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SERIES L: ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

Information and communication technology and adaptation of the fisheries sector to the effects of climate change

Recommendation ITU-T L.1505

ITU-T

ITU-T L-SERIES RECOMMENDATIONS

ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

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Recommendation ITU-T L.1505

Information and communication technology and adaptation of the fisheries sector to the effects of climate change

Summary

Climate change will affect both fish stocks and their habitats. Rising or falling temperatures will influence the abundance, migratory patterns and mortality rates of wild fish stocks and determine what species can be farmed in specific regions. Climate change can lead to changes in the volume of water in rivers and lakes. The composition of water bodies can affect the species and quantities of fish stocks. These climatic effects on fish stocks will have social and economic consequences for people dependent on fisheries and aquaculture ranging from fisheries workers to coastal communities as well as to the consumers of fish.

Recommendation ITU-T L.1505 includes a review of the effects of climate change on fisheries and fishing communities. It recognizes the need for adaptation and for the use and dissemination of relevant innovative techniques. It explores adaptation plans and the potential role of information and communication technologies (ICTs) in supporting the adaptation of the fisheries sector to cope with the effects of climate change.

History

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FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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Introduction

Climate change will affect both fish stocks and their habitats. Warmer or cooler temperatures will influence the abundance, migratory patterns and mortality rates of wild fish stocks and determine what species can be farmed in specific regions. Climate change can lead to changes in the volume of water in rivers and lakes. The composition of a body of water can affect the species and quantities of fish present. These climatic effects on fish will have social and economic consequences for people dependent on fisheries and aquaculture ranging from fisheries workers to coastal communities as well as to the consumers of fish [b-OECD].

The purpose of this Recommendation is to:

– Offer useful information to decision makers concerning areas of possible adaptive action using ICTs in both developing and developed countries in relation to climate change and the fisheries industry.

– Describe state-of-the-art ICT applications and systems, in addition to hybrid systems where traditional means of dealing with climate change adaptation effects are used hand-in-hand with new technologies in order to reach large and small-scale fishermen and other actors in the fisheries sector speedily and at minimum cost.

– Provide examples of success stories of the adoption of ICTs usage to adapt the fisheries sector to the events of climate change in order to bring general awareness for possible adoption by others.

Facilitate understanding of the role of ICTs in the fisheries sector for adaptation to climate change, paving the way for the adoption of ICTs to develop climate-smart fisheries, in particular achieving increased productivity and enhanced the resilience of small-scale fishermen despite the events of climate change.

Recommendation ITU-T L.1505

Information and communication technology and adaptation of the fisheries sector to the effects of climate change

1 Scope

This Recommendation includes a review of the effects of climate change on fisheries and fisheries communities. It recognizes the need for adaptation and for the use and dissemination of relevant innovative techniques. It explores adaptation plans and the potential of ICTs in supporting the adaptation of the fisheries sector to cope with the effects of climate change with reference to [ITU-T L.1500] and [ITU-T L.1501]. Examples of best practices from different countries on the use of ICT systems and tools to adapt the fisheries sector are also provided in this Recommendation.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T L.1500] Recommendation ITU-T L.1500 (2014), *Framework for information and communication technologies and adaptation to the effects of climate change*.

[ITU-T L.1501] Recommendation ITU-T L.1501 (2014), *Best practices on how countries can utilize ICTs to adapt to the effects of climate change*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 climate change [ITU-T L.1500]: Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity. The Intergovernmental Panel on Climate Change (IPCC) uses a relatively broad definition, referring to a change in the state of the climate that can be identified (e.g., using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forces, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

The IPCC makes a distinction between climate change that is directly attributable to human activities, and climate variability that is attributable to natural causes. For the purposes of this report, either definition may be suitable depending on the context of the analysis.

3.1.2 climate change adaptation [ITU-T L.1500]: Adaptation to climate change can be defined as the adjustment in ecological, social or economic systems in response to actual or expected climatic stimuli and their effects. It refers to changes in processes, practices and structures to moderate potential harm or benefit from opportunities associated with climate change.

3.1.3 food security [b-WHO 2001]: Food security is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

3.1.4 vulnerability to climate change [b-IPCC]: Degree to which a system is susceptible to injury, damage, or harm (one part – the problematic or detrimental part – of sensitivity).

3.1.5 climate variability [b-WMO]: Variations in the mean state and other statistics of the climate on all temporal and spatial scales, beyond individual weather events.

NOTE – Variability is the range of climate compared to its average. The fluctuations comprising climate variability can influence patterns of rainfall, temperature and other variables on timescales anywhere from a few weeks to a few decades.

3.1.6 climate change mitigation [b-UNEP]: Efforts to reduce or prevent emission of greenhouse gases.

NOTE – Mitigation can mean using new technologies and renewable energies, making older equipment more energy efficient, or changing management practices or consumer behaviour.

3.1.7 aquaculture [b-Indian University]: Farming fish and other aquatic organisms.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

EWS Early Warning System

FFMA The Fisher Friend Mobile Application

FFP The Fisher Friend Programme

GHG Greenhouse Gas

GIS Geographic Information Systems

ICT Information and Communication Technology

PFZ Potential Fishing Zone

5 Conventions

None.

6 Impacts of climate change on the fisheries sector

6.1 Ecosystem impacts

Climate change is having both physical and biological impact on ecosystems by modifying the distribution of marine and freshwater species. In general, warm-water species are being displaced towards the poles and are experiencing changes in the size and productivity of their habitats. In warmer parts of the world, ecosystem productivity is likely to be reduced in most tropical and subtropical oceans, seas and lakes and increased in high latitudes. Increased temperatures will also affect the physiological processes of fish, resulting in both positive and negative effects on fisheries and aquaculture systems depending on the region and latitude.

Climate change is already affecting the seasonality of particular biological processes, altering marine and freshwater food webs with unpredictable consequences for fish production. Increased risks of species invasions and the spreading of vector-borne diseases are additional concerns. Differential warming between land and oceans and between polar and tropical regions will affect the intensity, frequency and seasonality of climate patterns (e.g., El Niño) and extreme weather events (e.g., floods, droughts and storms).

These events will impact the stability of related marine and freshwater resources. Sea level rises, glacier melting, ocean acidification and changes in precipitation, groundwater and river flows will significantly affect coral reefs, wetlands, rivers, lakes and estuaries such as Chesapeake Bay in

Maryland. The bays surrounding the boroughs of New York City are also estuaries. San Francisco Bay in California and Lake Pontchartrain in Louisiana are other examples of large, developed estuaries requiring adaptive measures to exploit opportunities and minimize impacts on fisheries and aquaculture systems.

6.2 Impacts on livelihoods

Changes in distribution, the composition of species and habitats will require changes in fishing practices and aquaculture operations, as well as in the location of landing, farming and processing facilities.

Extreme events will also have an impact on the infrastructure, ranging from landing and farming sites to post-harvest facilities and transport routes. They will also affect safety at sea and settlements, with communities living in low-lying areas at particular risk. Water stress and competition for water resources will affect aquaculture operations and inland fisheries production and are likely to increase conflicts among water dependent activities.

Livelihood strategies will have to be modified, for example, with changes in fishers' migration patterns due to changes in the timing of fishing activities. Reduced livelihood options inside and outside the fisheries sector will force occupational changes and may increase social pressures. Livelihood diversification is an established means of risk transfer and reduction in the face of shocks, but reduced options for diversification will negatively affect the outcomes of livelihoods.

There are particular gender dimensions, including competition for resource access, risk from extreme events and occupational changes in areas such as markets, distribution and processing, in which women currently play a significant role. The implications of climate change affect the four dimensions of food security as follows:

- the availability of aquatic foods will vary through changes in habitats, stocks and species distribution;
- the stability of supply will be impacted by changes in seasonality, increased variance in ecosystem productivity and increased supply variability and risks;
- the access to aquatic foods will be affected by changes in livelihoods and catching or farming opportunities; and
- the utilization of aquatic products will also be impacted, for example, some societies and communities will need to adjust to species not traditionally consumed [b-FAO, 2009].

6.3 Economic impact on people

Countries in Central and Western Africa (e.g., Malawi, Guinea, Senegal and Uganda), North-Western South-America (Peru and Colombia) and four tropical Asian countries (Bangladesh, Cambodia, Pakistan, and Yemen) were identified as most vulnerable. This vulnerability is due to the combined effect of predicted warming, the relative importance of fisheries to national economies and diets and limited societal capacity to adapt to potential impacts and opportunities. Many vulnerable countries are also among the world's least developed countries whose inhabitants are among the world's poorest and who are twice as reliant on fish, which provides 27 per cent of dietary protein compared to 13 per cent in less vulnerable countries. These countries also produce 20 per cent of the world's fish exports and are in the greatest need of adaptation planning to maintain or enhance the contribution that fisheries can make to poverty reduction. [b-Wiley]

7 Climate change adaptation measures for the fisheries sector

Table 1, adapted from [b-FAO, 2014], shows climate change adaptation measures for the fisheries sector.

Table 1 – Climate change adaptation measures for the fisheries sector

Impact	Adaptation measure
Reduced yields	• Access higher-value markets • Increase fishing effort (risks overexploitation) • Shift aquaculture to non-carnivorous commodities • Selective breeding for increased resilience in aquaculture Moving/planning siting of cage aquaculture facilities • Change aquaculture feed management: fishmeal and fish oil replacement; find more • Appropriate feeds • Migration as fish distribution changes (risks overexploitation) • Research and investments into predicting where fish populations will move to (risks overexploitation) • Improve water-use efficiency and sharing efficacy (e.g., with rice paddy irrigators) in aquaculture • Aquaculture infrastructure investments (e.g., nylon netting and raised dykes in flood-prone pond systems)
Increased yield variability	• Diversify livelihood portfolio (e.g., algae cultivation for bio fuels or engage in non-fishery economic activity such as ecotourism) • Precautionary management • Ecosystem approach to fisheries/aquaculture and adaptive management • Shift to culture-based fisheries • Shift to propagated seed for previously wild-caught seed stocks (higher cost)
Reduced profitability	• Diversify livelihoods, markets and/or products • Exit fishery • Reduce costs to increase efficiency • Change aquaculture feed management • Shift to culture-based fisheries
Increased risk	• Adjustments in insurance markets • Insurance underwriting • Weather warning systems • Improved communication networks • Workshops to teach data gathering and interpretation • Monitoring of harmful algal blooms where molluscs farmed • Improved vessel stability/safety • Compensation for impacts
Increased vulnerability for those living near rivers and coasts	• Hard defences (e.g., sea walls) (risks affecting local ecosystem processes and/or local livelihoods) • Soft defences (e.g., wetland rehabilitation or managed retreat) (risks affecting local livelihoods) • Early warning systems and education • Rehabilitation and disaster response • Infrastructure provision (e.g., harbour and landing site protection, building aquaculture facilities to withstand increased storm damage) • Post-disaster recovery • Encourage native aquaculture species to reduce impacts if fish escape damaged facility

8 The eco-system of the fisheries sector to be involved in adaptation

The eco-system of the fisheries sector has many stakeholders: e.g., fishermen, fisheries communities, scientists, policy makers, extension officers, private sectors, non-profit organizations, laboratories, field-workers, market research institutes, management professionals, input suppliers, technical experts, self-help groups, government, etc.

Constraints in information and knowledge transfer may include content appropriateness, literacy, digital literacy, skill sets, digital scepticism, age-related, etc. Content appropriateness may also depend upon whether information is intended for the wider area or for the local level. The format in which it is delivered and livelihood priorities may also impact content appropriateness. There may be a requirement for forecasting, modelling and making projections. Adaptation and mitigation strategies may also require information concerning fisheries practices, resources and processes, as well as output processes.

In the context of fisheries, often characterized by poverty, remoteness and marginalization, ICTs can enable new responses to the challenges posed by more frequent and intense climatic events. ICTs can become a strategic enabler of action to create awareness to mitigate, monitor and adapt to climate change within fisheries. ICTs can also help in the adoption of innovative strategies based on emerging and traditional knowledge and information tools.

9 Trends in ICTs which are relevant to the fisheries sector

Recent increases in ICT affordability, accessibility and adaptability have resulted in their use even within rural homesteads relying on fisheries. Many of the information needs that could improve smallholder livelihoods can be fulfilled with the effective and easy use of ICTs, facilitated by the proliferation of innovations including small devices such as mobile or smart phones and infrastructure such as cloud computing facilities.

The following trends have been the key drivers of the use of ICTs in the fisheries sector, particularly for fishermen or producers:

- Low-cost and pervasive ICT connectivity;
- Adaptable and more affordable tools;
- Innovative business models and partnerships;
- The democratization of information, including the open access movement and social media;
- Access to information relevant to fisheries weather forecasts, marketing information, etc.

10 ICT components which are relevant to the fisheries sector

The following are frequently used ICT components in the agricultural sector that can also be applied to the fisheries sector:

- ICT systems: Data storage, computational resources.
- ICT network: Communication networks, fixed line networks, mobile networks and satellite networks for data acquisition and knowledge dissemination.
- ICT media types: Audio, video, text, image.
- ICT applications: Data analytic models, expert systems, forecasting models, early warning systems.
- ICT tools: Blogs, discussion forums, RSS feeds, social networking, spatial geo-tagging tools, online training, crowd sourcing, mobile Apps.
- ICT end-user devices/access points: Mobile feature phones, mobile smart phones, PCs, community Internet access points, e.g., touch kiosks.
- IoT devices: Wireless sensor networks, smart phones, etc.

- ICT device features: Personal information management tools, e.g., calendar, reminder, etc.

11 How can ICTs help sustain the fisheries sector in the events of climate change

11.1 ICT to monitor site condition

Among the various ICT possibilities, geographic information systems (GIS) represent a key tool for decision support for fishermen to make informed decisions about their own personal safety and the safety of their boats, as well as to make smart choices for fishing and marketing their catch.

GIS provides fishermen with immediate access to critical, near real-time knowledge and information services on weather, potential fishing zones, ocean state forecasts and market related information [b-FFMA]. Examples of how monitoring site conditions using ICTs can help sustain the fisheries sector are given in Appendices I to IV.

11.2 ICTs to promote knowledge sharing and improve management

Internet and community radio can be used to create awareness and provide access to content on fisheries codes (e.g., code of conduct for responsible fisheries) and regulations, as well as information on aquaculture management in different climatic conditions (e.g., feeding practices, selection of stock, etc.). Also, scientific information on water parameters in tanks, feed supply, shrimp growth, for example, and atmospheric conditions can be provided to aqua farmers through ICTs [b-NICCD]. Examples of how knowledge sharing using ICTs can help sustain the fisheries sector are given in Appendix III.

11.3 ICTs to predict weather and types of fish-catches

ICTs are increasingly being used to ensure safety at sea. Fishermen can have access to up-to-date weather information through community radio stations, loudspeakers and tele centres collecting and broadcasting information before setting out. Mobiles and radios also allow better communication with other boats and the shore [b-FAO].

In addition, improvements in the design of fishing equipment through the implementation of ICTs can increase the selectivity of the gear with the aim of catching only the preferred size and the right quality of the target species (selective catch). ICTs can help with the design of the equipment as well as its day-to-day operations [b-NORDEN, 2009]. Examples of how ICTs are used to predict weather and types of fish-catches are given in Appendix II.

11.4 ICTs for forecasting

Extensive weather station networks are needed for monitoring key climate parameters such as wind speed, precipitation, barometric pressure, soil moisture, wind direction, air temperature and relative humidity. These parameters may be used both for forecasting and for decadal climate modelling. The technologies needed include weather satellites and both local and remote automated weather stations. Similar to telecommunications networks, in general, there are logistical and financial problems to be overcome in order to achieve sufficient global coverage to collect the required data.

Satellite observations include visible spectrum cameras to detect storms and deforestation; infrared cameras to detect cloud cover and surface temperatures and sea level rises; particle detectors of solar emissions [b-WRI]. Examples of ICTs used for forecasting are given in Appendices I, II and IV.

11.5 ICTs for leveraging market realities

Good and timely knowledge is essential for competing in local and global markets. Information about prices and availability can be shared across value chains, increasing the power of smaller or otherwise disadvantaged groups while reducing the volatility of fish prices and wastage of fish.

Key ICTs are:

- Community or loudspeaker radio: price information received by a radio station or researched via specialist websites at a local telecentre is passed on to the community through established communication channels; and
- Mobile phones: provided there is network coverage, fishermen, buyers and traders communicate through voice calls, via SMS messages or by accessing specialist WAP services; the catch can be sold while still out at sea; buyers and processors can be informed of catch details before landing [b-FAO]. Examples of how ICTs are used for leveraging market realities are given in Appendices I and II.

11.6 ICTs for emergency/alert systems

ICTs can be used as warning systems to involve seismic and wave sensors, satellite links and relay centres that trigger sirens and radio and other alerts. At the local level, ICT equipment can be distributed together with boats and nets. Fishermen can then chart and report locations more securely using GPS and can communicate more easily to avert risks [b-FAO]. Examples of how ICTs are used for emergencies/alert systems are given in Appendix II.

11.7 ICTs for maritime boundaries

Fishermen can be warned by an alert when approaching within a few kilometres of international territorial waters. ICTs can be used to alert fishermen to steer clear from illegal entry of territorial waters or occupational hazards such as military training zones or submerged reefs, etc. In this way ICTs act to safeguard fishermen from potential international conflicts and distress at sea [b-FFMA]. Examples of how ICTs are used for maritime boundaries are given in Appendix II.

11.8 ICTs for efficient decision-making (example from Lake Victoria)

ICTs can enable access to user-friendly (e.g., using local languages, images and sound) regulatory content (e.g., policies, rights and obligations) that can help to inform decision making and management approaches, having an impact on fisheries productivity and sustainability.

ICTs can support institutions in the process of assessing available information (e.g., regarding vulnerability, climatic impacts, adaptive practices, etc.) in order to inform decision-making processes. Tools such as Internet-based platforms, mobile phones, radio and e-mail can enable open consultation processes to assess vulnerabilities, identify priorities and adaptation practices and systematize information gathered at the local level. ICT-enabled models and projections can help institutions to identify and assess current and future climatic risks [b-NICCD]. Examples of how ICTs are used for efficient decision-making are given in Appendix IV.

11.9 Technology for high-accuracy fuel efficiency estimation

The development of technology that uses analysis of ship-related big data to estimate fuel efficiency, speed and other performance in actual sea conditions, to a highly accurate margin of error of less than 5 per cent has been recently announced.

This newly developed technology utilizes a massive volume of measurement data gathered while the ship is underway, including sensor data of meteorological and hydrographic conditions such as wind, waves, and ocean currents, ship engine log data and data about the speed and position of the ship. By applying the results of this research, it was demonstrated that it could improve fuel efficiency by about 5 per cent when compared to previous results, with ships that navigate the shortest shipping routes.

With this technology, it is possible to accurately estimate a ship's performance in actual sea conditions, which previously had a large margin of error. The technology enables the evaluation of ship performance, design feedback, and significant improvements in fuel efficiency when used in ship navigation.

Examples of how the technology is used for high-accuracy fuel efficiency estimation through a ship's operational data is given in Appendix V.

Table 2 shows ICT tools, functions and benefits for fishermen [b-African Journal].

Table 2

ICT tools	Functions/benefits
GPS	Marking the areas of the fish location, GPS can assist fishermen to return to exactly the right place night or day. GPS provides information such as latitude, longitude, altitude, surface speed, sunrise and sunset times, odometer and accuracy warning system.
Sonar	Using sonar, fishermen can immediately get a complete, up to date, available map of the whole fishing area showing the exact location, extent, density, depth, movement, species and size of all fish shoals. In addition, information regarding sea bottom such as depth, contours, slopes and composition (rocky, sandy, muddy, etc.) can easily be attained.
Wireless set (VHF radio)	Radio (VHF) enhances security aspects for fishermen. If anything happens to them at sea they can communicate with other vessels and the responsible agencies so that immediate action can be taken. In addition, they can immediately share information regarding the fishing spots with the others. Moreover, using radio they can negotiate a better price with the dealer even when they are still at sea.
Computer	For record purposes (example: profit and loss, species caught, weather condition, markets, etc.).
Internet	Internet can be used to search for, disseminate and share fisheries related information such as market prices, online applications, weather conditions, professional advice, loan services, business opportunities, etc. among/between colleagues and related agencies.
Mobile phone	Mobile phones can be used to search for, disseminate and share fisheries related information such as market prices, online applications, weather conditions, professional advice, loan services, business opportunities, etc., among/between colleagues and related agencies. Moreover, using mobile phones they can negotiate a better price with the dealer even when they are still at sea.

Appendix I

SayadTec application to adapt to climate change effects in the fisheries sector

(This appendix does not form an integral part of this Recommendation.)

I.1 Introduction

For some countries and communities, the percentage of aquatic foods account for up to 50 per cent of animal protein in some small island states. The sector employs 43.5 million people, many of these in developing countries and the processing, marketing, distribution and supply industries associated with fishing and aquaculture employ up to another 200 million people [b-FAO, 2014].

Climate change will affect fisheries and aquaculture in ways such as acidification, changes in sea temperatures and circulation patterns, the frequency and severity of extreme events and sea-level rises and associated ecological changes. Both direct and indirect impacts include impacts on targeted populations' range and productivity, habitats and food webs as well as impacts on fisheries and aquaculture costs and productivity and livelihoods and safety of fishing communities.

Approaching climate change typically involves actions that either reduce the amount of carbon dioxide and other greenhouse gases (GHGs) in the atmosphere or that prepare society for the impacts associated with climate change via adaptation. Adaptation can be planned or it can be autonomous (i.e., spontaneous reaction to environmental change or planned action based on climate-induced changes). Autonomous adaptation in fisheries may include changing the timing or locations of fishing as species arrive early/late or shift to new areas. Planned adaptation in fisheries may include research funding for finding species resistant to salinity and temperature fluctuations for aquaculture.

Adaptation in fisheries and aquaculture can include a variety of policy and governance actions, specific technical support or community capacity building activities that address multiple sectors rather than just capture fisheries or aquaculture farmers. ICTs play a major role in adaptation in fisheries, including sonar applications for locating fish, global positioning systems (GPS) for navigation and location finding, radio programming with fishing communities, Web-based information and networking resources, etc.

In response to these impacts and in order to help the fisheries sector in Egypt to adapt to climate change impacts, The Egyptian National Authority for Remote Sensing & Space Sciences (NARSS), and the General Authority for Fish Resources Development (GAFRD), in cooperation with the information technology institute developed the SayadTec application to adapt to climate change effects in the fisheries sector.

I.2 SayadTec system description

SayadTec is intended to help fishermen in the Gulf of Suez to gain pre-fishing knowledge in order to increase their productivity, efficiency and income using ICTs services.

SayadTec aims to provide the following information:

- Finding fishing hot spots obtained through analysis on real time satellite images with coordinates (longitude and latitude).
- Detecting current location and informing fishermen of the nearest fishing spot and weather conditions on a daily basis utilizing GPS.
- Service broadcasting that warns fishermen about any sudden changes in weather.

The system has two interfaces: a website interface and a mobile interface.

I.3 SayadTec system modules

As shown in Figure I.1, the SayadTec system has seven modules; these modules are briefly described in clauses I.3.1 to I.3.7.

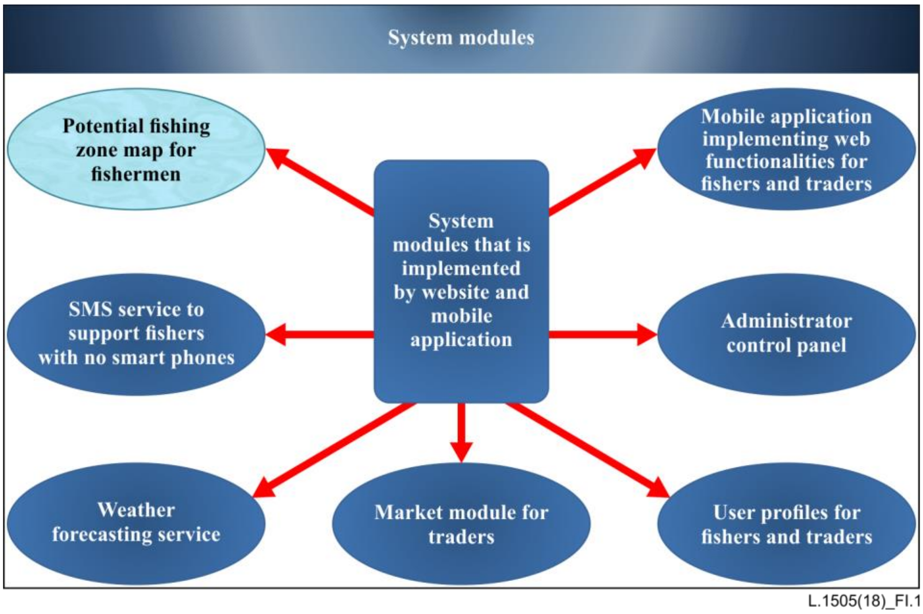


Figure I.1 – System modules of the SayadTec application

I.3.1 SayadTec website services

The SayadTec website provides maps that present fishing spots along the Egyptian coastline with coordinates (longitude and latitude), see Figure I.2.

Figure I.2 – Example of fishing spots mapping

I.3.2 SayadTec SMS service

SayadTec includes a daily SMS service to provide information to a wide range of fishermen (including those who do not possess smart phones). An example of a SayadTec SMS is shown in Figure I.3.

Figure I.3 – Snapshot of SMS services provided by SayadTec

I.3.3 SayadTec weather forecast service

SayadTec provides a ten day weather forecast according to the current detected location, see Figure I.4.

Figure I.4 – Sample of weather forecast by SayadTec

I.3.4 SayadTec market module for traders

SayadTec proposes an interactive interface between fishermen and traders, see Figure I.5.

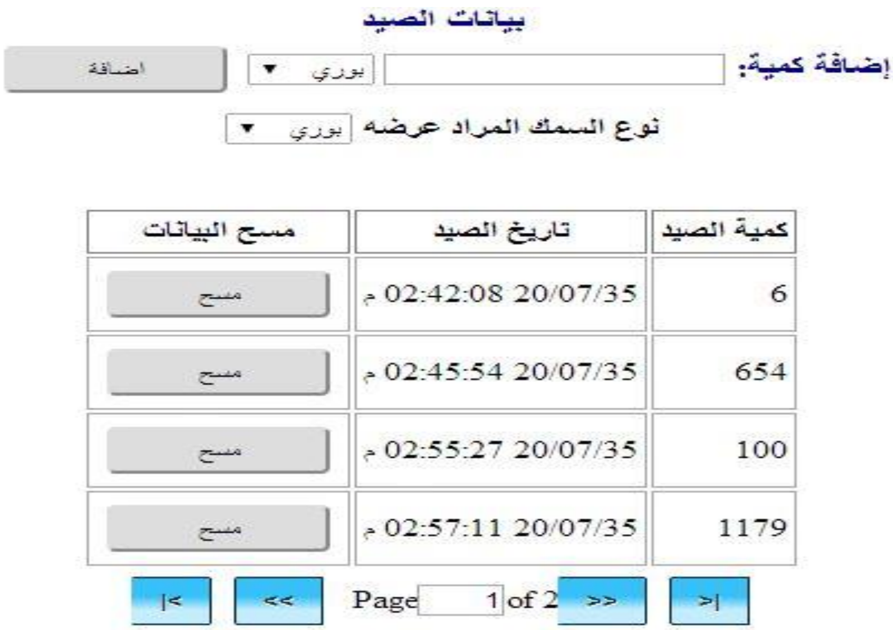
Figure I.5 – The interactive interface between fishermen and traders in Arabic

I.3.5 SayadTec user profile for fishermen and traders

SayadTec provide a user profile for fishermen and traders that contains data on:

- fishermen's catches;
- data of suspended deals to be accepted or rejected; and
- data on trading history.

Examples (web and mobile views) of the SayadTec application for user profiles for fishermen and traders are shown in Figure I.6.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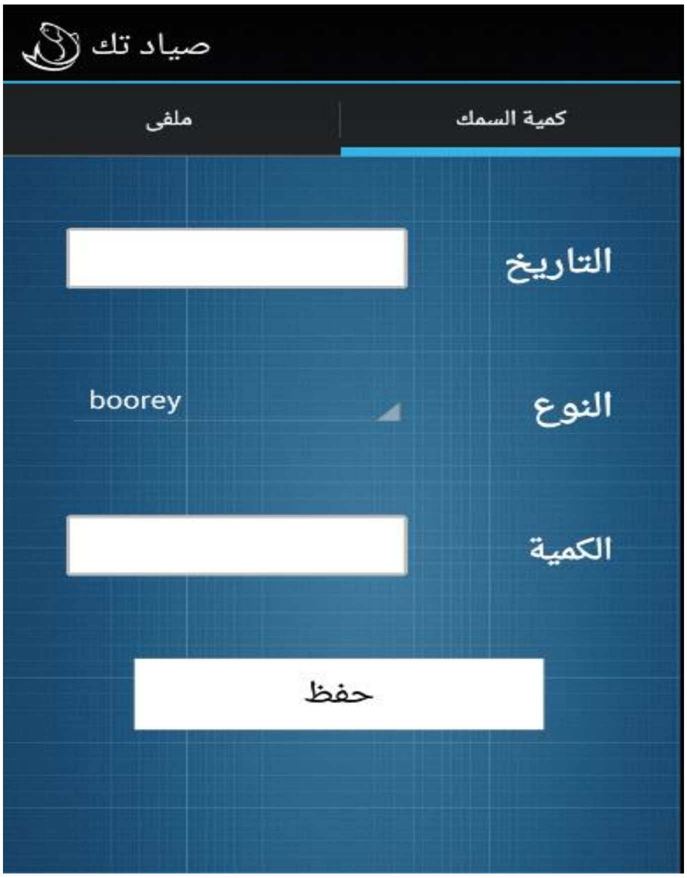
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Figure I.6 – User profiles for fishermen and traders (web and mobile view) in Arabic[1]

I.3.6 SayadTec administrative control panel

SayadTec uploads Excel sheets that contain satellite and geographic data broadcasts and emergency SMSs to all subscribers.

I.3.7 SayadTec mobile application implementing web functionalities

SayadTec uses GPS to inform users of their current location and to indicate the nearest fishing spot and local weather conditions on a daily basis.

I.4 Technologies and tools

As SayadTec is a Net project, Microsoft products are mainly used, namely:

- Visual studio 2013;
- SQL server 2012;
- Windows Azure; and
- Titanium.

I.5 Future SayadTec developments

The following are the intentions of some future developments of SayadTec:

- Widen the covered area from the Gulf of Suez to the entire Red Sea and then the Mediterranean;
- Include freshwater zone in addition to seawater zones;
- Add the ability to detect fish types available in each spot;
- Extend market functionality to simulate a real world scenario; and
- Include reviews for fishing spots.

[1] Figures are intended to illustrate through snapshots how information is provided to fishermen in their local languages.

Appendix II

Fisher friend mobile application (FFMA)
A mobile application using ICTs to adapt to climate change effects in the fisheries sector

(This appendix does not form an integral part of this Recommendation.)

II.1 Introduction

Fishing communities are among the poorest, most vulnerable and isolated communities of India. Their social exclusion due to geographical separation and cultural isolation contributes to poverty. The fishermen and women witness declining trends of livelihood security, increasing poverty and vulnerability leading to competition between various fishing systems, over exploitation and depletion of marine resources. Climate change and the rapid pace of development have put these vulnerable communities at high risk. Fishermen's lives are precarious, largely dependent on knowledge of the sea, weather and the markets for their lives and livelihoods.

The Fisher Friend Programme (FFP) developed by the M. S. Swaminathan Research Foundation (MSSRF) since 2009, helps as a robust, holistic intervention by protecting fishermen's lives and fishing assets from occupational hazards and by increasing the empowerment of their livelihoods. The programme underscores a shore-to-shore approach by acting as a fisherman's credible and accessible decision-making support system through every step of his daily fishing experience.

The FFP covers marginalized coastal communities in Tamil Nadu, Puducherry, Andhra Pradesh, Kerala and Odisha and operates in the English, Tamil, Telugu, Malayalam and Odiya languages. The entire southeast coastline was selected due to the diversity of needs, risks, vulnerability, disaster proneness and destruction of biodiversity.

II.2 FFMA system description

The fisher friend mobile application (FFMA) is a unique, single window solution for the holistic shore-to-shore needs of fishing communities, providing vulnerable fishermen with immediate access to critical, near real-time knowledge and information services on weather, potential fishing zones, ocean state forecasts and market related information.

The application is an efficient and effective decision support tool for actors in the fishing community to make informed decisions about their own personal safety and the safety of their boats, as well as smart choices relating to the fishing and marketing of their catch.

FFMA was developed on an android platform in partnership with Wireless Reach Qualcomm and Tata Consultancy Services and is currently available in English, Tamil, and Telugu.

II.3 FFMA system features

Clauses II.3.1 to II.3.9 briefly describe features of the FFMA application.

II.3.1 Potential fishing zones (PFZ)

Figure II.1 – GPS coordinates received on mobile

Using the potential fishing zones (PFZ) feature, fishermen receive GPS coordinates, as shown in Figure II.1, of large shoal concentrations through the PFZ advisories. Fishermen also receive in-season, species-specific advisories for high value fish which enable them to increase their incomes. PFZ helps fishermen to make informed decisions thereby minimizing expenditure of time, energy and fuel and boosts the fishermen's confidence of a good catch, even before setting out to sea.

II.3.2 Ocean state and weather forecast

Figure II.2 – Ocean and weather forecast feature on mobiles

The ocean state and weather forecast feature, as shown in Figure II.2, helps fishermen plan and control their fishing experience by protecting their lives and assets. When there are adverse weather conditions forecast, they stay ashore and their time can be gainfully employed in mending nets, avoiding possible threats to life and wasteful expenditures of fishing materials.

II.3.3 Global positioning system (GPS)

The GPS application, whether as a standalone device or as an application on a mobile phone or laptop computer, is an indispensable tool that assists fishermen in tracking the PFZ, reducing loitering time and fuel expenditure and recording navigation history. GPS also helps track sea routes and so helps fishermen return to shore safely, especially during turbulent and low visibility weather.

II.3.4 Danger zone alerts

FFMA crowd sources information from other sailors about marine hazards and makes this information available to fishermen to safeguard their lives and assets by providing warning of submerged dangers such as sunken ships, coral reefs, etc.

II.3.5 Disaster alerts

FFMA provides life-saving and timely disaster alerts about impending cyclones, tsunamis, etc. This information helps to protect fishermen and their assets.

II.3.6 Market realities information

Timely information about prevailing prices in landing centres aids fishermen in increasing their negotiating power and in leveraging market realities for their economic benefit.

II.3.7 Emergency contact numbers

Fishermen have immediate access to emergency contact numbers in case of maritime danger requiring immediate assistance.

II.3.8 International maritime border line (IBL)

Fishermen are warned by an alert when they arrive within 5 kilometres of an international territorial waters boundary. FFMA warns fishermen to steer clear of illegal occupational hazards and safeguards them from international conflict and distress. The Indian National Centre for Ocean Information Services (INCOIS) provides the scientific data while the Indian Coast Guard provides the IBL coordinates.

II.3.9 Other services

Other services such as news alerts, information on government schemes and subsidies, training programmes, latest information on technological innovations, etc. are provided to the fishermen on a regular basis, allowing them access to a range of knowledge services.

II.4 Impact of FFMA summary

The following gives a summary of the impact of FFMA:

- Increased life safety and asset security
- Timely and informed decision-making
- Shore-to-shore risk reduction
- Increased fishing efficiency
- Increased efficiency in fishing and quantity of catch
- Increased bargaining power
- Personalized user experience through archived navigational history

II.5 Awards

Figure II.3 – Snapshots from the award ceremony for the FFMA

Fisher Friend Mobile Application of MSSRF won the mBillionth Award South Asia 2014 competing against 300 entries from nine South Asian countries under the category of m-Agriculture and Ecology, on 18 July 2014, at the India Habitat Centre, Delhi. mBillionth South Asia Awards is an initiative of the Digital Empowerment Foundation. The Digital Empowerment Foundation is a dedicated platform to recognize innovators who are socially empowering the lives of people through the use of ICTs and digital media tools. Jury comments: "It is remarkable to see the continued use of the fisher friend mobile application (FFMA), an application that supports one of the most vulnerable communities in India that earns its livelihood by venturing into the rough sea each day. The application has been used as a model by other countries such as Sri Lanka because of its positive impact."

Appendix III

mKRISHI fisheries

A mobile application using ICTs to adapt to climate change effects in the fisheries sector

(This appendix does not form an integral part of this Recommendation.)

III.1 Introduction to the mKRISHI Fisheries application

Fishing is the main occupation of the coastal population of India, stretching over 8,000 kilometres of coastline. Most of the fishermen still use traditional knowledge to catch fish. This is more or less a trial and error approach which leads to uncertainty in the catch and possibly heavy diesel consumption. About 1.2 per cent of global oil consumption is used in fisheries and it has been found that fishing is the main contributor to global warming in the fisheries industry. In the Indian coastal waters, sea surface temperature increased by 0.2 to 0.3 degrees Celsius between 1960 and 2005 and is projected to increase by a further 2 to 3.5 degrees Celsius by 2099. A decline in the fish catch and an increase in fuel rates are two major concerns for fishermen today. Due to a large and growing population and the low-lying coastline, the Raigad district of Maharashtra is considered vulnerable to the impacts of climate change. Though services such as potential fishing zone (PFZ) and wind advisory services are available, they do not reach the majority of the fishermen because the current dissemination of media through fax and electrically powered devices depends on an electricity network, which requires maintenance and skills to operate. The Raigad district, where this solution was implemented, is the most prone to electricity failure hence all the electronic devices regularly fail to operate. ICTs, specifically mobile phones and related applications have the potential to overcome these challenges and bridge the gap between rural fishermen and research institutes in the fisheries domain.

The mKRISHI Fisheries service is an initiative to empower fisheries communities by providing vital information services such as PFZ and wind speed and direction indicator applications on fishermen's mobile phones. PFZ information addresses their livelihood (by indicating where the fish are located) whereas wind speed and direction indicator applications address their safety concerns. The Indian National Centre for Ocean Information Services (INCOIS) analyses satellite images and provides a four-day forecast on PFZ and wind speed and direction four times a day. Fishermen leverage this information in almost real time to optimize their operations.

III.2 mKRISHI system description

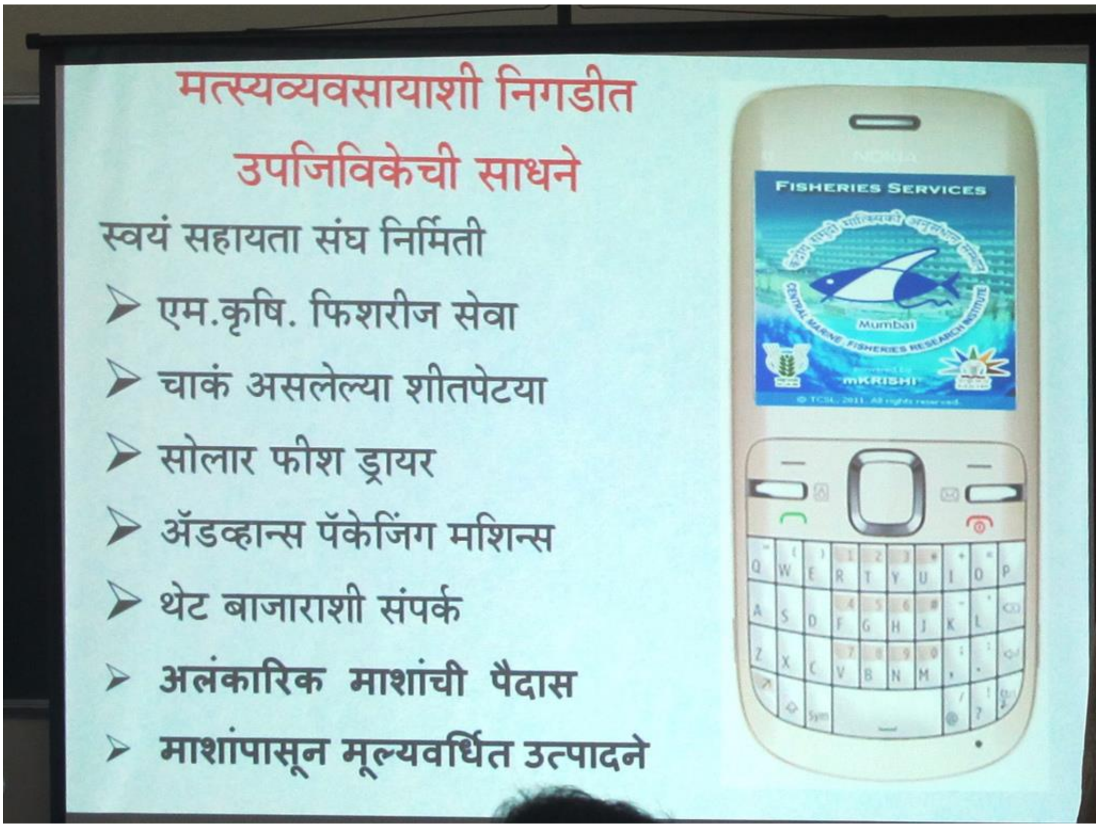

Figure III.1 – Information conveyed to fishermen

As shown in Figure III.1 by simply clicking a smart phone button, the mobile application will alert aquaculture farmers to cloud formation, rainfall and temperature forecasts, and in addition will provide guidance on measures to be taken to protect their stock.

The project, which was launched under the Digital India Programme on an experimental basis in Gujarat, will be extended across the country in three months.

Scientific information on water parameters in tanks, feed supply, shrimp growth and atmospheric conditions will be provided to aquaculture farmers by project experts.

To date aquaculture farmers have kept manual records, which do not provide up-to-date information to the aquaculture farmers on the latest trends in aquaculture. The mKRISHI Fisheries system will quickly help aquaculture farmers to become more confident.

The aquaculture farmer should have a smartphone with 2G, 3G or a Wi-Fi facility. Once details of his farm activity have been entered, the aquaculture farmer receives guidance from experts in graphical form. Do's and Don'ts and the best management practices will be provided in the form of texts, pictures and videos. The aquaculture farmer is also given information in the language of his choice.

In addition a mobile application on global shrimp prices, which was launched by the Ministry of Commerce and Industry recently, helps farmers follow the prices of shrimp varieties such as *L. Vannamei* and *Black Tiger* in the international markets through SMS messages.

Information on the latest international market trends is disseminated to aquaculture farmers through the Malaysia-based Infofish application. Helpfully the prices of shrimp varieties in Japan, Europe and US markets are sent to farmers in the form of the Indian Rupee currency.

III.3 Impact of the mKRISHI application

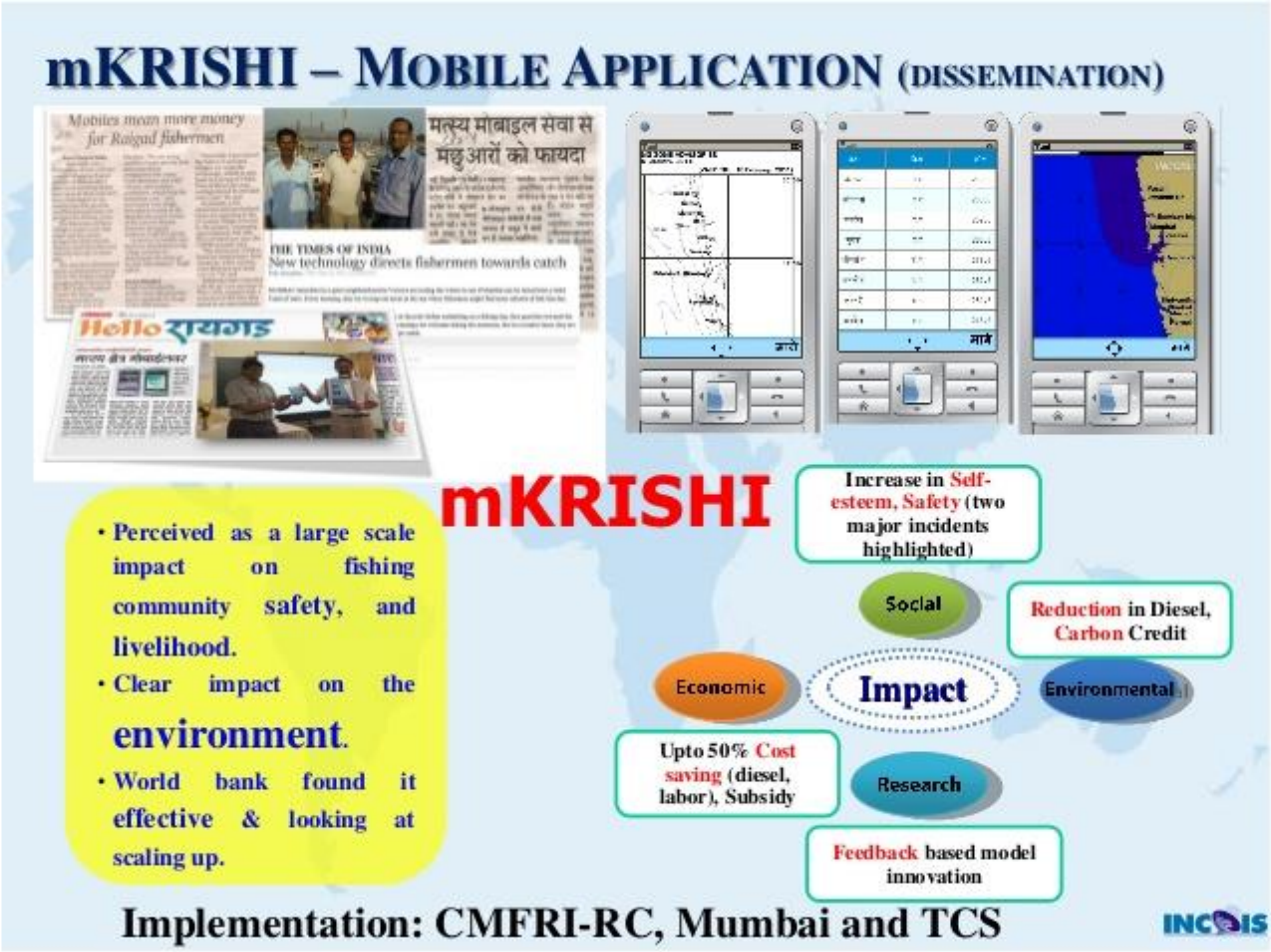

Figure III.2 – Dissemination plan of the mKRISHI application

The mKRISHI service was initially deployed in 13 fishing communities in the Raigad district on Maharashtra for about a year with participation from the Indian Government's Central Marine Fisheries Research Institute (CMFRI), the World Bank and Tata Consultancy Services (TCS). An analysis of the pilot data found that the fishing yield had improved by 30-40 per cent. Diesel consumption, wherever applicable, was reduced by 30-50 per cent. This resulted in a potential positive environmental impact. Expansion of services is currently being continued in 56 communities in the Raigad district.

Appendix IV

Localized weather alert service for fishing villages on Lake Victoria

(This appendix does not form an integral part of this Recommendation.)

The Uganda Department of Meteorology, the World Meteorological Organization (WMO), MTN, Ericsson, the National Lake Rescue Institute and the Kalangala fishing community have come together in a unique partnership combining mobile technology, weather forecasting and local know-how, to provide a localized weather alert service to fishing villages on Lake Victoria.

Mobile weather service

Mobile weather service improves safety of fishermen in Uganda and provide the following:

- Unique communications, meteorological and community partnership
- Information technology protects lives and livelihoods

WMO and Ericsson in partnership with MTN, Uganda Department of Meteorology and the National Lake Rescue Institute have made possible the delivery of daily weather forecasts and timely warnings in local languages. The service, still in its pilot phase, is being tested by over 1 000 fishermen in the Kalangala District of Lake Victoria. MTN, the Grameen Foundation AppLab Uganda and Ericsson together with the Uganda Department of Meteorology, are in the preparation stages of a wider service offer which will be made available for the entire Lake Victoria community in the next three months.

MTN Uganda, in partnership with Uganda Department of Meteorology will, upon completion of the pilot project, deliver the mobile service free of charge to MTN customers. The unique weather information service will enable fishermen and traders to make informed decisions on, for example, when and where to fish in Lake Victoria, thus helping to save lives and preserve livelihoods.

The pilot project involves training 19 fishing community representatives in a basic understanding of weather forecasts and how to respond to various alerts. Equipped with mobile phones, the community representatives then pass on their knowledge to fishermen and traders to sign up to the Mobile Weather Alert service. Thus far, the value of the Mobile Weather Alert forecast service is being repeatedly confirmed.

According to Foundation AppLab Uganda, of 200 fishermen using the Mobile Weather Alert service 96 per cent of the respondents said it has improved the safety of their lives.

Lake Victoria, the world's second-largest freshwater lake was chosen for the pilot project. Lake Victoria also provides a livelihood, directly and indirectly, to over 3.5 million people. The lake supports Africa's largest inland fishery and produces over 800 000 tons of fish annually, currently worth about USD 600 million and reported estimates indicate that as many as 5 000 members of the fishing community die in boating accidents in the lake each year because they are unprepared for bad weather conditions.

Michael Nkalubo, Commissioner for the Uganda Department of Meteorology said: "This is a real demonstration of the importance of meteorological expertise to our society. It has also provided the Uganda Department of Meteorology with valuable feedback on the reliability of our forecasts for the very localized conditions on Lake Victoria. In future we hope to be able to extend the Mobile Weather Alert project to other fishing communities and to farmers and other community sectors as part of a wider effort to improve the reliability and reach of severe weather forecasting."

MTN is excited about the pilot project and indeed this partnership, as it allows us to use mobile technology to further touch our communities in a way that brings about socio-economic change to their daily lives. We also believe that the pilot project holds great long-term benefits for the fishing community in the Lake Victoria region and the rest of the continent. Although it forms part of our corporate social investment, this initiative is integral to our continued efforts to find innovative mobile solutions that support the growth of agriculture and small-medium enterprises in emerging markets.

Mary Power, Director of Resource Mobilization at WMO, said "Severe weather and climate events account for almost 90 per cent of natural disasters and related losses of life and property globally. Establishing and sustaining early warning systems (EWS) in places vulnerable to these events, such as Lake Victoria, where low incomes and marginal living conditions increase people's vulnerability, is critical. WMO works with National Meteorological Services to bring these essential services to the people to support economic development and better lifestyles."

Working towards Ericsson's vision regarding a networked society in Africa is not just about building or expanding networks. It is about being able to address local issues as well as some of the world's biggest challenges, including security, climate change, sustainability and the availability of education and healthcare. These efforts are central to the transition to the networked society, a world where everything that can benefit from a connection will be connected enabling us to live and interact in new exciting and more sustainable ways.

Tim de Wet, Founder of the National Lake Rescue Institute said: "Saving lives on water and protecting the marine environment is our core objective for marine communities utilizing the waterways of East Africa. The provision of the free Mobile Weather Alert has accorded marine communities the basic human right of 'choice'. They can now make an informed decision as to whether they travel, trade or fish on the Lake. The default value of this is that it reduces the risks for water users, lessening loss of life. This, therefore, has a direct impact on their economies with the resultant effect of poverty reduction."

"In our work with small-holder farmers across Uganda, we have similarly found strong demand for timely and highly localized weather information. This solution, if properly contextualized, could be a powerful tool to also improve farm productivity and mitigate the risks of climate change through new products such as weather index-base crop insurance" said Sean Paavo Krepp the Grameen Foundation Country Director. Figure IV.1 shows scenes from Lake Victoria's fishing communities.

Figure IV.1 – Lake Victoria's fishing communities

Appendix V

Analysis of ship-related big data to estimate fuel efficiency, speed and other performance factors

(This appendix does not form an integral part of this Recommendation.)

Technological developments resulting from a joint research project between Fujitsu Laboratories Ltd. and Tokyo University of Marine Science and Technology enable highly precise estimates with a margin of error under 5 per cent and can also cut fuel consumption by 5 per cent.

Kawasaki, Japan, May 10, 2016

V.1 Introduction

Fujitsu Laboratories Ltd. announced the development of a technology that uses the analysis of ship-related big data to estimate fuel efficiency, speed and other performance related factors in actual sea conditions, to a highly accurate margin of error of less than 5 per cent.

This newly developed technology uses Fujitsu Laboratories' proprietary high-dimensional statistical analysis technology to estimate the performance of ships actually at sea. The technology utilizes a massive volume of measurement data gathered while the ship is underway, including sensor data of meteorological and hydrographic conditions such as wind, waves, and ocean currents, ship engine log data and data about the speed and position of the ship.

By applying the results of this research to the Tokyo University of Marine Science and Technology weather routing simulator for evaluation, Fujitsu Laboratories demonstrated it could improve fuel efficiency by about 5 per cent from previous results, with ships that navigate the shortest shipping routes.

With this technology, it is possible to accurately estimate a ship's performance in actual sea conditions, which previously had a large margin of error, enabling the evaluation of ship performance, design feedback and significant improvements in fuel efficiency when used in ship navigation.

This technology uses Fujitsu's AI technology, Human Centric AI Zinrai and Fujitsu Laboratories will continue to improve its estimation accuracy through further ongoing operational trials.

The technology was exhibited at Fujitsu Forum 2016, held on May 19th and 20th at the Tokyo International Forum (Tokyo, Japan).

V.2 Background

For the shipping industry, the impact of shipping on the environment and the economics and safety of navigation are huge issues. In 2012, the amount of CO2 emitted by seaborne shipping reached about 900 million tons, roughly 3 per cent of the world's total CO2 emissions. In line with revisions to a convention of the International Maritime Organization (IMO), which came into force in 2013, there are now restrictions on CO2 emissions for newly built ships.

There are also cases in the maritime shipping industry where a company's annual fuel costs may exceed several hundred billion Yen, so there is also a need for reductions in fuel costs.

V.3 Issues

If maritime operators have an accurate understanding of the effects of meteorological and hydrographic conditions on a ship's fuel performance, they can determine whether it is better, in terms of fuel efficiency, to take the shortest route, or to take a longer route to avoid the effects of adverse wind, waves and currents.

Previously ship performance estimation technologies relied on experiments with model ships in water tanks, or on physics model simulations. These simulations could not take into account the complicated interactions of the wind, waves, and ocean currents and ship conditions. This problem led to large margins of error in predictions.

V.4 About the new technology

Today, using Zinrai AI technology on big data from ships, Fujitsu Laboratories has developed a high-accuracy technology that estimates ship performance in actual sea conditions, with a margin of error less than 5per cent. In addition, by collecting and analysing operational data from ships actually at sea, this technology is being put to use in designing safe and economical ships and in improving the navigation of ships at sea.

This technology uses Fujitsu Laboratories' proprietary high-dimensional statistical analysis technology to analyse and learn from high-dimensional data that incorporates a variety of directly measured data from ships that are underway, including meteorological and hydrographical sensor data of wind, waves and ocean currents, as well as ship engine log data, ship speed and positional data. The technology then estimates the ship's performance under meteorological and hydrographical conditions for which there is no actual measurement data.

The key features of the technology are outlined in clauses V.4.1 and V.4.2.

V.4.1 Analysis technology that uses actual-travel unprocessed data

Fujitsu Laboratories' proprietary high-dimensional statistical analysis technology allowed measurement data obtained from ships on the move to be used directly, for the successful analysis of the influence of a variety of simultaneously integrated factors, such as meteorological and hydrographic conditions. This enables performance estimates that incorporate the complex interaction of conditions, including wind, waves and ocean currents, not based on synthesized data from experiments in tanks of water, but on data gathered directly from actual ships at sea.

V.4.2 Technology that automatically groups measurement data and adjusts the degree of machine learning for each group

Previously with physics models, because physical phenomena such as wind strength had to be expressed uniformly in a simplified model, it was impossible to raise the level of estimate accuracy (Figure V.1a). Using this new technology, the high-dimensional data, which incorporates a variety of measurement data, is automatically grouped by similar meteorological and hydrographical conditions and then machine learning and estimations are carried out on each group individually (Figure V.1b).

Overly prioritizing actual measured data for machine learning can create a problem where the estimation accuracy goes down for conditions which have not been experienced and there is no measurement data. This problem is solved by automatically adjusting the group boundaries so that no group has data that matches measurement data too closely. This enables a uniform reduction in prediction error.

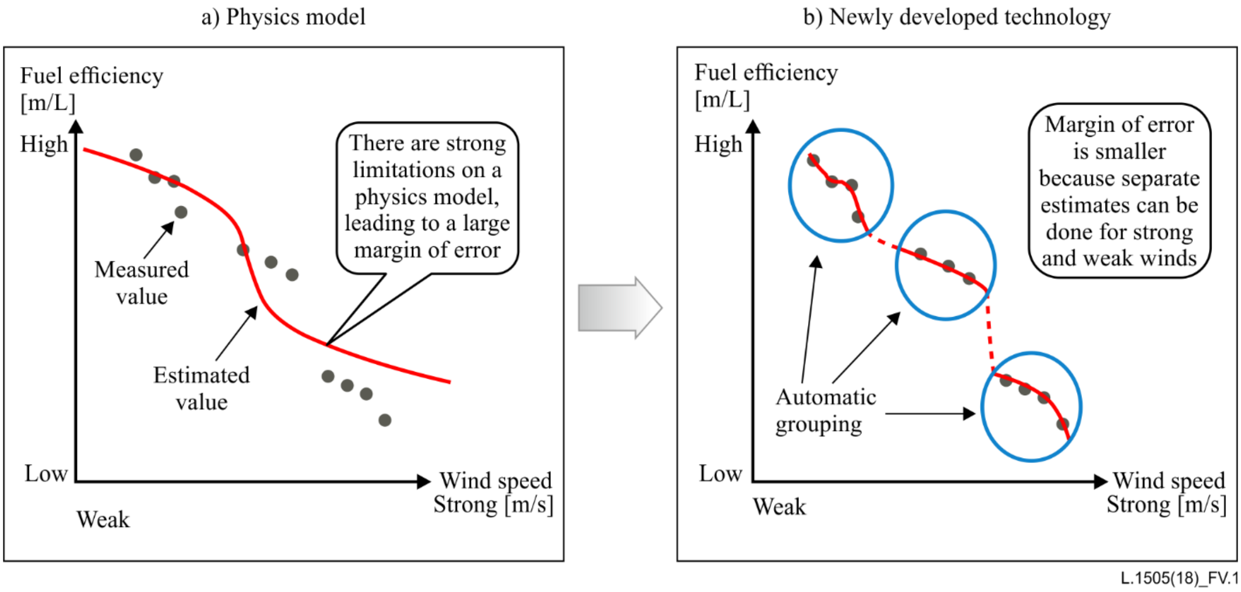

Figure V.1 – Physics model vs the newly developed technology

V.5 Results

Undertaking a joint research with Tokyo University of Marine Science and Technology, Fujitsu Laboratories applied this technology to measured data held by the university from actual ships at sea, including wind and wave data and ship's fuel consumption and accurately estimated the ship's speed performance and fuel consumption performance to within a 5 per cent margin of error. By combining this technology with the Tokyo University of Marine Science and Technology's weather routing simulation, they verified that, for a Pacific ocean shipping route from Tokyo to Los Angeles, taking an optimal route based on the ship's performance as determined by this technology, fuel consumption could be cut by about 5%, as opposed to the most direct route, which greatly reduces both fuel costs and CO_2 emissions.

Feeding back data from voyages by previously developed ships into the ship design process, this technology can enable the design of safe ships with high fuel efficiency. In addition, changes in ship performance before and after maintenance and also before and after applying various fuel-efficient technologies can be quantitatively evaluated.

V.6 Future plans

Fujitsu Laboratories will continue to improve prediction accuracy through joint research with the Tokyo University of Marine Science and Technology. In addition, trials were planned to be carried out in 2016 with a number of ship types and routes, aiming to offer services through Fujitsu's location information cloud service (FUJITSU Intelligent Society Solution SPATIOWL).

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