of 2GB and GPRS/4G capabilities. Notifications of user name and location can be made public to other mFisheries At-Sea users. Trip planner information accessible by designated parties as well as Coast Guard officials in cases of at-sea emergencies. 5. Constraints to adoption: Availability of ruggedised phone; cost of ruggedised smartphone (though in many jurisdictions this one-off cost has not been reported as a barrier), mobile data coverage at sea for social networking and trip planning notifications to friends and family – data service **not** required for data logging, trip planning or compass; relative accuracy of application functions vis a vis dedicated devices; battery life of phone selected for field trial. 6. Intended impact: To improve fisher livelihoods through added efficiencies and effectiveness of instrumental, informational and communications tools in support of harvesting operations. 7. Outcomes and impact to date: First cycle successfully deployed in Trinidad. Second cycle deployment in preparation for Tobago. Application easily adopted by small-scale fishers in field trial. Limited funds for field work have limited broader deployment. 8. Lessons learned from experiences: Digital literacy rates are higher than expected among small-scale fishers who use similar technologies in their daily lives; the development of this app suite component reinforced prior knowledge that the inclusion of grass root stakeholders from the beginning is critical to understand current practices and ground realities. Limited battery life and phone ruggedness guide further research. **WEBSITE**: http://cirp.org.tt/mfisheries/

Early warning systems		
App/country	*Key information*	*Further particulars*
M.A.D.E. – My App for Disasters and Emergencies Developed in Trinidad & Tobago Applicable, with customisation, to all countries	**OBJECTIVES**: To provide location-specific and actionable information about natural disasters; and to connect those in need with first responders and disaster response coordinators, enabling them to optimally allocate resources. **TARGET USER**: General public in Trinidad and Tobago, particularly commuters and Intra-regional tourists and other travellers **DEVELOPER:** M.A.D.E. My App for Disasters and Emergencies **DATES**: First cycle developed in 2013, Not yet deployed. **FUNDING**: Competition winnings (http://ventureoutchallenge.org/champions-announced/) + not otherwise specified	1. Component of value chain: Though targeted at the general public and not at the fisheries sector, this application may be used by all agents in the fisheries value chain, particularly harvesters who are the most vulnerable to natural disasters 2. Outreach mechanisms: About app: Web and traditional media articles regarding M.A.D.E.'s candidacy in VentureOut Challenge and Startup Weekend Trinidad and Tobago, both in 2013; In app: its social media platform supports crowd-sourcing of localised information about an emergency, with plans for continuous monitoring and transfer to national response authorities. 3. Constraints to dissemination: Product not yet completely developed, currently in pilot. 4. Terms of use: Free mobile application for Windows 8 and Android. 5. Constraints to adoption: Only available for smartphones with data connectivity for real-time updates. Also, users not familiar with social media networks may have difficulty navigating the application. 6. Intended impact: Mitigation of the effects of natural disasters though the use of early warning and first response systems. 7. Outcomes and impact to date: None at this time (still in pilot) 8. Lessons learned from experiences: Application developed in response to first hand experiences of flash flooding and other natural disasters. As the application is in the early stages of development, there is little else to report at this time. **WEBSITE**: http://www.getmade-tt.com/#!the-product/c1inc

TERA – Trilogy Emergency Response Application Developed for Haiti. Applicable, with customisation, to all countries	**OBJECTIVES**: To enable aid organisations to broadly and swiftly disseminate messages relating to disaster relief	1. Component of value chain: Though targeted at the general public and not at the fisheries sector, this application may be used by all agents in the fisheries value chain, particularly harvesters who are the most vulnerable to natural disasters 2. Outreach mechanisms: In conjunction with app: Combined with traditional channels such as radio, newsletters and personal contact, SMS messaging is a vital component of the Red Cross Red Crescent approach to beneficiary communication between all users 3. Constraints to dissemination: Costs/waiver of costs of SMS transmissions in times of disaster or outbreak of disease. 4. Terms of use: SMS, free to receive and widely available on feature phones as well as smartphones, without the need for data service. 5. Constraints to adoption: Limited use of cellular devices in the wake of a disaster. Also in Haiti, where TERA has been deployed, mobile penetration is comparatively very low. 6. Intended impact: To save more lives by delivering timely, targeted advice to disaster affected communities that make aid efforts more efficient; to give communities a voice, ensuring that the correct type of aid is delivered to the right places; to let disaster affected people know that they are not alone. 7. Outcomes and impact to date: TERA's first campaign targeted Haitian's in range of a free vaccination clinic. In this case, 16 million targeted SMS's resulted in 152,000 immunisations. In a campaign which followed a cholera epidemic, 4 million SMS's generated 90,000 calls to a free hotline. When TERA was originally opened up to all NGOs in Haiti, some of these organisations began spamming their customers. The service provider, Voila, has since worked more exclusively with the Red Cross. 8. Lessons learned from experiences: The importance of incorporating key features to support aid efforts and to minimise the impact on the host GSM networks. **WEBSITE**: http://healthmarketinnovations.org/program/trilogy-emergency-response-application-tera-technology-provider
	TARGET USER: Red Cross, other disaster relief organisations, populations threatened by disasters	
	DEVELOPER: Trilogy International Partners, three operating companies in New Zealand, Bolivia and the Dominican Republic.	
	DATES: Deployed after the 2010 earthquake in Haiti. Still existing.	
	FUNDING: Primary donor with provision of further financial and in-kind support from private sector	

Weather and tides		
Application/country	*Objectives/target user/dates*	*Further particulars*
mFisheries W&T Component of mobile fisheries At-Sea Tool kit Developed in Trinidad & Tobago Applicable to all countries	**OBJECTIVES**: To provide credible, scientific information concerning local weather, tide and moon phase to at-sea users **TARGET USER**: Small-scale fishers **DEVELOPER:** Caribbean ICT Research Programme **DATES**: Preliminary appraisal: 2009; first cycle development: 2010; field trial: 2011; deployment: 2012; second cycle development: 2013. **FUNDING**: Primarily donor (IDRC) with provision of further financial and in-kind support from private sector	1. Component of value chain: Primarily harvesting but may be used by all persons along the fisheries value chain. 2. Outreach mechanisms: About app: Caribbean ICT Research website, media channels, regular meetings with small-scale fishers, ad hoc meetings with other members of fisheries sector. Community outreach, use cases and role playing to demonstrate application. 3. Constraints to dissemination: Cost of face-to-face, print and other dissemination channels; scheduled time for meetings does not facilitate the attendance of all fishers. 4. Terms of use: Requires Android device running OS version 4.0 Ice-cream Sandwich with an internal memory of at least 2GB together with GPRS/4G capabilities. Application can access the user's location to obtain the current weather information. Information presented would be information obtained from the nearest weather station (weather) and buoy (tide). 5. Constraints to adoption: Accuracy of data tied to accuracy of source; Lack of specific weather conditions for different areas of the country; Lack of at-sea weather; Lack of buoys around Trinidad and Tobago to provide information for different landing sites; Ruggedness of device to withstand at-sea conditions. 6. Intended impact: To improve the safety at sea and efficient trip planning. 7. Outcomes and impact to date: Objective of providing weather and tide information was readily adopted by the small-scale fishers. However the concern on accuracy of information provided was raised. Application easily adopted by small-scale fishers in field trial. Limited funds for field work have limited broader deployment. First cycle successfully deployed in Trinidad. Second cycle deployment in preparation for Tobago. 8. Lessons learned from experiences: Converting textual information to visual representation would improve the reception of the information provided. Application update currently in pilot phase. Limited battery life and ruggedness of field trial phone have also guided further research. **WEBSITE**: http://cirp.org.tt/mfisheries/

Caribbean Tide Times Developed in Australia, customised for Caribbean countries: Bermuda, Bahamas, Cuba, Puerto Rico, Haiti, Dominican Republic, Jamaica, St Croix, St Johns and St Thomas	**OBJECTIVES**: To track tide times **TARGET USER**: All seafarers **DEVELOPER:** TXT Vault **DATES**: Updated 21 October 2013 **FUNDING**: Not disclosed	1. Component of value chain: Fish harvesters 2. Outreach mechanisms: Web and app stores 3. Constraints to dissemination: Cost of promoting an application to users in a competitive and over saturated market for tide and weather applications. Large regions of interest hence little or no face-to-face promotions. Relies on word of mouth and website presence. 4. Terms of use: Free Android, iOS apps, local storage of data so no need for internet connection once downloaded 5. Constraints to adoption: Smartphone, fast internet access required to download mapping application information, at-sea data connectivity, tide information mostly textual. 6. Intended impact: Efficiency and safety at sea 7. Outcomes and impact to date: Thousands of installs to date 8. Lessons learned from experiences: Not reported **WEBSITE**: https://play.google.com/store/apps/details?id=com.txtvault.android.tidetimesuscar&hl=en
Pacific Islands Tide Times Developed in Australia Customised for Rarotonga, Samoa, Tonga, Kiribati, Marshall Islands, Micronesia, Nauru, Palau Islands, Papua New Guinea, Solomon Islands, Tuvalu and Vanuatu	**OBJECTIVES**: To track tide times **TARGET USER**: All seafarers **DEVELOPER:** TXT Vault **DATES**: Updated 21 October 2013 **FUNDING**: Not disclosed	1. Component of value chain: Fish harvesters 2. Outreach mechanisms: Web and app stores 3. Constraints to dissemination: Cost of promoting an application to users in a competitive and over saturated market for tide and weather applications. Large regions of interest hence little or no face-to-face promotions. Relies on word of mouth and website presence. 4. Terms of use: Free Android, iOS apps, local storage of data so no need for internet connection once downloaded 5. Constraints to adoption: Smartphone, fast internet access required to download mapping application information, at-sea data connectivity, tide information mostly textual. 6. Intended impact: Efficiency and safety at sea 7. Outcomes and impact to date: Thousands of installs to date 8. Lessons learned from experiences: Not reported **WEBSITE**: https://play.google.com/store/apps/details?id=com.txtvault.android.tidetimespacific&hl=en

Buoy weather Developed in the US Customised for several Africa, Caribbean and Pacific countries	**OBJECTIVES**: To provide accurate long-range marine forecasts, charts and graphs, wind and weather data. **TARGET USERS**: Mariners, costal residents, fishermen and water sports enthusiasts **DEVELOPER**: Buoyweather.com **DATES**: Recent Update August 2013 **FUNDING**: Commercial	1. Component of value chain: Though targeted at the general mariner and not at the fisheries sector, this application may be used by fish harvesters who are the most vulnerable to natural disasters; and for whom navigational aids are useful. 2. Outreach mechanisms: About app: website; In app: Global network of shared data. 3. Constraints to dissemination: Commercial service; available only in one language. 4. Terms of use: Available only on GPS enabled devices. Free app download, paid subscription service. 5. Constraints to adoption: Available only on GPS enabled devices; buoys from which reading is taken not indicated on map, limiting the creditability of the information. 6. Intended impact: Commercial product, personal safety at sea. 7. Outcomes and impact to date: On commercial market 8. Lessons learned from experiences: According to user reviews the application's data retrieval is slow and prevents users from accessing weather charts quickly. **WEBSITE**: http://www.buoyweather.com/index2.jsp
Safety at sea		
Application/ country	*Objectives/target user/ dates*	*Further particulars*
mFisheries Safety Component within mobile Fisheries At-Sea Tool kit Developed in Trinidad & Tobago Applicable to all countries	**OBJECTIVES**: To provide emergency support for fishers through the use of geofenced tracking and SOS alert. **TARGET USER**: Small-scale fishers**,** but applicable to all seafarers **DEVELOPER:** Caribbean ICT Research Programme **DATES**: Preliminary appraisal: 2009; first cycle development:	1. Component of value chain: Harvesting 2. Outreach mechanisms: About app: Caribbean ICT Research website, media channels, regular meetings with small-scale fishers, ad hoc meetings with other members of fisheries sector, local field trial, conferences, community outreach, academic papers, use cases and role playing to demonstrate application. In App: Trip and incident sharing capabilities, and social networking. 3. Constraints to dissemination: Cost of face-to-face, print and other dissemination channels; scheduled face-to-face meetings not convenient for all target fishers. 4. Terms of use: Free open-source application downloaded from the CIRP website. Requires Android device running OS version 4.0 Ice-cream Sandwich with an internal memory of at least 2GB together with GPRS/4G capabilities for full mFisheries suite support though may be used standalone with less functional requirements. Notifications of device IMEI, registered user name, GPS coordinates, date and time of day, sent to national authorities and predefined recipients via

	2010; field trial: 2011; deployment: 2012; second cycle development: 2013. **FUNDING**: Primary donor (IDRC) with provision of further financial and in-kind support from private sector	automatic SMS and email. Automatic phone call made to pre-designated national authority. 5. Constraints to adoption: Availability of ruggedised phone; cost of ruggedised smartphone (though in many jurisdictions this one-off cost has not been reported as a barrier), mobile data coverage at sea for tracking and SOS – data service **not** required for local data caching, automatically uploaded to server when phone returns to coverage area. 6. Intended impact: To reduce fatal and catastrophic outcomes of emergencies faced by fishers 7. Outcomes and impact to date: mFisheries users have used the Safety features several times and each time the Trinidad and Tobago Coast Guard has responded promptly, resolving the issue over the phone or dispatching rescue vessels and aircraft, as appropriate. 8. Lessons learned from experiences: The combination of infrequency and criticality of emergencies poses a significant challenge to the solution of safety communications for fishers. A cellular solution is the most natural as fishers typically take their phones on trips whereas their use of marine radios is generally far, far less. However, limited cellular coverage at sea is a vexing problem. Standard satellite solutions, while the most natural technological solution, are prohibitively expensive. This remains a rich area for investigation. **WEBSITE**: http://cirp.org.tt/mfisheries/
Virtual marketplace		
Application/ country	*Link/objectives/dates*	*Description*
EFMIS-Ke – Enhanced Fish Market Information Service Developed in Kenya Customised for Kenya and parts of West Africa	**OBJECTIVES**: To enhance fish trade and incomes of the fisher community by improving access to market information **TARGET USERS**: All agents engaging in market activity in the small-scale fisheries sector **DEVELOPER**: Team led by Richard Abila and implemented through the Kenya Marine & Fisheries Research Institute	1. Component of value chain: Distribution from fish harvester to factory, with a focus on traceability along the chain from processors to vendors. 2. Outreach mechanisms: About app: website, application featured in web articles, journal articles e.g. “Using ICT for Fishing: The EMFMIS model in Kenya” published by Practical Action Publishing, 18 June 2013. Stakeholder workshops and meetings attended by fishers, fish traders, fish exporters, cooperatives, government representatives, NGOs, the media; Highly publicised project launch; publicity campaign comprising: banners, wall posters, brochures, flyers, tee shirts distributed to fisher communities and other target groups; Exhibitions and demonstrations during agri-business shows and other forms across the country; Fisheries extension with the support of Departments of Fisheries, Beach Management Units and Cooperative Societies; scaled from Lake Victoria to country-wide in Kenya; output report; website; conferences; monthly Market Bulletin.

	DATES: Project started 2009 Currently in operation	In App: Network of shared data. 3. Constraints to dissemination: Limited cellular coverage in rural communities in West Africa. 4. Terms of use: Free open-source. 5. Constraints to adoption: Cost of cellular phones and limited cellular coverage. 6. Intended impact: Reduce poverty and improve fish sales by transparent fish prices, reduced marketing costs and less post-harvest fish losses. 7. Outcomes and impact to date: The intervention started on 9th March 2011 and scaled from Lake Victoria to country-wide in Kenya. It has engaged a total of 165 fish markets comprising 150 landing sites and 15 urban-based markets; 20,000 SMS queries for market information were submitted to the database. 8. Lessons learned from experiences: The importance of developing a national system to reach a larger audience to expand the production and distribution of key fish markets and pricing; sustainability of the system beyond donor funding is a key concern. The exercise revealed the many challenges of rolling out ICTs in rural areas. These relate, inter alia, to infrastructure, costs of handsets, limited basic and digital literacies of users, socioeconomic and cultural factors. The absence of standardisation of fish quality and pricing are also critical factors that yield variability in interpretation of prices, that is to say a low price can ambiguously reflect poor quality or can reflect unfavourable market conditions. **WEBSITE: http://www.businessdailyafrica.com/Fish-traders-land-bigger-returns-with-market-tracking-system/-/1248928/2131390/-/item/0/-/n9ljkfz/-/index.html**
	FUNDING: supported by the International Labour Organisation in the initial phase, up-scaling of the programme was funded by the EU.	

mFisheries Virtual Marketplace Developed in Trinidad & Tobago Customisable to all countries	**OBJECTIVES:** To provide mobile and web tools (virtual market) for easy communication between small-scale fisheries and processors. **TARGET USERS:** Harvesters and processors. **DEVELOPER:** Caribbean ICT Research Programme **DATES**: Preliminary appraisal: 2009; first cycle development: 2010; field trial: 2011; deployment: 2012; second cycle development: 2013. **FUNDING**: Primary donor (IDRC) with provision of further financial and in-kind support from private sector	1. Component of value chain: All stages of the value chain that include the sale or purchase of fish or the tracking of market prices 2. Outreach mechanisms: About app: Caribbean ICT Research website, media channels, regular meetings with small-scale fishers, restaurateurs, vendors, ad hoc meetings with other members of fisheries sector, local field trial, conferences, community outreach, academic papers, use cases and role playing to demonstrate application. In App: Trip and incident sharing capabilities and social networking. 3. Constraints to dissemination: Cost of face-to-face, print and other dissemination channels; scheduled face-to-face meetings not convenient for all target fishers. Communication with vendors and restaurateurs. 4. Terms of use: Free open-source application downloaded from the CIRP website. Requires Android device running OS version 4.0 Ice-cream Sandwich with an internal memory of at least 2GB together with GPRS/4G capabilities. Notifications of user name and location can be made public to other virtual market users. 5. Constraints to adoption: It requires an entire market ecosystem of agents (fishers, vendors, wholesalers, retailers, consumers) to subscribe. 6. Intended impact: To improve the marketing process of fish caught by improving the ease of communication, efficiency, effectiveness and portability. 7. Outcomes and impact to date: First cycle successfully deployed in Trinidad among field trial participants and valuable feedback received regarding usability. The field trial did not include a broad cross-section of agents in the market ecosystem so there has not yet been an opportunity for operational assessment. The second cycle field trial is under preparation for Tobago where it will be applied to a limited scope within a representative portion of the full ecosystem. 8. Lessons learned from experiences: It uses the first four orders in the vertical small-scale fisheries value chain, requiring the participation of all agents in the value chain. Its implementation therefore requires the engagement of all agents for systemic incorporation in operational practices. Such implementation relies on the comprehensive partnership between the research agents and boundary partners. **WEBSITE**: http://cirp.org.tt/mfisheries/

Extension & awareness building		
Application/ country	*Objectives/target user/ dates*	*Further particulars*
mFisheries Training Companions Component within mFisheries application suite Developed in Trinidad & Tobago Applicable to all countries	**OBJECTIVES**: To provide non-traditional learning opportunities through various media formats **TARGET USER**: Small-scale fishers and fisheries training agencies. **DEVELOPER**: Caribbean ICT Research Programme; presenting content created by (CFTDI) Caribbean Fisheries Training & Development Institute through the "Podcasting in your nets" project and through content delivered in face-to-face training and compressed by Trinidad and Tobago's Ministry of Science, Technology and Tertiary Education for mobile delivery **DATES**: Date published 14 Sep 2011 **FUNDING**: CFTDI, The Ministry of Science, Technology and Tertiary Education & Caribbean ICT Research Programme	1. Component of value chain: Fish harvesters and training agencies. 2. Outreach mechanisms: About App: Web outreach via the Caribbean ICT Research website and CFTDI web channels. In App: Open and distance learning training companions. 3. Constraints to dissemination: Cost of dissemination, availability of media channels, hosting meetings and recording podcast. 4. Terms of use (including total cost of use) and availability: Free audio and synchronised text/ image walk-throughs of first aid procedures available free as stand alone podcast transferable via Bluetooth or bundled with the mFisheries application suite audio. 5. Constraints to adoption: Access to content from other users, CFTDI or CIRP channels 6. Intended impact: To provide alternative learning programmes to rural communities to improve livelihoods and access to education. 7. Outcomes and impact to date: Incorporated into the mFisheries suite; first time use reported as interesting and useful but static nature and limited range of content limits impact. 8. Lessons learned from experiences: The importance of alternative learning methods and dynamic creation of content. **WEBSITE:** http://scsee.uwi.tt/mfisheries/map/reports/view/11

Radio Ada Developed in Ghana	**OBJECTIVES:** To provide information and communication services to strengthen fishers' livelihoods and linkages with advocacy groups and civil societies **TARGET USER:** Fishers, Advocacy Groups, Agricultural Communities **DATES:** Release date September, 2005 **DEVELOPER:** None specified **FUNDING:** Part funded by UNESCO	1. Component of value chain: Fish harvesters, government agencies, community markets, retailers and advocacy groups. 2. Outreach mechanisms: About App: Radio broadcast, web streaming of shows, publicity and traditional media outreach by UNESCO. In App: Networking, peer learning and data sharing. 3. Constraints to dissemination: Availability of media channels, access to radio and cellular devices, language barriers. 4. Terms of use (including total cost of use) and availability: Purchase licence for the application for radio. 5. Constraints to adoption: Cost of cellular phones, network connectivity, lack of community based response. 6. Intended impact: Improving and strengthening the lives of small-scale fishers, increasing the educational gap among rural communities. 7. Outcomes and impact to date: Radio Ada has benefitted from additional funding and the aid of various communities after becoming a UNESCO Community Multimedia Centre (CMC) in 2005 8. Lessons learned from experiences: Radio Ada forged the way for community collaboration using radio and voice messages to facilitate open discussion and highlight important problems to relevant authorities. **WEBSITE**: www.ghanacommunityradio.org/course/radio-ada/
WWF-SASSI application Southern African Sustainable Seafood Initiative (SASSI) Customisable for ACP countries.	**OBJECTIVES**: To inform and educate all participants in the seafood trade, from wholesalers to restaurateurs through to seafood lovers on sustainable fishing and fish species. **TARGET USER:** All members of the seafood supply chain from independent fishers to fishing companies. **DATES:** Updates November 2013	1. Component of value chain: All members of the fishing supply chain from harvesters, restaurateurs, processors and wholesalers. 2. Outreach mechanisms: About App: Web articles e.g.: SASSI website, other online media and publications by collaborative groups e.g.: World Wildlife Federation website. In App: Video and text based data, sharing technology to build a community of users. 3. Constraints to dissemination: Available for Blackberry and via the web but not for other devices. 4. Terms of use: Free web-based application downloaded from official website. 5. Constraints to adoption: Cost of smartphone, language, digital literacy, cellular and data coverage at sea, only for blackberry, mostly textual information presented.

	DEVELOPER: Southern African Sustainable Seafood Initiative (SASSI) **FUNDING**: SASSI is a collaborative initiative between the World Wildlife Federation-South Africa, the Department of Environmental Affairs and Tourism, Ezemvelo KZN Wildlife, Two Oceans Aquarium, The South African Institute for Aquatic Biodiversity (SAIAB) and the Endangered Wildlife Trust.	6. Intended impact: To reverse the effects of unsustainable fishing practices by developing an ecosystems approach to fisheries, shifting consumer demand away from over-exploited species to more sustainable options. 7. Outcomes and impact to date: The Seafood Certification and Eco-labelling programme and the Marine Stewardship Council (MSC), began using QR codes on fish products to encourage consumers to utilise smartphone technology to join the debate and play an active role in finding out about sustainable food choices. 8. Lessons learned from experiences: The importance of education in playing a role in making citizens aware of the issues in the fishing industry. This lesson has been actualised in the collaboration with the World Wildlife Federation-South Africa and Wildlife Trust to educate citizens on sustainable fishing. **WEBSITE:** http://www.wwfsassi.co.za/?m=3&s=2&idkey=635 http://www.seaworld.org.za/content/page/sassi
Traceability		
Application/ country	*Objectives/target user/ dates*	*Further particulars*
Tracefish-Ke Developed in Kenya	**OBJECTIVES:** To establish an electronic traceability system for Nile perch from Lake Victoria and seafood products from marine fisheries **TARGET USER**: lobster and octopus fishers; 21,000 fishing crew in the Nile perch fishing fleets. Secondary beneficiaries include the Nile perch fishing vessel owners and traders who link fishing units and fish factories.	1. Component of value chain: Distribution from fisher to factory, with a focus on traceability along the chain 2. Outreach mechanisms: About App: Stakeholder workshops and meetings attended by fishers, fish traders, fish exporters, cooperatives, government representatives, NGOs, the media; Highly publicised project launch; publicity campaign comprising: banners, wall posters, brochures, flyers, tee shirts distributed to fisher communities and other target groups; Exhibitions and demonstrations during agri-business shows and other forms across the country; Fisheries extension with the support of Departments of Fisheries, Beach Management Units and Cooperative Societies; scaled from Lake Victoria to country-wide in Kenya; output report; website; conferences. In App: Networking channels, SMS messaging, data sharing. 3. Constraints to dissemination: Privacy, some fishers may wish to keep their information private such as fishing gear, fishing vessel and catch value. 4. Terms of use: Free open-source Application.

	DEVELOPER: Micro-Enterprises Support Programme Trust (MESPT) **DATES:** Project started 9 March 2011; Duration 12 months from start date **FUNDING:** Funded by DFID through the International Labour Organisation and its Cooperative Facility for Africa Fund (CoopAfricaChallenge Fund)	5. Constraints to adoption: Access to the internet, cost of smartphones, network coverage, digital literacy. 6. Intended impact: To increase traceability along the value chain, improve business efficiencies, increase transparency especially relating to pricing along the value chain and enhance compliance to production and supply regulations linked to future eco-labelling possibilities. 7. Outcomes and impact to date: Increase efficiency of several functions of traceability such as to tracing food safety issues to its source, tracking the distribution of unsafe items, and recalling them from commerce. Efficiency in the timeliness of issuance of fish quality assurance certificates needed for export. 8. Lessons learned from experience: Increasing transparency will reduce the exploitation of fishers in price negotiations. **WEBSITE: http://mespt1.sabalink.co.ke/index.php/about-us/our-corporate-social-responsibility/14-sample-data-articles/159-mespt-asmep-fisheries**
Data collection		
Application/ country	*Objectives/target user/ dates*	*Further particulars*
Digital Deck, HapiFis Developed for Solomon Islands	**OBJECTIVES:** Mobile data capture at sea, access to catch history, meeting agency logbook requirements and to track progress towards fishery management goals. **TARGET USERS:** Harvesters and fisheries management agencies **DEVELOPER**: Point 97 **DATES:** not specified **FUNDING:** Solomon Islands Government and the Coral Triangle Initiative.	1. Component of value chain: Harvest and overarching fisheries management 2. Outreach mechanisms: About App: Web articles e.g.: Point 97 web page, traditional advertising and digital media outlets. In App: data transmissions, collaborative research and spatial planning. 3. Constraints to dissemination: Cost, Languages and literacy rates. 4. Terms of use (including total cost of use) and availability: Open-source licence 5. Constraints to adoption: Cost of application, access to internet and digital literacy. 6. Intended impact: To ultimately increase food security for inshore fisheries by improving catch data collection methods 7. Outcomes and impact to date: Application not yet deployed, none to date. 8. Lessons learned from experiences: Not yet reported. **WEBSITE**: http://marinesciencetoday.com/2013/11/15/point-97-new-technology-to-manage-and-protect-the-oceans/

As the table shows, the ICT solutions developed for and by ACP countries in support of the small-scale fisheries sector include facilities for:

- navigation: 1 open-source app currently in use among field trial participants (Total: 1)
- early warning systems: 1 open-source app in first cycle development; another free to receive SMS messages, successfully applied with significant impact in Haiti after a national disaster (total: 2)
- weather and tides: 1 open-source app currently in use among field trial participants; 2 on global marketplace with thousands of downloads to date; 1 available through paid subscription (total: 4)
- safety at sea: 1 open-source app currently in use among field trial participants (Total: 1)
- Virtual Marketplace: 2 open source: 1 currently in use among field trial participants and the other widely deployed (Total: 2)
- training and extension: 1 open-source app with limited deployment; 1 radio programme broadcasting to approximately 600,000 people of whom 60% are not literate (Total: 2)
- traceability: 1 open-source app inception phase completed (Total: 1)
- data collection: 1 open source not yet deployed (Total: 1).

Table 5 reveals that the most widely adopted mobile applications have required extensive dissemination and extension support and benefitted from considerable funds in support of deployment.

7. Value chain transformations

The vertical small-scale fisheries value chain is the basis for a general framework for assessing value chain transformations. Within this framework, stratified success factors can be defined as well as the essential aspects of the small-scale fisheries value chain that have been transformed or perturbed by the introduction of existing ICT interventions. Interventions have generally yielded modest transformations with this basic framework and considering the ICT applications currently in use in the small-scale fisheries value chain (Table 5).

Table 5 shows that a scan of ICTs currently used in and available for the small-scale fisheries sector in ACP states reveals only a few solutions, most of which are mobile applications. Based on a sample of ICT solutions found through desk research, support is primarily available for the first stage in the horizontal value chain: harvesting. This support is by way of first-order physical/instrumental enablers for navigation and safety at sea; and second-order informational enablers: early warning systems, weather and tides. Mobile applications are also available to support the sales activities in the horizontal value chain through the provision of second-order, informational enablers, as well as process and organisational enablers. Training and extension support is available through both mobile applications and radio. Applications are also available for traceability and data collection, important enablers for quality and sector management.

Impacts have generally been of the first and second orders, with little penetration to higher orders in the value chain, despite the substantial scope for transformative impact. Though ICTs are clearly being used to advantage in the small-scale fisheries industry in several ACP countries, sustainability and scaling would require a greater systematisation of its planning and execution across the

horizontal, and up the vertical, value chains. The embedding of ICT as a core function within sector management would appear to be an important first step.

8. Outlook: Strategic ICT intervention in small-scale fisheries

FAO has assessed that there is an urgent need for strategic application of ICTs in fisheries. Their *2007 policy brief* (FAO, 2007) provided a useful counterbalance to the *Review of ICT in the European fishing industry* (EFILWC, 2003). In particular, it pays less attention to the use of ICT to leverage industry productivity, efficiency and yield and more attention to the use of these technologies to meet the needs of the poor and on the facilitation of participative, people-centred communications for development and knowledge-sharing. Without explicit reference to specific technologies, the FAO Brief categorised ICT applications and offered example focal points as follows:

1) fishing and trading activities: market and price information; advice and services; e-credit; e-government; post-harvest;
2) people and communities: vulnerability reduction; increasing safety; social inclusion; social mobilisation (empowering fishing communities in owning and communicating information); advocacy;
3) resource management and conservation: monitoring, control and surveillance; co-management of fisheries resources.

The International Partnership for African Fisheries Governance and Trade (PAF), an AU programme, aims to resolve the tensions between the competing social, economic and biological/environmental aspects of the development and management of fisheries; it has a tight focus on illegal fishing and trade and access to markets. PAF contributes to the vision of The New Partnership for Africa's Development (NEPAD) that recognises governance as a strategic imperative. The Caribbean and Pacific ACP states are also treating these matters as strategic imperatives for the development of the small-scale fisheries sector.

An emphasis on ecosystems-based approaches to fisheries governance will give rise to an even spread of enablers across the vertical value chain for both the economic and the social-focused development strategies, in contrast to the profile derived from Satia and Gardiner (2004) and illustrated in Table 4. This spreading will reflect necessary changes as small-scale fishers take greater control of their productive capacities; and economic-focused development strategies increasingly align with multi-stakeholder needs in the ecosystem. It will also be accompanied by strong linkages, facilitated by rich, user-centric communications facilities between agents in the small-scale fisheries ecosystem. Contemporary ICTs (which provide comprehensive support for multi-modal [voice, data, video, audio, semantic] human engagement and interaction, data capture, generation and retrieval) as well as astounding processing, analytics and visualisation (with rich and intuitive display capabilities and remote storage) all offer opportunities to make strong linkages up the vertical value chain from primary small-scale fisheries agent up to policy and other strategic enablers. The growing commitment of governments for the provision of universal access to broadband holds the promise of democratising governance through access to ICT channels that are as commonplace and as physically, socially and logically accessible as tv and radio are among many of the world's small-scale fishers today.

Implementation of the policy cycle, the cornerstone of good governance, is a natural application space for ICTs, with its components: (i) generation of data and information (ii) analysis of data and information and generation of advice (iii) decision-making (iv) implementation and (v) review and evaluation (Berry and Tietze, 2011). Within an ecosystems approach to fisheries management, ICTs offer an unparalleled opportunity to link data sets of disparate component systems and to perform rich analytics, visualisations and programmatic automations. Figure 5 provides some examples of the strategic use of contemporary ICTs in the policy cycle.

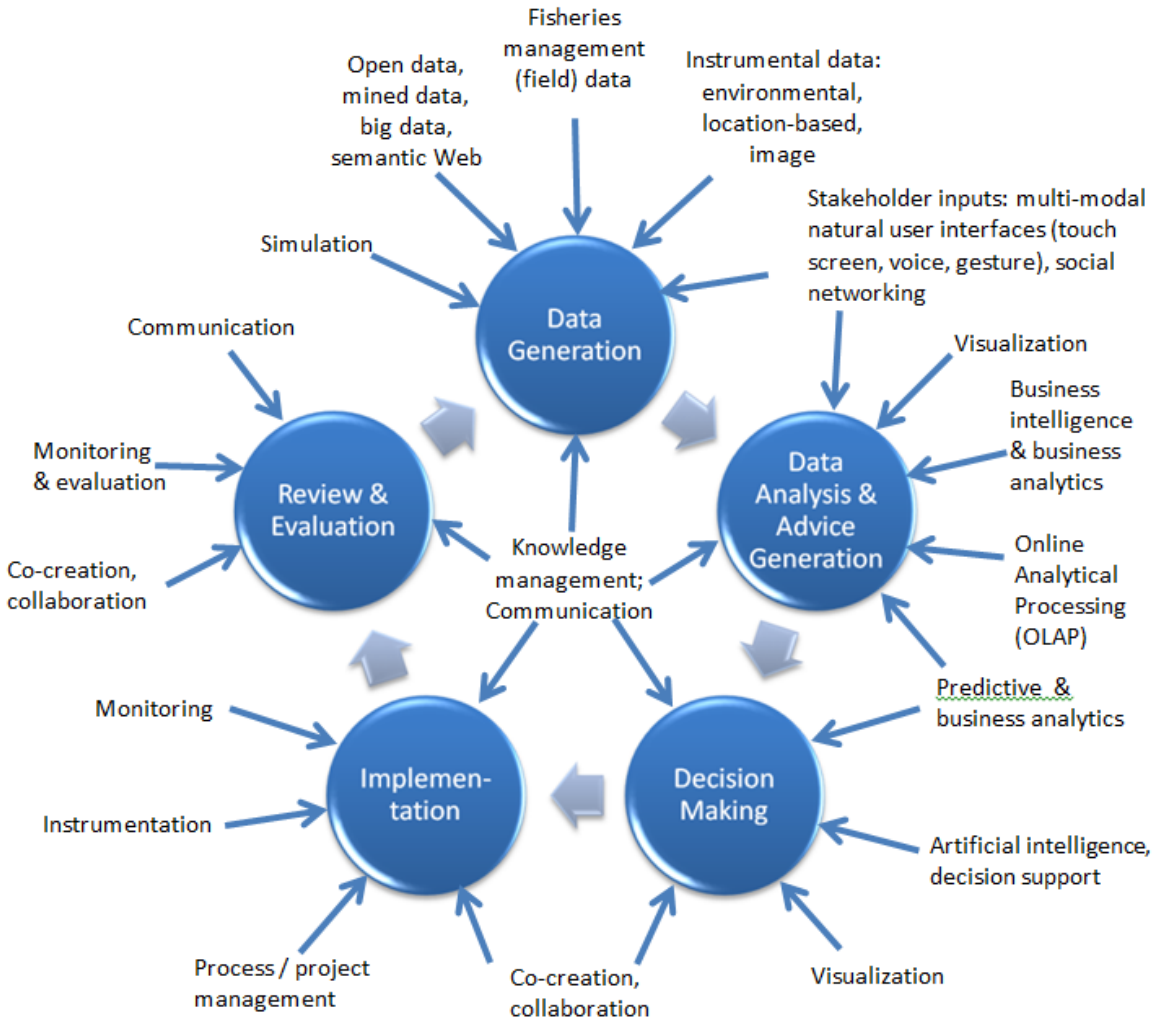

Figure 5: Application of ICTs in policy cycle

The strategic application of ICTs also has powerful potential for the longitudinal alleviation of poverty through a deliberate pathway to social inclusion and equity via progressive, context-appropriate ICT support up the vertical value chain. Mallalieu and Rocke (2011) provide a systematic approach through the use of the Percolator model as a framework to guide the selection of technological intervention solutions. The model comprises three domains: the broad contextual or "Base" Domain, the User Domain and the Technology Domain. The Base Domain loosely defines the

scope of livelihoods that are compatible with national or provincial developmental objectives and are realistic in a particular political and cultural setting. The User Domain defines technical requirements that derive from the attributes ascribed to information and communications in the context of traditions of abilities and interaction as well as from sectoral objectives, where such exist. The Technology Domain defines the set of ICT solutions, from among the available set of information and communications technologies, which are suited to the physical context of particular communities and which are constrained by the technical requirements that have percolated up the two underlying domains.

9. Conclusion

Kaplinsky and Morris (2002) emphasised the importance of incorporating a knowledge-based, information systems and communications focus in value chains. In excess of 10 years on, ICT capabilities have substantially advanced in functionality, power, scope, performance and adoption. Yet, the small-scale fisheries sector around the world has failed to apply ICTs for transformative gain in the value chain. Chief among the reasons for this are:

1) Small-scale fisheries value chains are very different from those of large-scale enterprise value chains. In particular, the activities of small-scale fishers are typically handed over from independent agent to independent agent, outside of a single, overarching institutional enabling environment. Each small-scale agent often manages a disparate set of activities such as gear procurement, maintenance, fishing and sales. There is thus little room for specialisation and the efficiencies that accrue therein for larger scale enterprises (Porter, 2002). Many of the traditional foundations of value chain analysis are thus inappropriate for small-scale fisheries.
2) The economic accounting associated with primary activities in the value chain, which has typically been the focus of value chain analyses, is inadequate to reveal the fundamental gaps and opportunities in the vertical small-scale fisheries value chain, necessary for transformational improvements across and in the ecosystem. Models and methodologies to support context-appropriate value chain analysis are required.
3) The demographics of small-scale fishers in different ACP jurisdictions are varied and therefore solutions applicable to one jurisdiction are not necessarily suited to another. Although small-scale fisheries is often associated with low-income earners and the informal sector, many ACP small-scale fishers own and make regular use of radio, television and)mobile phones. In Trinidad and Tobago, many fishers now own smartphones, have access to computers and the internet, and have at least a primary school education. Yet in other ACP countries, such as Ghana, there are areas where non-literacy rates among fishers are very high (McKay 2003).
4) The penetration into the vertical value chain for small-scale fishers in ACP countries is generally shallow. Strategic interventions require the establishment of intermediary organisational, process and information systems before they can take root. The ICT applications currently available to ACP countries address these areas separately. Contemporary ICTs offer the capability to affect unbroken threads from each activity up to fifth-order, strategic, enablers. Contemporary ICTs in particular offer the full gamut of capabilities to acquire, aggregate, access, analyse, visualise and apply information, data and knowledge in an iterative growth path of the policy cycle, as depicted in Figure 5. They also have the capability to engage with users in a way

that is as natural and intuitive as using a familiar appliance such as a television or a traditional phone.

5) In contrast to the historical treatment of ICTs which have often been applied in support of specific activities, with emphasis on the horizontal value chain, contemporary and emerging technologies lend themselves to integration up the vertical value chain, while providing linked support to all activities in the horizontal value chain. Fisheries management,

   the integrated process of information gathering, analysis, planning, consultation, decision-making, allocation of resources and formulation and implementation, with enforcement as necessary, of regulations or rules which govern fisheries activities in order to ensure the continued productivity of the resources and accomplishment of other fisheries objectives (FAO, 1997)

   is natural for the vertical application of ICTs but there has been little attention to this integration in the design of ICT solutions.

6) A key barrier is the perception that ICT is simply a tool that will magically solve problems whose solutions are not well articulated. In fact, like all technologies, responsible ICT interventions are designed on the basis of structured requirements specifications, which call for the considerable engagement of multiple stakeholders. As many of these solutions are context-specific and are not well established, most profit can be gained by integrally including software architects, developers and systems engineers in the strategic planning and operations of the small-scale fisheries enterprise, from catch to consumption; and from activity to strategy and back.
7) Strategic ICT intervention requires that ICT and other complementary disciplines are consistently embedded in the development cycle. A specific programme of ICT interventions is most profitably designed according to a set of strategic and operational objectives. In the case of small-scale fisheries, there is no single defining set of either, due to the different priorities of the many stakeholders with competing interest in the fisheries resource. This amplifies the need for early, multi-disciplinary embeddedness in intervention planning.
8) Rejuvenation of the small-scale fisheries sector with its complex interdependencies and rich ecosystem is not an easy, mechanical or even technical challenge. The integration of ICTs in the small-scale fisheries sector requires the development of various cognitive and skills-based capacities, as well as the formation, refinement and authentic ownership of new attitudes and behaviours. It calls for the human systems to be established to, in turn, articulate the various processes that in concert, aggregate to achieve bold, meaningful and consensual outcomes. Technology cannot take the place of collaboration, engagement and negotiation, and can do little to take the place of time. Technology cannot provide a solution to the fundamental challenges, which limit participatory governance in fisheries anywhere in the world, far less in ACP countries. It can only be as good as its human partners who must plan, design, implement and nurture the sector, its agents and its growth.
9) The path to sector rejuvenation is necessarily a slow but is an entirely achievable one. It requires the deliberate commitment to build the capacities, shared understandings and negotiated agreements of strategists, managers, fishers, application developers and other sectoral and development agencies.

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