ICT TOOLS' DIFFUSION, DETERMINANTS, AND ITS ECONOMIC PERFORMANCE ON SMALL-SCALE MOTORISED FISHING BOATS IN KERALA: A CASE STUDY

A thesis submitted
in partial fulfillment for the degree of

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by

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Abstract

The new Information and Communication Technology (ICT) plays an important role in fishing and its related activities of Kerala marine sector. ICT tools such as GPS, mobile phone, echo sounder, wireless set (marine VHF radio) and beacon help the fishermen to increase fuel efficiency and income; reduces trip cost and fishing time. When we analyse the diffusion of technology in the marine sector, the capability of effective use of ICT tools by motorised fishermen poses an important challenge. The present study aims to understand the determining factors of adoption by assessing the usage level of ICT tools, and to study the benefits of their technology among small-scale motorised fishing sector. The study is based on both qualitative and quantitative research methods. The primary data was collected by using multistage random sampling method from five hundred registered motorised fishing crafts of six coastal districts of Kerala: Kozhikode, Malappuram, Alappuzha, Ernakulam, Kollam, and Thiruvananthapuram. Research methods such as logistic growth function, principal component analysis, and binomial logistic regression model were applied to analyse the research objectives of the study. Results show that the diffusion curves of ICT tools of all the coastal districts follow a *sigmoid shape* and proved the theoretical characteristics of the curve. The phase of rapid adoption of ICT tools among motorised crafts was observed during the period of 2007-2012. The study also found that, Alappuzha coastal district has the lowest adoption rates among all districts in the state. GPS was preferred as the most important ICT tool in terms of efficiency and income saving. Interpersonal communication (social interaction), role of government, and easy access of a tool are the three main determining factors of the adoption of ICT tools. The study findings support the *epidemic effect* (users to non-users) of diffusion theory in the sector. The odds ratio of logistic regression function of socioeconomic features shows that, the chance of occurrence of the adoption of an advanced ICT tool are five times for higher education (High school and above), five times for lower age (18-35), 15 times for more distance of fishing (>50 nautical miles), and 11 times for large craft size. The study confirmed the influence of internal, external, and organisational factors for the adoption of ICT tools in the sector and revealed the positive relationship between the adoption index of ICT tools and revenue per trip of single day and multiday small-scale motorised crafts in the sector. The study refined the understanding of present usage capacity of advanced technologies of traditional small-scale motorised fishermen, which will help in developing various effective management policies in the future.

Certificate

This is to certify that the thesis entitled, **"ICT Tools' Diffusion, Determinants, and its Economic Performance on Small-Scale Motorised Fishing Boats in Kerala: A Case Study"**, submitted by **Sabu M**, to the Indian Institute of Space Science and Technology, Thiruvananthapuram, in partial fulfilment for the award of the degree of **Doctor of Philosophy**, is a bona fide record of the research work carried out by him under my supervision. The contents of this thesis, in full or in parts, have not been submitted to any other Institute or University for the award of any degree or diploma.

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Declaration

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Abstract

The new Information and Communication Technology (ICT) plays an important role in fishing and its related activities of Kerala marine sector. ICT tools such as GPS, mobile phone, echo sounder, wireless set (marine VHF radio) and beacon help the fishermen to increase fuel efficiency and income; reduces trip cost and fishing time. When we analyse the diffusion of technology in the marine sector, the capability of effective use of ICT tools by motorised fishermen poses an important challenge. The present study aims to understand the determining factors of adoption by assessing the usage level of ICT tools, and to study the benefits of their technology among small-scale motorised fishing sector. The study is based on both qualitative and quantitative research methods. The primary data was collected by using multistage random sampling method from five hundred registered motorised fishing crafts of six coastal districts of Kerala: Kozhikode, Malappuram, Alappuzha, Ernakulam, Kollam, and Thiruvananthapuram. Research methods such as logistic growth function, principal component analysis, and binomial logistic regression model were applied to analyse the research objectives of the study. Results show that the diffusion curves of ICT tools of all the coastal districts follow a *sigmoid shape* and proved the theoretical characteristics of the curve. The phase of rapid adoption of ICT tools among motorised crafts was observed during the period of 2007-2012. The study also found that, Alappuzha coastal district has the lowest adoption rates among all districts in the state. GPS was preferred as the most important ICT tool in terms of efficiency and income saving. Interpersonal communication (social interaction), role of government, and easy access of a tool are the three main determining factors of the adoption of ICT tools. The study findings support the *epidemic effect* (users to non-users) of diffusion theory in the sector. The odds ratio of logistic regression function of socioeconomic features shows that, the chance of occurrence of the adoption of an advanced ICT tool are five times for higher education (High school and above), five times for lower age (18-35), 15 times for more distance of fishing (>50 nautical miles), and 11 times for large craft size. The study confirmed the influence of internal, external, and organisational factors for the adoption of ICT tools in the sector and revealed the positive relationship between the adoption index of ICT tools and revenue per trip of single day and multiday small-scale motorised crafts in the sector. The study refined the understanding of present usage capacity of advanced technologies of traditional small-scale motorised fishermen, which will help in developing various effective management policies in the future.

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Abbreviations

CMFRI	Central Marine Fisheries Research Institute
CPUE	Catch Per Unit Effort
DAT	Distress Alert Transmitter
DTS	Distress Transmitter System
FAO	Food and Agriculture Organization
EEZ	Exclusive Economic Zone
FPZ	Fish Potential Zone
GPS	Global Positioning System
ICAR	Indian Council of Agricultural Research
ICT	Information and Communication Technology
ICST	Information Communication and Space Technology
IBM	Inboard Motor
INCOIS	Indian National Centre for Ocean Information Services
INSAT	Indian National Satellite System
ISRO	Indian Space Research Organisation
KSMTF	Kerala Swathantra Matsyathozhilai Federation
LAAP	Learning Anywhere Anytime Partnerships
Mastyafed	Mastyathozhilali Federation
MD	Multi Day
MPEDA	Marine Products Exports Development Authority
MFRA	Marine Fisheries Regulation Act
NGO	Non-Governmental Organisation
NIC	National Informatics Center
OBM	Outboard Motor
OAL	Overall Length
PCA	Principal component Analysis
SD	Single Day
SIFFS	South Indian Federation of Fishermen Societies
SPSS	Statistical Package for the Social Science
SSF	Small-Scale Fishing
SST	Sea Surface Temperature
TAM	Technology Acceptance Model
TCS	Tata Consultancy Services
UNCTAD	United Nation Conference on Trade and Development
VHF	Very High Frequency
VKC	Village Knowledge Centre
VRC	Village Resource Centre

Notations

L_{OA}	Overall length
NM	Nautical mile
t	Tonnes
hp	Horsepower
χ^2	Chi square
H_0	Null hypothesis
p	P value

Chapter 1

INTRODUCTION

In this chapter, a brief introduction of the importance and role of ICT usage among small-scale fishermen is presented. The importance of diffusion of a new technology among traditional fishermen is discussed. The significance, research design, and methods of analysis of the present study are also discussed here.

1.1 Background of the Study

Adoption of a new technology determines the pace of growth rate of change of productivity of any sector. A new technology is a powerful tool to produce cost-effective products or services and a time-saver through enhancement of productive yields (Husain et al., 2002). This technological progress crucially depends on the diffusion and adoption of new technologies (Fuentelsaz et al., 2003). The contribution of technological progress to economic growth can only be realized when and if the new technology is widely diffused and effectively used (Hall and Khan, 2003). Thus, technology diffusion (a new technology from users to non-users) plays a significant role in bringing in more income, more output and social welfare (Angst et al., 2010), in most of the sectors of the country. Thus, managing the process of technology diffusion is crucial to ensure the implementation of a new technology (Rogers, 2003). Adoption of Information and Communication Technologies (ICTs) and its diffusion are increasing globally in recent decades and it plays a significant role in the economy and rural development processes of the country.

Information plays an important role in production and related activities for several decades where digital and other electronic technologies are transforming the economies, societies and lives. An advanced and revolutionary technology of the twenty-first century, Information and Communication Technology (ICT) plays a central point in information and communication activities. ICT refers to 'technologies that facilitate communication and the processing and transmission of information by electronic means'[1]. Role of ICTs in agriculture is increasing as it plays an important role in agricultural value chains and is necessary to disseminate the information of new technologies, inputs or raw materials, various seasons, and improve welfare measures of the farmers. Integration of ICTs with space technology has made the technology and dissemination of information more accessible and available in a more affordable manner (Olla, 2008).

Fisher population and fisheries sector are the most important beneficiaries of the diffusion of ICT in the country. Fisheries sector occupies a very important place in the socio-economic development of the country. It is an important generator of income and employment and it is also considered a good foreign exchange earner. More importantly, it is a source of livelihood for a large section of economic and socially backward communities of the country. The main challenges faced by fisheries development in the country include accurate data on assessment of fishery resources and their potential in terms of fish production, development of sustainable technologies for fin and shellfish culture, yield optimization, harvest and post-harvest operations, landing and berthing facilities for fishing vessels and welfare of fishermen (Gangadhar, 2012).

Fishing is an important industry in Kerala. Development of Kerala economy and livelihood of a large number of poor section of the people are depended on marine fishing and its related activities. Overall landings of fishing in Kerala over the recent decade shows a better position in the country. This is due to the adoption of new ICT tools which has helped the active fishermen using both mechanised and motorised crafts for fishing in inshore and offshore waters of the sea.

Information and Communication Technologies (ICTs) and its diffusion in the fisheries sector has been identified by national and international policy-makers, scientists and researchers as an important driver for economic development. At the macro level, high penetration of technology among fisher population benefits the sector by improving the quality and availability of fish and increasing the sustainability of sea resources. At the micro level, fisher population accesses new ICT tools to gain several advantages, such

[1]It is a widely accepted definition from the Department for International Development (DFID) of the United Kingdom of Great Britain and Northern Ireland (2002) and encompasses the full range of ICTs form radio and television to telephones, computers and the internet

as obtaining better access to information and knowledge, improving communication efficiency, and gaining technological skills which are important for the development of the fisheries sector.

Information and Communication Technology (ICT) plays a significant role in the marine sector in various ways and is perceived as a catalyst for economic development and growth. New ICTs, such as Global Positioning System (GPS), echo-sounder, mobile phone and sonar, radio programmes and web-based information, are being used across the fisheries sector from resource assessment and capture to processing and commercialisation (FAO, 2007). Sonar or echo-sounder, a specialist application technology, is used for finding out the fish shoal and reef. Others are general purposive technologies such as GPS, used for location finding and navigation purpose, mobile phones for trading, information exchange and emergencies, radio for programmes about fishing communities and web-based information for a better catch. Benefits of the cost of any new technology also help its successful adoption. Sonar or echo-sounder costs ₹35,000, GPS costs ₹10,000 on an average, Wireless set costs around ₹15,000 on an average and mobile phone costs around ₹2000 (Sabu et al., 2018). Cost effective ICT tools would help to access the market to perform better and thereby increase income and welfare of the fishermen (Jensen, 2007; Abraham, 2007; Srinivasan and Burrell, 2013a). Therefore, it is important to study the level of ICT tools adoption and diffusion and its socio-economic role to understand the benefits that such tools can provide to both the fishermen and the sector.

1.2 Significance of the Study

Historical perspective of Kerala fisheries sector is important to understand its present role in the economy. Kerala is a small maritime State, situated in the South-Western end of the Indian peninsula. Fisheries sector plays an important role in Kerala's economy, which contributes 1.07% of the state's SDP and 12.5% share of the Primary Sector in 2014-15. It also provides 15% share to total exports of marine products of the country, which have the money value of ₹51660 million (GoK, 2016). More than one million fisher population are employed directly in fishing sector (CMFRI, 2012; GoK, 2016) with the participation of almost 200 thousand active fishermen. The total marine fish landings along the Kerala coast during 2015 was 482499 tonnes (CMFRI, 2016) with the contribution of 14.2% to the total landings of India. The contribution to the total marine fish landings of the motorised sector (which holds 51% of the total crafts in the state)[2] is 33.5% and 60% in 2015 by 11,175 (51%) and 4722 crafts respectively (CMFRI, 2015, 2012).

Since, the formation of the state of Kerala, the marine fisheries sector has experienced several technological changes in various aspects of fishing. Technological changes happened in the form of mechanisation and motorisation of crafts in 1950 and 1980 (Kurien and Willmann, 1982; Korakandy, 1994; Vijayan et al., 2000; Hapke, 2001; Yohannan et al., 1999; Jacob et al., 1987). The mechanisation of crafts[3] was considered as the first technological development in the state and that was initiated in 1953 as part of Indo-Norwegian Project (INP). The number of mechanised crafts and their high competition of operation inshore waters prompted traditional fishermen to adopt more small-scale motorised crafts to expand their fishing operation area during the 1980s resulting in better financial returns (Pillai and Katiha, 2004). Motorisation of plywood boat was introduced in 1979 at Kerala (Jacob et al., 1987) due to the large demand and protest by traditional fishermen against the mechanisation of boats and the adoption of motorised crafts was increased in later years (Kurien and Willmann, 1982). The advantages of motorization of traditional craft over mechanised boats include increasing fishing time and labour efficiency, more operational area and enabling tapping additional resources and better quality fish (fresh and higher unit value of fish resources) (Balan et al., 1989).

We observe that, from the formation of the state to 1990s, the technological progress in the fishing sector has occurred in the form of changes and innovations in the fishing boats and gears. Since 1990, the major technological changes took place in the form of adoption of various information and communication technologies for locating boats,

[2]The fishing crafts in the Kerala marine sector are mainly categorized into three types, namely, mechanised, motorised and non-motorised. Motorised craft includes Plywood boats, where engines are fitted outside the haul only for propulsion (Outboard Motor) and Inboard engine fitted crafts (inboard vallom, where engines are fitted inside the boats for propulsion purpose (Harikumar and Rajendran, 2007)

[3]The Indo-Norwegian Project (INP) was set up in 1953 in Kerala (Quilon) following a tripartite agreement signed by the Governments of Norway, India and the United Nations in October 1952, with the objective of mechanising the Indian fisheries sector. Initially, it was a failure but later in 1963 mechanisation of shrimp trawling was introduced successfully by changing diesel engine from 8hp to 16hp (Pillai and Katiha, 2004)

finding fish shoal, and communicating with other fishermen. Since 1990, an increasing number of fishing crafts and continuous operation in inshore waters, decreasing catch per unit effort of crafts, and adoption of more new ICT tools prompted small-scale motorised fishermen to go to offshore waters and helped Outboard and Inboard motorised boats (OBM & IBM) to stay for several days for fishing operations for economic reasons (Pillai and Katiha, 2004).

Motorised fishermen require medium size boat with a minimum number of engines maintenance cost with sophisticated information and communication technologies (ICTs) to go to the deep sea. The use of ICT tools helps the fishermen to increase their income and welfare of the society. The effective use of ICT tools of appropriate tools for fishing and communication purposes. Appropriate use of tools depends on its costs, benefits and skill to use. Likewise, the adoption process is not easy for the traditional motorised fishermen due to their cultural, economic and social barriers. Understanding such barriers for the effective adoption of ICT tools leads the fishermen and the fisheries sector to enrich its maximum growth potential that many researchers were not able to explore. Same time, the status of ICT usage among traditional fishermen is necessary and very relevant in the more challenging sector of the country.

1.3 Research Problem

Marine fish species within the range of 50-60 km from the shore, in Kerala, is exploited by small-scale fishermen, even though, there is a large potential for fishing within and outside of this region. Several types of fishing crafts; trawling boats, purse seine nets (large fishing nets used to catch fish in bulk) fishing, shore seine fishing, gill net and other types of net fishing etc. have made the sector more competitive nature. Continuous exploitation and competition in the sector raised the sustainability issues of both the fish and fishermen, forcing fishermen to go deeper into the ocean in its search and making them stay for several days in the sea. Deep sea fishing (beyond 50-60 km and > 200 metre depth) is one of the best solutions for improving the present situation for motorised fishermen, because of the variability of high-value fish and fishing zone (CMFRI, 2013).

Deep-sea fishing can be sustainable only where the fish population regrows quickly and fisherfolk use small-scale motorised boats with gear that does not destroy their habitats. Deep sea fishing is carried out largely with traditional small-scale OBM motorised boats with traditional gears of gillnet and long-line method has been used since recent years. The main challenges faced by small-scale motorised boats in Deep sea fishing, especially beyond the Exclusive Economic Zone (EEZ) are the safety of fishermen and information and knowledge of fish resources. The risk is more when such small-scale motorised fishermen stay more days (about one week in a 9 - 11m overall length (L_{OA}) size open craft). The role of new ICT tools is very important for reducing the risks of fishing, especially when it is deep sea fishing. New ICT tools such as GPS, echo-sounder, wireless set, mobile phone, and beacon are available in the market to go deeper using boats with size 9 - 11m (L_{OA}), to increase their boat catch and communicate with each other about fishing and related activities when they are at deep sea. However, what type of ICT tools are being used by the small-scale motorised boats for fishing and fishing-related activities, what kind of factors are affecting the traditionally illiterate small-scale motorised fishermen in the marine sector of Kerala are important problems of the study. However, a significant limitation of the sector is that fishermen of the motorised fishing crafts (most vulnerable section of the society) who use a small-scale motorised crafts are unable to get accurate data on assessment of fishery resources, nor are they able to use sustainable technologies, lack potential fish catch, unable to participate in effective communication, landing and berthing facilities and not much improvement in fishermen welfare with available infrastructure facilities in Kerala.

Another challenge faced by state on the policy side, is lack of idea about the determining factors in the adoption of ICT tools. Responsible and effective use of ICT tools and a better idea about the influencing factors of adoption of ICT tools (for effective marine policy management) can contribute constructively, both to livelihoods enhancement and poverty reduction in small-scale fishing communities.

Many researchers have found that the introduction of new ICT technology (especially, mobile phone) has helped reduce the information asymmetry, increased market efficiency, promoted market integration, and enhanced user's network capability in Kerala marine sector. Most of the studies in Kerala analysed only the use of mobile phone technology in fishing related activities. Mobile phones were used in conjunction with Gramin GPS and echo-sounders for marking the exact location and specifying the fish shoals (Pillai and Katiha, 2004; Jensen, 2007; Abraham, 2007; Sreekumar, 2011; Srinivasan and Burrell, 2013b). Along with mobile phones fishermen also use wireless sets in both trawling and ring seine boats in emergency situations (Srinivasan and Burrell, 2013b). Most of the studies are focused only on mobile phone technology and its benefits over the sector in general. Specifically, there are several other ICT tools which can help the small-scale motorised fishing in inshore and offshore waters and contribute a significant share in total landing income of the sector. However, no studies were conducted so far on the diffusion and usage level of ICT tools among small-scale motorised boats, the determining factors in adoption of ICT tools for fishing,steps to improve revenue through ICTs nor on the effectiveness of the recently distributed ISRO developed ICT tool; Disaster Alert Transmitter (DAT) (otherwise called Beacon[4]). This makes the present study more relevant and meaningful.

1.4 Objectives of the Study

The **general objective** of the study is to understand the diffusion, determinants of adoption and economic performance of ICT tools on small-scale motorised fishermen in Kerala marine fisheries sector. Within this broad framework, the **specific objectives** of the study are:

1. To find the extent of usage of ICT tools among small-scale motorised fishing crafts.
2. To estimate the characteristics of the diffusion of ICT tools.
3. To identify the factors that determine the adoption of ICT tools among the small-scale motorised fishermen.
4. To analysis, the socio-economic factors that influence the adoption of ICT tools among the small-scale motorised fishermen in the study area.

[4]It is used to establish communications with offshore fishermen and the Government authorities, especially during emergencies.

5. To calculate the economic performance of ICT tools adopted among the small-scale motorised crafts.

1.5 Research Hypotheses

1. There exists a significant positive relationship between the usage of Information and Communication Technology (ICT) Tools and the economic performance of small-scale motorised crafts in the marine fisheries
2. The trend of ICT tools adoption among small-scale motorised crafts follows an *'S'* shape curve in the marine fisheries sector

1.6 Conceptual Framework

The conceptual framework of the study helps to understand how particular variables connect with each other. The variables are adopted from previous established studies and modified to suit the present study. The following are the important variables or concepts on which the present study is laid upon.

1. *Information and Communication Technologies(ICTs)*: GPS, Echo-sounder, Mobile Phone, Beacon, and Sonar are the ICT tools, being used across the fisheries sector, for resource capture, estimation, processing and selling (Adopted from FAO report, 2007, page 2).
2. *Small-scale Fisheries*: It implies those fishermen who use relatively small size gear and vessel for fishing. The term has sometimes added a connotation of low levels of technology and capital investment per fishermen. This may not be true in all cases (Adopted from FAO technical report, 2005, page 4).
3. *Motorised craft*: Any fishing craft fitted with an electric motor is called motorised crafts. These are two forms of motorised craft; inboard and outboard. An engine fitted temporarily outside (Outboard Motorised) or inside (Inboard Motorised) the craft which is used only for propulsion and not for fishing operations are identified

as motorised. Motorised boats are of two types; plywood boats and fibre boats. The study assumes both as one and the same. The motorised fishing craft has been classified as **Single day (SD)** and **Multiday (MD)** fishing, according to the nature of days they spend in the sea (Adopted from CMFRI census, 2010).

4. *Active Fishermen*: Those fishermen who are active/full time/traditional fishermen, and active fishermen belongs to the age group of 18-60 (Adopted from CMFRI census, 2010).

1.7 Research Materials and Methods

The study is a mixture of both qualitative and quantitative methods. Quantitative data was collected from 500 samples units which were enriched using qualitative analysis. *Multistage random sampling technique* is used for collecting the primary data (Kothari, 2004). The sample size for primary data collection was done based on Cochran's (2007) *representative sample for proportion method* [5].

Secondary data was collected from various Government and Non-Government agencies. Marine fish landings statistics, the number of fisher population and rate of crafts and gears compiled from various CMFRI annual reports of 2005-2016. Marine fish landings, the socio-economic and demographic data of Kerala coastal districts were accessed from Socio-Economic Survey of the fisherfolk of Kerala (2013) and marine fisheries statistics (2015) of the Department of Fisheries, Government of Kerala.

Research methodology part of this study is divided into two major sections. Section 1.7.1 presents the research design and the sampling technique. Section 1.7.2 shows, the data analysis of the study.

[5] For selecting sample size from the large population, Cocharan (1963, 2007) developed representative sample for proportion method. It is shown in the equation; $n_0 = \frac{Z^2pq}{e^2}$, where sample size, Z = Z value from the statistical table which contains area under the normal curve, e = desired level of precision, p = estimated proportion of an attribute, and $q = 1 - P$.(Cochran, 2007)

1.7.1 Research Design

Kerala is one of the principal maritime states, occupying 590 km of South-West coast of India. The state has a total number of 222 fisheries villages spread across 9 coastal districts. Data has been collected from the fishermen of the six coastal districts of Kerala.

Selection of Coastal Districts

The coastline of Kerala has been divided into three regions-i.e., Southern, Central, and Northern. Total six coastal districts were selected as the representation of the state population. Kollam & Thiruvananthapuram were selected from the Southern region, Ernakulam & Alappuzha from the central region and Malappuram & Kozhikode from Northern region on the basis of the stratified random sampling method. The total fisher population of the three regions is 78,770 (i.e., 54% of total active fishermen of Kerala) and the total number of the motorised fishing crafts is 6,214 (i.e., 56% of total motorised boats of Kerala). The primary data was collected from the users of the motorised crafts of these three regions.

Selection of Coastal Villages

The sample villages were selected from the identified region based on the following parameters; (a) the reliability of the data from the pilot study (b) more representativeness of the sample units and (c) the different geographic conditions of the regions. Based on these parameters, the coastal villages of the present study were selected and maintained the following characteristics of each selected coastal villages for collecting accurate data. They are; (1) A village with a good mix of craft-gear combinations, (2) A village was the Fisheries Cooperative Society has good contacts with the fishermen, and (3) A village with the more effective participation of active fishermen.

Sample villages of six coastal districts were selected with the help of systematic sampling technique. Total three coastal villages were selected from each district except Ernakulam and Alappuzha, where two coastal villages were selected from each district (because 60-70% of motorised fishing crafts in Ernakulam and Alappuzha lands at the two

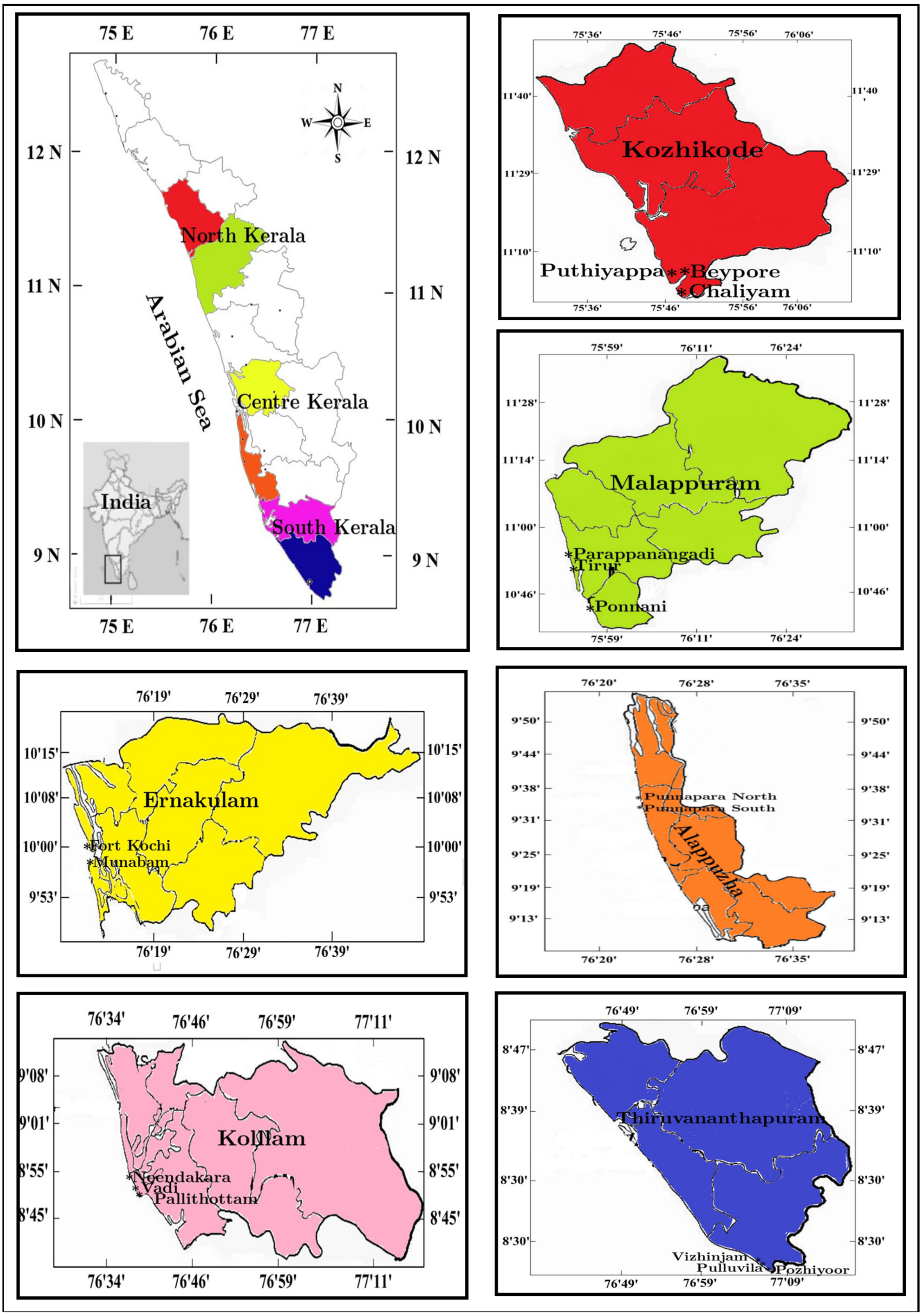


Figure 1.1: Map of the study areas showing coastal districts and villages of Kerala (sampled coastal villages with asterisks)

Table 1.1
Samples selected from each coastal villages of the study

Region	Coastal district	Coastal village	SD	MD	Total
South	Kollam	Neendakara	2	8	10
		Vadi	8	2	10
		Pallithottam	10	0	10
	Thiruvananthapuram	Vizhinjam	40	10	50
		Pulluvila	40	10	50
		Pozhiyoor	5	55	60
Center	Ernakulam	Munambam	0	20	20
		Fort Kochi	0	10	10
	Alappuzha	Punnapara North	45	0	45
		Punnapara South	40	0	40
North	Kozhikode	Beypore	28	22	50
		Chaliyam	20	25	45
		Puthiyappa	7	3	10
	Malappuram	Tanur	23	27	50
		Ponnani	7	13	20
		Parapanangadi	10	10	20
Total			**285**	**215**	**500**

coastal villages/harbours). The selected coastal villages are shown in Table 1.1 and Figure 1.2. Table 1.1 shows that the selected coastal villages from Kozhikode and Malappuram are Beypore, Chaliyam, Puthiyappa, Tanur, Ponnani, and Parappanangadi. The selected coastal villages from Ernakulam and Alappuzha are Munambam, Fort Kochi, Punnapara North, and Punnapara South. The selected coastal villages from Southern Kerala are Neendakara, Vadi, Pallithottam (Kollam), Vizhinjam, Pulluvila, and Pozhiyoor (Thiruvananthapuram).

Selection of Sample

The Universe of the study are all the fisherfolk in Kerala and sample units of the study is a small-scale motorised fisherman and their craft[6]. The study is focused only on the Outboard Motorised (OBM) and Inboard Motorised (IBM) motorised plywood/fibre crafts of

[6]Any craft that has an engine fitted temporarily outside (called Outboard Motorised (OBM)) or inside (called Inboard Motorised (IBM)) the craft which is used only for propulsion and not for fishing operations. Motorised boats are of two types: plywood and fibre. It is classified as Multi-day (MD) and Single Day (SD) fishing according to nature of days they spend on the sea. SD means, spending less than 24 hours (normally, fishermen starts at evening (3-4pm) and reach back at landing centres/sea shore next morning around 6-7am. MD means, spending 2-3 days or 2-10 days at sea on a trip.

Single Day (SD) and Multi-Day (MD) fishing with gears of Gillnets and hook & line. Normally, multi-day fishing varies from three to twenty-five days depending on the size of crafts and gears used. However, the present study assumes all of them as MD fishing crafts for the simplicity of analysis.

The total number (N) of the motorised crafts in the sector is 11,175. Cochran's *representative sample for proportions* method (see Appendix A.1) is used for selecting the total number of sample size. The total sample size of the study is 500. All the selected coastal villages were given equal weights for the selection and the given weights depend on the total number of crafts in the sector. Out of 500, 160 (32% of total motorised fishing boats) samples were collected from small-scale OBM crafts from Thiruvananthapuram. Thirty samples (6% of total motorised fishing crafts of study) from Kollam OBM and IBM crafts were selected for the representation of the Southern region. Out of 500, 85 (17% of total motorised fishing crafts of study) samples were collected from small-scale OBM crafts from Alappuzha. 30 samples (6% of total motorised fishing crafts of study) from Ernakulam OBM and IBM crafts were selected for the representation of the Central region. 105, out of 500, (21% of total motorised fishing crafts of study) samples were collected from traditional Inboard Motorised (IBM) and Outboard Motorised (OBM) crafts from Kozhikode. 90 samples (18% of total crafts of study) from Malappuram (OBM) were selected for the representation of the Northern coastal region of Kerala. The simple random sampling method was used for selecting each coastal village for collecting the samples. The detailed classification of a sample of each coastal villages is shown in Table 1.1 and Figure 1.2.

Method of Data Collection

A well-structured questionnaire was used for the collection of primary data. After an extensive literature review, a pilot survey was conducted by using semi-structured questionnaire on 60 samples for an in-depth understanding of the research problems and a pre-test for data reliability. A few changes were made before the final actual field survey. A well-structured questionnaire with 89 questions was used for data collection including close and open-ended questions. The respondents of the questionnaire were either an owner or a *shrank*[7] of OBM and IBM craft in the sector. The questionnaire has five parts. Part 1 contained questions of the socio-demographic features of motorised fishermen, Part 2 dealt with the basic profile of the motorised crafts, Part 3 examined the details of ICT tools usage, Part 4 dealt with cost, revenue, and catch details of motorised crafts, and Part 5 provided internal, external, and organisational factors influencing the adoption of ICT tools. Five-point Likert-scale questions were also included in the last part of the questionnaire. The data were collected in two seasons (Season I- June-July, 2015 and Season II- Sept-Oct, 2015), for avoiding the seasonal variations in the observed variables. One Focus Group Discussion (FGD) each were held in all selected coastal districts to eliminate a large number of the variance in the components. The checklist for the FGD is shown in the appendix A.3.

Basic descriptive statistical analyses such as mean, standard deviation (Std.D), χ^2 test, mathematical estimation and modelling such as Logistic Growth Function, Principal Component Analysis (PCA), and Binomial Logistic Regression were used for analysis of the data. Recall data comes from self-reports of fishermen. Recall data were collected during the period of the survey and used it to fit the logistic growth model in the study. Recall data can be used and is appropriate in certain cases of primary surveys (Beegle et al., 2011; Meghir and Pistaferri, 2004) which provides very less error in the mean value and the variance is significantly lower by 7% (De Nicola and Giné, 2012). Findings of recall data are very important in risk-sharing studies(Meghir and Pistaferri, 2004) like fisheries sector. All the analyses were performed through the Statistical Package for Social Science (SPSS) software. The diagrams and graphs are plotted through a scientific graph plotting software called, OriginPro.

1.7.2 Methods of Data Analysis

To understand the level of usage the study calculated *adoption index* (normalising the values of ICT tools according to weights) for all the selected study villages with respect to their crafts and daily spending. *Principal Component Analysis (PCA)* is used for finding out the dominant factor influencing the adoption of technology. *Model fit*

[7] who controls the technical aspects of crafts

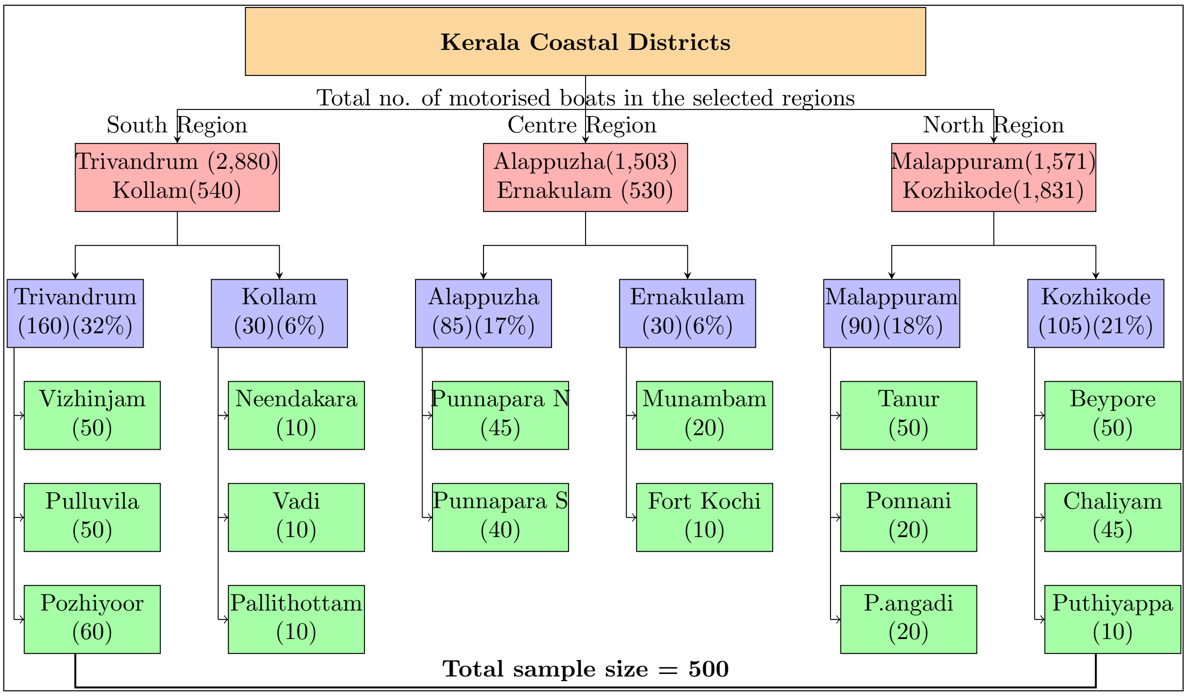


Figure 1.2: Flow chart of the primary data collection process of the six coastal districts of the study

based on recalled data was used with the help of Logistics growth function. Correlation and simple multiple regression were performed to understand the relationship between socio-economic factors and adoption index. Economic efficiency of motorised boats was assessed through the input-output relationship. This relationship was analysed by calculating capital productivity (operating ratio = operating cost/gross revenue), labour productivity ((gross fish catch/crew size)/total trip), fixed ratio, gross ratio (Total Cost/Gross Revenue) and Net Operating Ratio (Gross Revenue-Operating Cost) and Investment of SD and MD crafts.

An *adoption index* was used to understand level of adoption of ICT tools among motorised fishermen. The adoption index was calculated to understand the capability of technology use among fishermen. Once the index is calculated, district wise comparison of technology use can be estimated. The Equation 1.1 was used to calculate the adoption rate. A high value of the index shows high level of adoption and vice versa.

$$ICT_i = \frac{\sum_{i=j}^{n}\sum_{i=j}^{m} ICT_{ij}}{NT} \times 100 \tag{1.1}$$

The Equation 1.1 shows that, summation of all the individual values $(n_1, n_2, \ldots, n_n)$ of ICT tools as ICT_{t1}, ICT_{t2}, ..., ICT_{tn} of each item, that is divided by total number of sample size (n) and then, multiplied with the total number of tool i.e., five (NT) (i.e., total number of tools; mobile phone, GPS, wireless set, echo-sounder and beacon) available attributes in the sector. The Adoption rate is expressed in percentage by multiplying by 100. Adoption level shows that, when a fisherman uses the only mobile phone for the fishing purpose, denoted by one, mobile and GPS denoted by two, and mobile phone, GPS & wireless set denoted by three. The index was prepared for ranking the coastal villages and districts based on the usage of a number of ICT tools. Adoption index was used to compare the adoption level and revenue per trip of each coastal districts. The study assumed that when adoption index is high, the intensity of adoption and revenue will also be high.

Principal Component Analysis(PCA)

The study used PCA to find out the main influencing factors of ICT tools in the motorised sector. PCA is a multivariate statistical technique, used to reduce the number of variables in a data into a smaller number of dimensions and it has been applied to every substantiate area including various fields of social science (Vyas and Kumaranayake, 2006; Dunteman, 1989).

PCA technique of the present study was constructed by a small correlation matrix involving nine components (Y_1 to Y_9) such as; interpersonal communication (IC), government (G), media (M), institutions (I), agents (A), relative advantage (RA), cost-effectiveness (C), accessibility (A), and demonstration effect (DE) generated from the collected primary data. PCA found the variances of these nine variables $IC(\lambda_1), \ldots, DE(\lambda_9)$ ordered by size and associated variable weights vectors, since it was formulated by five-point Likert-scale. Thus, each associated weight vector contains five elements, one corresponding to each other. If $IC = Y_1 = (a_{11}, a_{12}, a_{13}, a_{14}, a_{15})$ has five weights associated with the largest principal component whose variance is λ_1. This process of calculation continues till variance of all the components are calculated, which in turn helps to find the largest variance of the matrix.

For example, given a data matrix with k variables and n samples, the data are first centred on the means of each variable. The first principal component (Y_1) is given by linear combination of the variables $X_1, X_2, ...X_n$, that is shown in the equation 1.2 .

$$Y_1 = a_{11}X_1 + a_{12}X_2+, \ldots, a_{1n}X_n = \sum_{1=n}^{n} a_{1i}X_i \tag{1.2}$$

The second principal component, Y_2 involves a second weight vector $(a_{21}x_1 + a_{22}x_2+, \ldots, a_{2n}xn)$ such that variance of $\sum_{1=n}^{n} a_1X_1$. For calculating Y_2 we use the equation 1.3.

$$Y_2 = a_{21}X_1 + a_{22}X_2+, \ldots, a_{2n}X_n = \sum_{1=n}^{n} a_{2i}X_i \tag{1.3}$$

The Equation 1.3 is maximised subject to the constraint that it is uncorrelated with the first principal component and $\sum_{1=n}^{n} a_{21}^2 = 1$ is achieved.

In short, the principal component is calculated in such a way that it accounts for the greatest possible variance in the data set. These weights are calculated with the constraint that their sum of square is one. Y_2 is the next largest sum of squared correlation with the original variables. The first two principal components together have the highest possible sum of squared multiple correlation $(i.e., \sum_{i=1}^{n} R_{x1 \cdot y_1 \cdot y_2}^2)$ with the n variables. This process of testing continues until variance of all components has been calculated.

Logistic Growth Function: A Model Fitting

Major diffusion models have been used for measuring technology diffusion processes are the Logistics Model, Bass Model, and Gompertz Model (Mahajan and Peterson, 1985). They are empirically tested in Indian telephone industry (Singh, 2008). All these models analysed technology diffusion rates and their speeds among selected samples and predicted an 'S'-shaped curve. Logistics growth model is one of the basic models of measuring the characteristics of 'S' shape (Michalakelis et al., 2008; Wu and Chu, 2010a; Botelho and Pinto, 2004). It is a superior forecasting method because its trend grows more rapidly towards maximum point than the other growth models (Botelho and Pinto, 2004). The study attempts an empirical analysis of diffusion trends of ICT tools and thus, use the logistic function, as shown in Equation 1.4.

$$Y(x) = \frac{a}{1 + e^{-k(x-xc)}} \tag{1.4}$$

Y is the total existing adopters of ICT tools at time x, and a, k, and xc are the parameters to be estimated. The symbol a represents the maximum number of people adopted ICT tools. $x - xc$ shows the time period/year of adoption of ICT tools. These three important elements determine the shape of the curve (Gruber and Verboven, 2001). Total number of potential fishermen adopters is denoted by a. The location/slope of a variable is denoted by k. $x - xc$ measures the speed of adoption of ICT tools. The Logistics function ranges from a lower asymptote of zero to upper bound k, and t ranges from $-\alpha$ to $+\alpha$. The parameters α and β determines the location and shape of the curve accordingly. The maximum adoption rate (a of ICT tools) is achieved when $y_t = k/e$, i.e., when y_t reaches about 50 percent of its upper bound.

1.8 Organisation of the Thesis

The thesis is organised into seven chapters. In **Chapter 1**, the background and introduction of the study are explained. Research problem, objectives, hypotheses, conceptual framework, the significance of the study, and research methodology are discussed in this chapter. The chapter ends by reviewing some limitations of the present study.

In **Chapter 2**, the detailed literature review pertaining to the use of ICT tools is discussed. Section one of this chapter deals with the role of ICT in the fisheries sector in general. Section two and three of the same chapter present studies related on the influencing factors of adoption of a new technology along with some empirical studies of fitting logistics curve on secondary data.

The theoretical background of this study is presented in the **Chapter 3**. Theories of technological development and its diffusion, adoption, and determinants are also reviewed in three sections in this chapter.

Chapter 4, presents a historical background of the overall conditions of the marine fisheries sector. Section one of this chapter discusses the overall status of world marine sector and its present challenges. Section two and three explain present socio-demographic, growth, and development of India as well as Kerala marine sector. It also reviews about technological development of Kerala marine fisheries sector. Technological development in the sector is classified into different phases from traditional technological change to the adoption of advanced ICT tools. Present status of adoption of ICT tools in different coastal districts is also discussed.

Based on the data collected from field survey, **Chapter 5** assesses the adoption level of ICT tools, influencing factors, and economic efficiency of motorised crafts. The first section of the chapter provides socio-demographic and basic profiles of motorised crafts of each region. Measuring the characteristics of the sigmoid shape and fitting the primary data for 'S' shaped curve are discussed in the second section. Economic efficiency of motorised crafts of each region is calculated in the third section of this chapter. Various factors that influence the adoption of ICT tools, in general, is discussed in the last section of this chapter.

Major findings and discussion are explained in **Chapter 6**. Major findings related with present research objectives are discussed in detail in this chapter. This chapter is divided into five sections and it explains findings and discussion.

Conclusion and policy implication that are derived from the study forms the last chapter, **Chapter 7**. From the findings of the study, some suggestions and recommendations are made which will help to reduce the information asymmetry through the use of ICT tools.

1.9 Limitations of the Study

The study did not distinguish between the different size of motorised crafts such as, plywood/fibre crafts that carry gears such as gillnet, and hooking, as it is mathematical analysis impact of ICT tools is too difficult due to lack of control variables (i.e., users of ICT tools and non users of ICT tools). Hence adoption index was calculated based on the number of tools and used the index of different regions for the comparison of adoption of ICT tools and economic performance of small-scale motorised crafts in the sector.

Chapter 2

LITERATURE REVIEW

In this chapter, a detailed review of existing literature related to the research is discussed. The studies related to the use of ICT tools in fisheries sector in various countries, adoption factors and the determining factors of adoption are discussed. The scope and relevance of the present study are also discussed.

2.1 Introduction

The major objective of the study is to understand the socio-economic impact of the usage of ICT tools and factors influencing its adoption in Kerala marine fisheries sector. This chapter is divided into three sections. First Section 2.2 deals with the socio-economic benefits of the usage of ICT tools. The second Section 2.3 presents the various studies that state about the influencing factors in the adoption of a new technology.

2.2 ICT and Socio-Economic Impact

Technology and technological change are the two major ingredient factors for economic growth and development. Invention and innovation make the technological change in its forms and operation. The diffusion of technology brings the technological change in practice. The potential benefit of any technology is analysed only when a new and more advanced technology is successfully diffused to a large number of end users.

The Section2.2 has classified the relevant literature on socio-economic impacts of ICT into the literature of World, India, and Kerala. This systematic explanation of the related studies helps to get an idea of the research gap and to understand the importance of the present study.

2.2.1 World

Yamanaka (1982) has conducted a study on the application of space technology on the Japanese fisheries sector. He found that information such as sea temperature, oceanic circulations etc. are extremely useful and valuable to commercial fishermen, for which remote sensing technology is used. Various satellite information and LANDSAT data were used for disseminating information to fishermen for optimizing their fish catch. data and fishermen used it for communication purposes also. With the help of NIMBUS-7 (CZCS) satellite, the study found the data of schooling behaviour of fish and temperature patterns which indicate the dynamic aspects of the ocean, such as oceanic circulation, fronts, up-welling, etc. Coastal Zone Color Scanner (CZCS) which gave a clear picture of chlorophyll with the range of $r = 0.67 - 0.85$. All these factors played a significant role for the development of the Japanese Fisheries Industry. However, the study did not measure the usage level of this information about sea resources.

Akegbejo-Samsons (2006) conducted a study on pilot fishnet initiative (FNI), a model information network of the Ilaje Local Government area of Ondo State, Nigeria. FNI was established with the aim of networking all the fisher population in the administrative area through various means such as workshops, training courses, study tours, conferences and sharing printed publications of information. Various cooperative groups were used for the dissemination of information about the marketing and fish distribution through traditional methods like village meetings and modern communication methods such as Television, leaflets, radio, posters etc. The level of effectiveness of this information was observed for a period of six months. The study found that the ICT tools have larger coverage and more effectiveness. The study focused only on the role of FNI for extensive activities of technology diffusion but it lacks the measurement of its utility.

Omar et al. (2011) stated that there is a significant relationship between ICT and Community Development in the Malaysian coastal belt. Groups such as farmers, students, teachers, rural administrators, and entrepreneurs have benefited from the usage of ICT. It was found that the ICT tools such as GPS, Sonar system, wireless set, fisheries remote sensing, computer, internet, and mobile phones have offered large benefits to the Malaysian fishermen. These fishermen were encouraged to use the online services provided by the Department of Fisheries (DOF) and the Fisheries Development Authority of Malaysia (LKIM). DOF has introduced Networking System of Fisheries Information (NSFI) which provides services like E-training, E-extension, E-aquaculture, Vessel Monitoring System (VSM), E-license, E-fund, E-fishermen, and Fish Online. The study also found that that ICT tools have helped to increase the fishermen's knowledge, rural community literacy level, communication process, and reduced the digital divide, and thereby enhanced the socio-economic development. ICT increased productivity and provided the right information for enhancing the fisheries inputs, weather, markets, new production techniques, and farming technologies. The study also cited various obstacles in the usage of ICT; such as lack of interest, risk factors, low bandwidth, lack of proper hardware and software, lack of appropriate infrastructure, low number of websites, weak telecommunication systems, high cost of access, increase in maintenance cost and lack of investment by private and public sectors. Technophobia, the negative attitude about modern technology, lack of social interaction and prejudiced beliefs are major social barriers in the adoption of ICT. A significant limitation of the study is that it focuses neither on the capability level of ICT usage of fishermen and nor identified determining factors.

Salia et al. (2011) assessed the effects of mobile phone usage on the artisanal fishermen in the Effutu Municipality of Ghana. They found that the usage of mobile phones among fishermen enhanced the efficiency of input and output markets for artisanal fishing and also improved their businesses relations and livelihoods. Usage of mobile phones resulted in market efficiency, better fish price, improved income, expanded markets network, improved safety at the sea, and easy communication between the family members and with other fishermen. One of the major findings of the study was that the fishermen used their mobile phones as 'umbilical cords' which connected them to their suppliers [1], buyers and families. This has reduced the transaction costs tremendously and the risk involved in the supplies of essential goods, and also enabled them to access information in minimum time. These frequent interactions helped the fishermen them to build trust and confidence among them in their businesses. Through Principal Component Analysis, the study found four major categories of reasons for using mobile phones, namely cost

[1](70% of the fishermen visited more than two landing centres which show statistically significant rate, $Z= 10.074$, $p<0.05$)

reducing factors, safety factors, coordination factors, and market expansion factors. The cost reduction factors loaded most strongly on three items, with loadings ranging from 0.76 to 0.79 and 27.9% of variance. Safety factors (loadings of ranging of PCA was from 0.76 to 0.80, with 14.5% of the variance) refer in particular to the usefulness of the phone during the time of emergencies such as engine breakdowns, change in weather conditions etc. The study revealed that mobile phones helped the fishermen to expand their markets by finding new customers and to best prices from within and outside their local landing sites. Among the service providers the best service was given by Vodafone (96%). The major challenge was facing by fishermen using mobile phone is the problem of network coverage. In effect, mobile phones helped the fishermen to make informed decisions on who, where and how much to sell their fish catch. The study focused only on the mobile phone technology and not studied about other ICT technologies.

Shaffril et al. (2012) carried a pre-test study to understand the reliability of the usage of ICT tools such as; GPS, sonar, echo sounder, the wireless set and mobile phone among the fishermen of Port Dickson, Malaysia. The study found that ICT tools helped the fishermen in saving time, more money, saving the life, and fuel. They did a pre-test process among 30 randomly chosen registered fishermen and applied a reliability analysis and thus developed the Unified Theory of Acceptance and Use of Technology (UTAUT) model[2]. Cronbach alpha value of measured parameters was ranging from 0.714 - 0.970, whereas performance expectancy showed 0.949, social influence showed 0.860, facilitating condition 0.897, behavioural intention 0.856, effort expectancy 0.933 and voluntariness of use showed the highest value of 0.970. The study focused on how ICT projects such as Rural Internet Center and Rural Info Center in encouraging the usage of ICT in the community. A major limitation of the study was not measuring the diffusion rate of each ICT tools.

Omar et al. (2012) studied the role of ICT in the socio-economic development of fishermen and found that mobile phones, GPS, sonar, radio, television and internet were benefited for the poor people. The study found that mobile phone are the most preferred tool for enhancing the (97%) market efficiency, made information faster and cheaper, helped to communicate with their friends, relatives Meteorological Department, access to

[2]UTAUT is the modified version of Technology Acceptance Model (TAM). Davis Jr (1986) proposed Technology Acceptance Model (TAM) to address why users accept or reject information technology

market buyers and also helped to new update new events. The study found GPS (31.5%) as the second most preferred tool after mobile phone. GPS helped the fishermen to identify the location and to ensure their safety. They also found that the fishermen resorted to the radio (45%) and TV (65%) also for updating the market prices and weather information. The results revealed that ICT brought about significant improvement in their life.

Bolong et al. (2013) found that technology usage was recognized as one of the ways of increasing productivity through the study of the readiness to use geographical positioning systems (GPS) by younger fishermen in their fishing operation. The study found that 80% of young fishermen of Malaysia used mobile phone and GPS was used only by 25%. The study also identified significant and positive correlations between GPS usage and young fishermen's income $(r = 0.194, p < 0.05)$ and usage of echo- sounders and young fishermen's income.$(r = 0.209, p < 0.021)$. To analyse this, they developed an Extended Technology Acceptance Model (ETAM). The model was pre-tested for the reliability analysis and used Cronbach alpha test to understand the knowledge, problem, usage, and readiness of young fishermen in Malaysia. The major limitation of the study is that the research used only reliability analysis to study the impact of ICT in the fishing sector.

Zaremohzzabieh et al. (2014) used Structural equation model to find out the factors influencing acceptance of ICT tools among 400 Malaysian fishermen. They applied Unified Theory of Acceptance and Use of Technology (UTAUT) model and its attributes to test behavioural intention of the use of ICT tools and used the Structural Equation Model (SEM) to test the relationship of ICT, age and experience. The study found the variance of 25% in the adoption of ICTs which was due to user intention, facilitating condition, performance expectancy, and effort expectancy with the help of UTAUT. Factors such as, facilitating condition $(\beta = 0.7CR = 1.136, p = 0.00)$, performance expectancy $(\beta = 0.138CR = 1.987, p = 0.047)$, and effort expectancy $(\beta = 0.197CR = 3.304, p = 0.000)$ were found main influencing element of ICT usage. The study also found a moderate effect on the age and experience of fishermen in using ICT tools and their analysis. The major limitation of the study is that the researcher used only external determining factors in the adoption of ICTs and failed to use internal and organisational factors.

2.2.2 India

Information and Communication Technologies (ICT) play a very important role in economic growth and development of India. (Jakhar, 2005) concluded that ICT has contributed profusely to promoting the economic growth of the nation through employment generation, GDP contribution, exports and to development of the industry.

Gine and Klonner (2008) conducted a study in Tamil Nadu on the diffusion of plastic reinforced fibre boat (FRP) and analysed the income inequality status among the fishermen. They found that wealthier entrepreneurs adopted the FRP earlier than the rest and the technology adoption widens the gap between the rich and the poor. But after the entire community completed the introducing FRP, the inequality dropped to a lower level than before. This implies that, in the long run, the innovation benefited the poor more than proportionately as suggested by Kuznet's (1955) in his inverted 'U' shaped income distribution curve. The study found that constraints of credit and uncertainty cited as the major problems in the adoption of FRP. The study also found that adoption of new technology and inequality in income increased in the initial period (Gini index was increased from 0.34% to 0.38%) and after adoption, average income was increased and the inequality between rich and poor decreased substantially to 0.31. The study was also observed that only the boat-owning fishermen made the operation of fibre plywood boat (FRP) economically viable by optimally resolving the trade-off between maximizing daily catches and harming the gear. Adoption was preferred to non-adoption if $(1/1+r)t* yF > yC+ra0$, where substituting for t and simplifying get $yF > yC + rK$. Yf is income from fibre boat, yc income from cattamaram, ra is total wealth, and k is an investment. This study was based only on the income aspects of the adoption and did not focus on any other constraints in the adoption of a new craft.

De et al. (2008) studied the uses of ICT tools among the aquaculture farmers in the various state of India. They stated that improved communication and information access was directly related to the social and economic development of aquaculture farmers. The study focused on the role of Agricultural Technology Information Centres (ATIC) which serves as a single window system with an objective to help farmers and other stakeholders. It provided a solution to their location-specific problems related to aquaculture farming and made make available all the technological information. The study also revealed that ATIC played a major role for the effective use of ICT projects in various parts of India, like e-choupal for helping the poor to improve their lives through the application of ICT, named Aqua Choupal in Andra Pradesh. It found that modern communication technologies helped to improve communication, dissemination of information and sharing the knowledge and skill of farmers. The major drawback of the study is that it analysed only the supply side of the dissemination of information about new technologies and not the capability of farmers' knowledge on the new technology of the adoption.

Solanki et al. (2008) analysed the usage of satellite data particularly Ocean Colour Monitor (OCM) for chlorophyll concentration and sea surface temperature (SST) by fishermen of Gujarat to identify the fish potential zones (FPZ). OCM data helped the scientists to retrieve information on ocean colour parameters such as, phytoplankton pigment (i.e., chlorophyll concentration) which helped in the estimation of certain fish shoals in the Arabian Sea. The study also observed the anti-cyclone eddies using satellites which helped the fishermen not to operate in such an area of the sea. The study has estimated the FPZ areas and distributed the information to the fishermen, which helped them to identify specific regions of fish shoals and it increases their fish catch. However, the study did not mention how effectively the fishermen were able to use GPS and other ICT tools for fishing, without which locating the FPZ is very difficult.

Joshi and Ayyangar (2010) conducted a study about the use of satellite communication technology for fishing in India. They found that satellite communication was one of the most preferred medium of communication which helped the fishermen to access timely, reliable and accurate information on meteorological and oceanographic parameters. The ICT tools such as radio, wireless sets (marine walkie-talkie), and mobile phones, were useful for effective communication among the fishermen. The study found that the affordable ICT gadgets like the mobile phone have helped the fishermen to effective communication. The study also found that Remote sensing application was primarily used for identification of PFZ and forecasting of weather and cyclone in Indian coastal regions. But, these tools were not put to effective use by those fishermen who, prefer deep sea fishing. They concluded the study by stating that the satellite communication was an effective solution for the fishermen community and it would reduce the distance barrier.

However, they were sceptical about the usage of this tool by these fishermen. The major limitation of the study is that the study has provided a generalised idea about communication technologies without any experimental studies.

Govindaraju and Mabel (2010) studied the role of VKC (Village Knowledge Center) in a coastal village, initiated by the local Parish Council in Kovalam in Southern Tamil Nadu. The main objective of VKC was to serve the people with the e-governance, e-agriculture, e-education, e-health and other services free of cost. The study revealed that the people of Kovalam was accessing the services of VKC and did not show any disinterest in the introduction of new technology. Fishermen of this coastal village used mobile phone with GPS services for fishing and related activities. The study also revealed the massive influence of VKC's in the daily life of students and the women of the fishing community. VKC has helped to spread awareness about technologies among the villagers and thus brought social development in the region. The major limitation of this study is that it studied about the role of the organisation in the dissemination of the information only and ignored the adaptive capacity of each fisherman in using ICT tools.

Gangadhar (2011) found the correlation between the innovation in the field of information flow and its application in deriving larger benefits through sectoral development. Mobile phones played the role of carriers and conduits of information and helped the fishermen for reducing the information asymmetries in fisheries markets. Mobile phones helped to coordinate the economic activities of the market and helped to maximize the revenue through information about price in various markets. He also found that the ICT helped the fishermen to spend less time idling on shore and at sea, and owners and agents went to the landing centres only when they had received information (via mobile phones) about their boats. The study concluded that the claimed that the markets became more efficient and thereby the uncertainty of information the price dispersion has reduced. ICTs contributed constructively both to livelihoods enhancement and poverty reduction of fishing communities. The major limitation of the study is that it focused only on the usage of mobile phones among the fishing community.

2.2.3 Kerala

Studies on the impact of ICT tools in the marine sector of Kerala are very limited. Most of the studies are related to the usage of mobile phone among fishermen. Abraham (2007) studied the influence of mobile phones among the fishermen in Kerala and observed that the introduction of mobile phones reduced the risk of fishing. Mobile phones helped to reduce the uncertainty of price fluctuations in the fisheries sector and thereby enhanced the productivity and quality of the fish catch. Fishermen use the mobile phone to share information about life-saving equipment, fishing location and fish pricing. Mobile phones played a significant role in Kerala marine industry. The study found that more than 80% of the total respondents believe that mobile phone is very useful for fishing activities. The major beneficiaries of the mobile phone are fish merchants, transporters (50% got productivity gain and profit by reaching on time) and agents whose waiting time has been reduced by seventy per cent. The study clearly found that the use of mobile phone in fishing has led to gains in productivity and existence of Marshallian surplus (sum of consumer and producer surplus), which reduced the mismatch between the demand and supply in the fishing sector. The use of mobile has also improved the welfare and standard of living of fishermen community. The major limitation of this study is that only looked at mobile phones as ICT tools by ignoring the role of other ICT tools.

Jensen (2007) has studied about the use of mobile phone among the fishermen in Kerala. He found that the use of mobile phone reduced price dispersion in fish markets, (declined from 60-70 to 15% or less), and reduction in fish wastage. He claimed that the fisheries sector transformed from a collection of essentially autarkic fishing markets to a state of near-perfect spatial arbitrage due to the usage of mobile phones. He also found that the use of mobile phone helped the fishermen to increase profits by eight percent, reduced consumer price by four percent and enhanced consumer surplus by six percent. He used the monotone likelihood ratio property, a property ratio assuming two probability density functions (PDFs) [3] of fish catch zone and Bayes-Nash equilibrium methods for analysing the effective use of mobile phones communication in the sector. The study

[3]PDF shows (x_i/H) and $f(x_i/L)$ where catchment zone can be either a high (H) or low (L) density state. The catch for fisherman i thus follows the distribution $f(x_i/d)$, where x_i takes values from zero to x_max. So that (x_i/H) and $f(x_i/L)$ is increasing in x, i.e., catches are more in high density than low-density areas

found that the mobile phone helped the fishermen to sell their fish in the non-local market if their high catch yields more profit (more than operating cost plus transport charge) than the local markets. He conducted the study on the usage of mobile phone and its benefits among the fishermen but did not mention about the benefits of other ICT tools such as GPS, wireless set and beacon for enhancing their income and welfare.

Pillai and Nair (2010) has conducted a study on the use of Potential Fishing Zone (PFZ) information generated by the Indian National Centre for Ocean Information Services (INCOIS) by ring seiners along the Kerala coast during the period 2006-2010. They found a positive and significant relationship between PFZ and the occurrence of commercially important pelagic fishes. The study found that PFZ data was useful for artisanal, motorized and small mechanized ring seine fishermen to help to catch more pelagic fish resources and thereby improves their income. The study analysis also showed that the catch per unit effort (CPUE)[4] of fish was more in notified areas compared to non-notified areas. The study also found that SST based advisories were more and the advantageous for locating mackerel, tuna, anchovies and carangids fishes, whereas Chlorophyll based advisories were more and the advantageous for locating matured oilsardine. The study revealed that the quantity of fish caught in notified areas is about 2 to 6 times more, the percentage of monetary benefit obtained in notified areas is about 2 to 7 times more than the usual. The major limitation of this study is that it is focused on the experimental study by using specific data which could not be generalised. This study lacks the clarity on the usage level of GPS, which is the main technology for successful application of PFZ information.

Sreekumar (2011) studied the social and cultural dimension of the adoption of mobile phones among fishermen in Kerala. He stated that fishermen in Kerala use mobile phones due to cultural and ecologically factors. He found that they used mobile phone to transfer information about the availability accessibility of fish in a particular area. The study also found that the usage of mobile phone helped to improve cooperation among the marginalized group of fishermen, especially in sharing information about fishing location, safety and rescue in the sea. He called the mobile phone gadget as ‘collectivist machine’

[4]Catch per unit of fishing effort (CPUE) is the total catch divided by the total amount of effort used to harvest the catch.

due to its benefits. The study found that the presence of collusion behaviour of buyers due to the mobile phone marginalised women fish vendor. The major limitation of the study is that it did not mention the use of other ICT tools which are also prime cause for enhancement of income and welfare of the fishermen.

Srinivasan and Burrell (2013b) found that mobile phone was a rapidly diffused ICT tool in Kerala fisheries sector which helped the fishermen to get the right market price for their catch. They found that fishermen used the mobile phones to communicate with their family members about their schedules of fishing and other personal matters. They were also used mobile phone for calling auctioneers and export dealers rather than the buyer for a better price. The latest market information also accessed through the mobile phone while they are at the sea. They found that fishermen of Kerala use GPS and echo-sounder along with mobile phones to share fishing location among the fishermen. They also use wireless set to connect with the shore and other fishermen in case of any emergency situations such as insufficient fuel, damaged engine etc. The study found that fishermen used GPS to mark and specify the exact location of fish shoals. The study has concentrated only on the benefits of ICT tools in Kerala marine sector and not studied the diffusion or adoption of ICT tools among the fishermen.

Steyn and Das (2016) conducted a study about the role of the mobile phone in Kerala fisheries sector and they found some contrary results to that of Jensen (2007). They found that mobile phone was used by the fishermen for getting finance, knowing the time of landing of their boat, price information etc. also. The study also claimed that Jensen (2007) presented his study as an over-generalization by considering different market condition, oceanography, fish species, weather patterns, infrastructure, market practices, and more as unique. The study found that fishermen used mobile phones not to determine the market price, but, to communicate to the land on bad weather. He found that multi-day fishing boat (trawlers) use ICT tools such as GPS, echo sounder, and wireless set along with the mobile phone. The study also found that the fishermen did not use the mobile phone for their economic welfare, but used it for the enhancement of emotional and social welfare.

From this comprehensive literature review, the present study observed that most of the studies have considered only the use of mobile phone as ICT tool in the fishing sector. All the studies focused only on the benefits of the mobile phones in fishing and generalized the capability of the use of new technology by the fishermen is ignored. No study in Kerala has conducted on the usage and benefits of ICT tools other than the mobile phone. The fishermen are using GPS, echo-sounder, wireless set and beacon, especially the traditional small-scale motorised fisher population. Further, understanding the present usage level of ICT tools small-scale fishermen of motorised fishing crafts will immensely help to make future marine policies for the fisheries sector. Thus, the present research work carried out to study systematically about the importance and usage level of all available ICT tools for fishing among the small-scale motorised fishermen.

2.3 ICT and its Determinants

A clear understanding of the determining factors of the adoption of a new technology is crucial for analysing the intensity of adoption of the technology. The success of an effective ICT diffusion is perceived in terms of the factors that influence technology adoption (Peansupap and Walker, 2005). Rogers Everett (1995) claims that relative advantage, compatibility, complexity, trialability, and observability are the main internal factors that affect the adoption of new technology in a social system. Also, geographical difference, culture, skill development, infrastructure (Hall and Khan, 2003), and organisational support (Wilson et al., 2002) facilities are the external factors influences the adoption process. Factors such as management skill, individual interaction, new technology, and work environment are found to have a positive influence on ICT diffusion in the Australian construction sector (Peansupap and Walker, 2005). Government policies, human capital, wealth, and infrastructure facilities are found the influencing factors of ICT expansion in five Latin American countries (Ngwenyama and Morawczynski, 2009). Researchers in agriculture sector found that factors like infrastructure, level of income, and human capital (education, technical skill, social networks) have led to a significant influence on adoption of a new technology (Feder and Slade, 1984; Rahm and Huffman, 1984).

Related knowledge and experience of innovation are associated with the faster rate of adoption process of a technology (Dickerson and Gentry, 1983). Stoneman and Kwon (1996) states that, profit is increased when a new technology is adopted which determined the rank and stock effect in the UK engineering industry during 1982-86. Del Aguila-Obra and Padilla-Melendez (2006) found a contrary result in his study. He found that the size of a company or a firm does not influence the adoption of internet technologies but the managerial capabilities of people influence for the same. The smaller the size of the firm, the greater is the possibilities of using external advice for adopting Internet technologies. Because small firms usually have fewer managerial capabilities. Arvanitis and Hollenstein (2001) have studied the adoption behaviour of Swiss manufacturing firms in the field of Advanced Manufacturing Technology (AMT). They found that benefits and costs of adoption, the firm's ability to absorb knowledge from other firms, firm size, and experience are the main influencing factors in the adoption of a new technology. Bandiera and Rasul (2006) found that the family and friends are major influencing factors of the adoption of new crop among farmers of Zambezia region of Northern Mozambique. He found that the shape of the adoption process shows an inverse-U. This is due to the social effects of the individual adoption decision were positive when there were a few adapters in the individual's information network, and negative when there were many adopters.

Based on the available studies, the present study has segregated the various factors that affect the adoption of a new technology into three categories namely, internal, external and organisational factors (Butler and Sellbom, 2002). Table 2.1 shows the different categories of determinant factors of adoption of a new technology.

Table 2.1
Studies related to determining factors in adoption of a new technology

Area/Sector	Authors	Internal factors	External factors	Organisational factors
	Feder and Slade (1984)	Income	Social influence	R&D
	Kripa and Mohamed (2008)	Tariff	Social system	Farm size
Agriculture	Mittal et al. (2010)	Cost	Time	
	Mazuki et al. (2013)	Ease of use		
	Ofuoku et al. (2008)			
	Hall and Khan (2003)	Profit	Geographical features	Infrastructure
	Walker (1969)		Culture	Work place
	Hollenstein (2004)		Occupational status	Size of industry
Industry	Giunta and Trivieri (2007)		Age	
			Social influence	
			Experience	Market conditions
	Karshenas and Stoneman (1993)			R&D
	Rogers (1995)	Relative advantage	Social interaction	farm size
	Kargin and Basoglu (2006)	Compatibility	Demonstration	Population size
	Baliamoune-Lutz (2003)	Observability	Education	Trade police
Service	Wareham et al. (2004)	Profit	Age	Freedom
	Massini (2004)	Usage		Market conditions
	Yang (2005)	New idea		
	Macharia and Nyakwende (2009)	Income		
	Lee et al. (2011)			

Source: Compiled from the previous studies

2.4 Summary

The literature survey shows that ICT tools benefited the fishermen in various ways including enhanced communication, understanding the distribution of fish resources, enhancing the fish catch, and for improving their income. The epidemic approach was used as one of the main approaches to the diffusion of a new technology in the agricultural sector. There are various diffusion models successfully tested empirically in the agriculture and industry sectors such as Logistics, Bass, and Gompertz methods. There are several factors influencing the adoption of a new technology in the sector, suggested by various researches.

Chapter 3

THEORTICAL AND EMPERICAL LITERATURE ON DIFFUSION: AN OVERVIEW

In this chapter, a detailed introduction of concepts of technology, diffusion and adoption process along with theoretical framework of technology adoption and its diffusion process is discussed. This chapter begins with various views of diffusion and ends with some empirical evidences of the diffusion process.

3.1 Introduction

Technology is a fundamental component of production and the main driver of growth. Technology and technological changes also play a significant role in the socio-economic development of any country. Technology means the goods and services produced and the means by which they are produced in a firm, an industry or an economy. Technological change refers to the application of a new knowledge or previously ignored or rejected production methods of scientific, engineering, or agronomic principles to techniques of production across a broad spectrum of economic activity which enables the economy to obtain greater outputs from the same inputs, as time proceeds (Atkinson and Stiglitz, 1969; Strassmann, 1968). Concept of the technology in economics is a subject of increasing concern in the modern world; it is also a subject that remains controversial and speculative in nature (Pytlik et al., 1985; Mowery and Rosenberg, 1991). Meanwhile, technology, technological change, and technological diffusion play a central role in the theory of resource allocations in economics. A serious study of the process of technology change, diffusion and its adoption by economists began only in the 1950s (Ruttan, 1996).

In this chapter, Section 3.2 discusses the technological theory in economics which begins from Classicals, Neo-classicals, and the New growth theories. Section 3.3 presents the theoretical view of technological diffusion.

3.2 Perspectives of Technological Change

Technology and technological change are the main ingredient factors of economic growth and development. The Classical Theory is based on the works of three English economists of the early nineteenth century - Thomas R. Malthus, David Ricardo, and John Stuart Mill who were pessimistic about the possibility of a sustained economic growth. In the late-eighteenth century Classical economist Adam Smith, in his *Wealth of Nations*, emphasised that division of labour and capital accumulation are powerful factors in the organisation and efficiency of scientific progress (Antonelli, 2009). The exogenous growth model developed by Robert M. Solow observed that technological change is an exogenous phenomenon (Solow, 1957) and other Neo-classical economics largely did not try to explain what caused technology to improve over time. Contrary to the Neoclassical ideas, Kaldor (1957); Verdoorn (1949); Fabricant et al. (1942); Young (1928); Arrow (1962) and Uzawa (1965) introduced models of *learning by doing* as a source of technological progress and formulated full-fledged growth models with endogenous technological change (Paul M. Romer and Robert E. Lucas) in the late 1980s and early 1990s. The central notion of the endogenous theory is that increasing returns is associated with accumulation of new knowledge, human capital and technology (Lucas, 1988; Romer, 1994; Cortright, 2001) that serve as the engine of economic growth. The question of what kind of structure promotes rapid technological progress in an economy was answered by Joseph Schumpeter[1] who opined that a large market with market power accelerate the rate of invention, innovation, and diffusion[2] (Ruttan, 1959; Nicholas, 2003). It is a linear progression from invention to innovation and innovation to imitation/diffusion (Sarkar, 1998). In Schumpeter's analysis, the invention phase or the basic innovation have less of an impact, while the diffusion and imitation process have a much greater influence on the state of an economy (Sledzik, 2013). Schumpeter (1934) observed that innovation or technological progress is the only determinant of economic growth.When the level of technology becomes constant the process of growth stops. Thus, it is the technological

[1] J Schumpeter is considered as the father of the study of diffusion in Economics(Stoneman, 1995)

[2] Invention means new concepts or products that derive from individual's ideas or from scientific research. Innovation means an idea, practice, or objective that perceived as new by an individual or other unit of adoption. In simple, diffusion means a process by which an innovation is communicated through certain channels over time among the members of social system (Rogers Everett, 1995)

progress which keeps the economy moving. Inventions and innovations have been largely responsible for rapid economic growth in developed countries.

3.3 Technological Diffusion

Diffusion of innovation theory attempts to explain how new ideas and practices spread within and between communities. Diffusion of new technology takes time, often a considerable period of time (Stoneman, 1995). Diffusion theory is one of the most widely used theories of communication (Gatignon and Robertson, 1985). The theory emerged from various disciplines, anthropology, economics, geography, sociology, and marketing (Robertson, 1971; Brown, 1981) in the 1920s, 1930s and 1940s (Rogers Everett, 1995). By the late 1950s and mid-1960s, more economists started to contribute the adoption and diffusion literature, and the most important among them were the works of Griliches (1957); Mansfield (1961); Hanel and Niosi (2007); Dixon (1980); Stoneman (2002). The adoption of technology depends on the characteristics of the potential adopters and its absorptive capacity (Cohen and Levinthal, 1990) in the system which focuses on the demand side of the technological diffusion. The theoretical approach of technology diffusion can be divided into supply and demand approaches.

Most of the modelling frameworks of the diffusion process have considered only the demand side to explain diffusion process. However, the observed diffusion pattern is the result of interaction between the forces of both supply and demand approaches (Karshenas and Stoneman, 1993). The interaction of both the supply and demand approaches is discussed in the models like epidemic model, rank model, stock, and order model.

3.3.1 Epidemic Model

Epidemic model is one of earliest model of technological diffusion process. The best examples of this model are studies by Griliches (1957) and Bain (1963). This model assumes that, the use of new technology is constrained by the number of the fishermen who know and who do not know about the existence of that technology. As time proceeds, users and non-users mix socially and make contact with each other, leading to further spread of information. Over time, number of users increases and with constant mixing of the population, there is a greater chance of a non-user meeting a user and becoming a user. It could be assumed that all potential adopters know that the technology exists but knowledge of the performance characteristics of the technology is limited and epidemic model shows transferring of knowledge through social contact. This model is self perpetuating and once it starts, it will finish only when all potential members accessed the technology. The model also is a disequilibrium model, because along the diffusion the actual level of use of technology is always less than the equilibrium level of use.

3.3.2 Probit or Rank Approach

The Probit model or the rank model are the other important diffusion approaches (Karshenas and Stoneman, 1993; Davies, 1979). In the rank model, the population can be ranked in terms of the benefits derived from its adoption. Population of a society is assumed to be heterogeneous, and different members of the population would get different benefits from the technology. Thus, in this system, an individual considering acquisition of technology will compare its benefits against its cost. A new technology is adopted if the gross benefit of the technologies greater than the cost of acquisition i.e. $B(t) \geq C(t)$. The costs of acquisition of new technology also depends on its R&D programmes and they are able to assimilate new technology more easily (Cohen and Levinthal, 1989) than others.

The stock model of diffusion is a similar work by Schumpeter (Stoneman, 2002). It shows that, the return to adoption depends on the number of uses at any point in time. It states that the innovation leads the entrepreneur to generate excess or entrepreneurial profits. These profits then act as a signal to other potential users of the technology who follow the lead of the entrepreneur in the search for profits.

3.3.3 Evolutionary Model

Evolutionary model of diffusion is based on a micro perspective of technology adoption and was mainly done by Nelson (1968); Nelson and Winter (2009); Hanel and Niosi (2007) & Stoneman (1995). Viewed from the point of view of an individual, firm or other organization, models of this type estimate the factors (characteristics of firms, industries and technologies) that increase or decrease the probability of adoption of the new technology by the observed unit (Hanel and Niosi, 2007). Here, technological adoption takes place in a context of uncertainty and limited information. It states that diffusion of a technology to be a confrontation between the old and the new instead of considering that, at any time there are a variety of technologies available and that diffusion is the outcome of the process of competitive selection across these technologies (Metcalfe, 1987). A Rosenberg-type "learning by using" process occurs in the adopters, whereas a "learning by searching" progression takes places in the innovating firms together with an Arrow-type 'learning by doing' enhances the original adoption (Hanel and Niosi, 2007). This new strand of evolutionary models is based on complexity and systems dynamics inspired by the work of Jay Forrester and John Sterman at MIT and W. B. Arthur and David Lane at the Santa Fe Institute (Sterman, 2000; Lane et al., 2009).

3.4 Various Perspectives of Diffusion

The major concern of the diffusion of a new technology is that, all the members of the population of potential adopters do not adopt simultaneously and some never adopt. For better understanding of this complex situation, Brown (1981) classified four major diffusion perspectives. They are: (1) adoption perspective,(2) the market and infrastructure perspective, (3) the economical and historical perspective, and (4) the development perspective. Each of these perspectives addresses the diffusion aspect in various ways, but to some extent, they are considered as complimentary to each other, which provide a comprehensive view of the innovation-diffusion process.

3.4.1 Adoption Perspective

Adoption Perspective is a traditional and more dominant approach to diffusion studies. Thus, primarily focusing on the process through which adoption occurs. It assumes that everybody has an equal opportunity to adopt and explains the differences in actual time of adoption with individual characteristics (Rogers and Shoemaker, 1971). The best tenet of this conceptualization of the spread of innovation across the landscape is that the adoption of an innovation is primarily the outcome of learning process. The fundamental step in the process of diffusion is identification of factors and characteristics related to the effective flow of information, information reception and resistances to adoption (Brown, 1981).

3.4.2 Market and Infrastructure Perspective

Market and Infrastructure Perspective is a complimentary approach to adoption perspective and it holds the supply aspects of diffusion. Diffusion process is carried out by undertaking three activities (Brown, 1981); (1) establishment of diffusion agencies (2) strategy to implement, termed as establishment of innovation, and (3) adoption of the innovation. The establishment of diffusion agencies and the operating procedures of each agency are, more generally, aspects of marketing the innovation. This marketing involves both the creation of infrastructure and its utilization. Thus the characteristics of the relevant public and private infrastructures - such a service, delivery, information, transportation, electricity or water systems- also have an important influence upon the rate and spatial patterning of diffusion. In short, the market and infrastructure perspective emphasizes on the role of diffusion agencies instead of the adopter.

3.4.3 Economical and Historical Perspectives

Both the adoption and the market and infrastructure perspective present a static approach to innovation because they implicitly presume innovation to be same throughout the diffusion process. In contrast, the economic historians talk about the dynamic approach of innovation, by emphasizing upon both the preconditions of diffusion as well as continuity of innovation. The traditional interpretation of economic historians are more concerned with the invention than with the diffusion process. The reinterpretation of economic history conveys that innovation is a continuous process and this is characterized by innovation-diffusion interaction. This continuity of innovation affects the temporal and spatial pattern of diffusion in both supply and demand viewpoints. From supply point of view, market or potential adopters have significant bearing on the location and timing of the supply of new technology (or innovation) and its adoption. The time of the diffusion process depends upon the nature of the new technology, its novelty and complexity, and its profitability. On the demand side, even if innovation is made available, some potential adopters (individual or firms) might prefer to delay their decision expecting further improvements in the innovation system. Specifically it can be said that, economic history perspectives examines three complementary aspects of innovation diffusion, namely, dynamism of innovation, process through which innovations are made available to potential adopters and the demand side factors (Brown, 1981).

3.4.4 Development Perspective

This approach is a logical extension of the market and infrastructure perspective. One of the major areas of research is the impact of innovation diffusion, such as its effects on economic development, social change and individual welfare. Development perspective represents a reaction to a discontinuity between belief and fact. It is concerned with two aspects (1) the ways in which the levels of development affects the diffusion process. (2) the outcome or impact of that process on development. The first aspect can be related to the availability of infrastructure and other public goods in the economy, which have a significant influence on the extent of diffusion and the types of innovation diffused. Good access facilities, well developed transport, easy availability of credit etc., are factors which have a significant promotional effect on potential adopters and thus stimulates innovation-diffusion.

3.5 Measuring Technological Diffusion

The study about the spread of use (as stated by epidemic model) and or ownership of new technology is known as technological diffusion. The diffusion of technology takes time and it improves over time. It is also shown that the diffusion rates differ across industries, regions or states and countries and also across technologies. Suppose there are N potential users of a new technology and each one adopt the technology when they get information about it at time t. Under the assumption of homogeneous mix of population, at time t, $y_{(t)}$ firms have adopted and $N - y(t)$ have not, if the information passes from central sources, reaching $\alpha\%$ of the population each period. If $\alpha = 1$, then sources contact all N potential users in the first period, and diffusion is instantaneous. On the other hand, if $\alpha < 1$, then the information spreads gradually, and so does the uses of the new technology. A transmitter that contacts $\alpha\%$ of the current population of non-users, $N - y_{(t)}$, at time t over the time interval Δt increases awareness (usage) by an amount change $y(t) = \alpha N - y(t)\Delta t$, taking the limit as Δt tends to zero and solving for the time path of usage provides the Equation 3.1. This expression is the standard logistic curve, often used to represent the sigmoid shape of the diffusion process. This illustrates that, a low initial rate of growth of ownership follows by faster rate of growth up to the point of inflexion, after which, although still positive rates of growth declines. The diffusion process and its various stage of adoption is presented in Figure 3.1 and Table 3.1.

$$y_{(t)} = N(1 - exp[-\alpha t]) \tag{3.1}$$

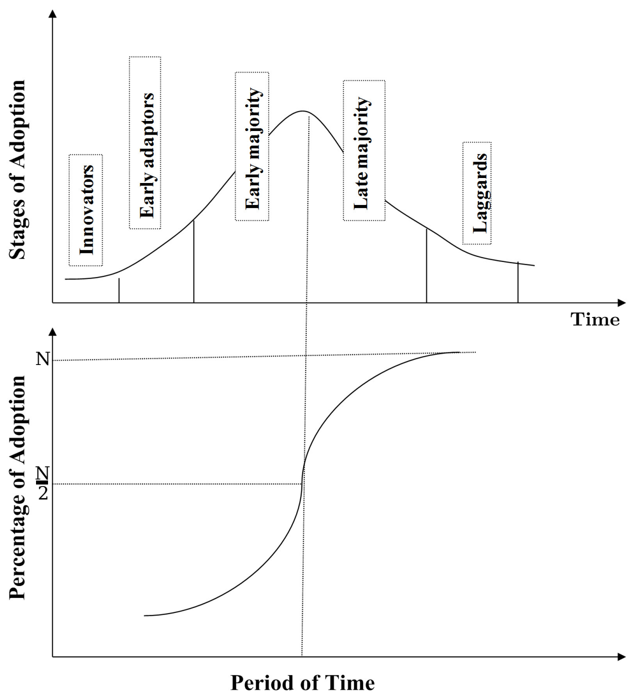


Figure 3.1: Theoretical 'S' shaped curve (compiled from Rogers Everett (1995) Rogers & Stoneman (2002)

A new technology is consumed in the beginning of the process by some innovator users, and later on by an increasing number of users (imitators) as shown in Figure 3.1.

At a certain point, adoption level starts to decrease (when most of the technology is used), and finally the marginal change in the amount of new adopters approaches zero where full penetration of a new technology is achieved (Jaakkola et al., 1998). This process of adoption gives sigmoid shape or S shape curve. The theoretical justification for this shape commonly used by economists is the hypothesis which is usually referred to as the *demonstration* or *bandwagon effects* (Jensen, 1983).

Table 3.1
Three different views of the stages of new technology adoption

Beal and Bohlen 1957	**Rogers** 1995	**Manueli et.al.** 2007
Innovators	Innovators	No ICT adoption
Early adopters	Early adopters	Basic ICT adoption
Early majority	Early majority	Intermediate ICT adoption
Majority	Late majority	Advanced ICT adoption
Non- adopters	Laggards	

Source: Compiled by the researcher, from Beal and Bohlen (1957); Rogers Everett (1995) and Manueli et al. (2007)

To apply and interpret the results of any diffusion model, we must understand its concepts and mathematical foundations. There are different models for finding out the diffusion pattern of the technology and predict the trend of adopters as shown in the Table 3.2. One of the fundamental diffusion models is expressed as in the following differential Equation 3.2.

$$\frac{dnt}{dt} = (gt) = [\bar{N} - N_t] \tag{3.2}$$

With the boundary condition $N_{(t=t_0)} = N_0$, $N_{(t)}$ is the cumulative numbers of adopters at time t, $N_{(t)} = \int_{t0}^{t} d(t), n(t)$ being the non-cumulative number of adopters at time t, $\bar{N}$ is the total number of potential adopters in the social system at time t, $\frac{dnt}{dt}$ is the rate of diffusion at time t. Diffusion of an innovation at any time t is a function of (i.e., is directly proportional to) the difference between the total number of possible adopters existing at that time and the total number of previous adopters at that time $[\bar{N} - N(t)]$. The model shows that as the cumulative number of prior adopters, $N(t)$, approaches the total number of possible adopters in the social system, $\bar{N}$, the rate of diffusion decreases.

The nature of relationship between the rate of diffusion and the number of potential

Table 3.2
Diffusion models and their application of a new technology

No.	Diffusion models	Equation	Shape	Inflexion point	Application
1	Logistics function	$y_t = \frac{a}{1+e^{-k(x-xc)}}$	S	0.5	Telecom innovation
2	Gompertz function	$y_t = ke^{\alpha e^{-\beta}}$	NS	0.37	Consumer durable goods (vcd, TV), agriculture, telecom innovation
3	Bass model	$yt = N[\frac{1-e^{(p+q)t}}{1+(q/pe^{(p+q)})}]$	S	0.0-0.5	Consumer durable goods (vcd, TV), retail service agriculture, industrial process
4	Fisher Pry model				
5	Floyd model	$bF = (1 - F^2)$	NS	0.33	
6	Sharif - Kabir model		S or NS	0.33-0.5	
7	Jeuland model	$(a + bF)(1 - F)^{(1+y)}$	S or NS	0.0-0.5	
8	Non uniform influence	$(a + bF)^{\delta}(1 - F)$	S or NS	0.0-1.0	
9	Non symmetric responding	$(bF)^{\delta}(1 - F)$	S or NS	0.0-1.0	
10	Von Bertalanffy model	$\frac{b}{1-\theta}F^{\theta}1 - F^{(1-\theta)}$	S or NS	0.0-1.0	

Source: (EASINGWOOD and MULLER, 1983)

adopters as shown existing at t, $[\bar{N} - N(t)]$, is controlled by $g(t)$, the coefficient of diffusion. The specific value of $g(t)$ depends on the characteristics of diffusion process such as the nature of the innovation, communication channels used, and attributes of social system. In addition, $g(t)$ can be interpreted as the probability of an adoption time t. If this interpretation is used, then $g(t)$. $[\bar{N} - N(t)]$ represents the expected number of adopters at time t, $n(t)$. Furthermore, if $n(t)$ is viewed as the number of members in social system transferred from potential adopter status to non potential adopter status at time t, then $g(t)$ can also be considered a transfer mechanism, a conductivity coefficient or a coefficient of conversion. Two distinct approaches have been used to represent $g_{(t)}$, viz; as a function of time and as a function of the number of previous adopters.

3.6 Technology Acceptance Theories and Models

Understanding the influencing factors of adoption is important to the present study. Finding out the reason of adopting or rejecting any new technology by users has become one of the most important areas in the information communication technology (Momani and Jamous, 2017). Technology acceptance theories and models aim to convey the concept of how users may understand and accept the new technology and how they may use it (Fishbein and Ajzen, 1975). For any new technology, there are many variables affect the individual's decision-making process about how and when they will use it.

Thus, the most important eleven theories are reviewed as follows: the Theory of Reasoned Action (TRA) (Fishbein and Ajzen, 1975), the Theory of Planned Behaviour (TPB) Ajzen (1985), the Decomposed Theory of Planned Behaviour (DTPB) (Taylor and Todd, 1995), the Technology Acceptance Model (TAM) (Davis, 1985), Extended Technology Acceptance Model (TAM2) (Venkatesh and Davis, 2000), the Combined TAM and TPB (C-TAM-TPB) (Taylor and Todd, 1995), The Model of PC Utilization (MPCU) (Triandis, 1979), the Innovation Diffusion Theory (IDT) (Rogers, 2003), the Motivational Model (MM) (Deci and Ryan, 1985), the Social Cognitive Theory (SCT) (Compeau et al., 1999), and The Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003) are developed in several scientific and social fields and are reviewed as well.

3.6.1 Theory of Reasoned Action (TRA)

TRA is one of the earliest technology acceptance theories. It was developed in the field of social psychology by Ajzen and Fishbein in 1967 (Vallerand et al., 1992). It is one of the most fundamental theories of human behaviour (Wang et al., 2009). In this model, any human behaviour is predicted and explained through three main cognitive components including attitudes (unfavourableness or favourableness of person's feeling for a behaviour), social norms (social influence), and intentions (individual's decision do or do not do a behaviour) (Taherdoost, 2018). Their aim was to develop a theory that could predict, explain, and influence human behaviour. They considered that this theory is moderated by two main constructs; attitude toward behaviour and subjective norm .

3.6.2 Theory of Planned Behavior (TPB)

TPB is an extension of TRA, developed by Ajzen (Ajzen, 1985). It was extended by adding a new construct which was perceived behavioural control(Armitage and Conner, 2001). It is theorized to be an additional determinant of intention and behaviour. TPB has been successfully applied to the understanding of individual acceptance and usage of many different technologies. Ajzen (1985) considered that this theory is moderated by three main constructs; attitude toward behaviour and subjective norm of TRA, with the new one, the perceived behavioural control.

3.6.3 Decomposed Theory of Planned Behavior (DTPB)

The DTPB has been discussed two times in separate studies by Taylor and Todd (Taylor and Todd, 1995). It decomposes attitude toward behaviour, subjective norm, and perceived behavioural control into multi-dimensional belief constructs within technology adoption contexts. As an extension to TPB, which was an enhancement of TRA, the DTPB expanded the TPB by including three factors from the Innovation Diffusion Theory (IDT). IDT includes relative advantage, compatibility, and complexity. The relative advantage and compatibility were joined together in order to make some effect on perceived behavioural control (Taylor and Todd, 1995). According to Taylor and Todd (Taylor and Todd, 1995) examination to TRA, TPB, and DTPB, they found that TRA and TPB are good in pre-dating the behaviour, but DTPB proved effective in explaining the behaviour.

3.6.4 Technology Acceptance Model (TAM)

TAM is an adaptation of TRA done by Davis (Davis Jr, 1986). It replaced TRA's attitude toward behaviour with two technology acceptance measures. They are perceived usefulness and perceived ease of use (Davis et al., 1989). TAM did not include the TRA's subjective norms in its structure. It is developed in information technology field while TRA and TPB developed in the psychology field, so that it is less general than TRA and TPB (Venkatesh et al., 2003). The development for TAM comes through three phases: adoption, validation, and extension.

3.6.5 Extended Technology Acceptance Model (TAM2)

TAM2 was extended model of TAM by Venkatesh and Davis(Venkatesh and Davis, 2000). It explains perceived usefulness and perceived ease of use from the social influence and cognitive instrumental processes' viewpoints. Social influence processes refer to: subjective norm, voluntariness, and image, while cognitive instrumental processes refer to: job relevance, output quality, result demonstrability, and perceived ease of use. Unlike TAM, Venkatesh and Davis inserted subjective norm as an additional construct by adopting from TRA and TPB models. Subjective norm has direct relations with perceived usefulness and intention of use. Its relation with perceived usefulness is moderated by the user experience, while its relation with intention of use is moderated by the user experience and voluntariness of use. Extending TAM to TAM2 by including some constructs from older theories in addition to some moderators to perceived usefulness and perceived ease of use will enhance the performance to the model. As an example, the existence of experience moderator will show the increase in the level of users' experience in technology over the time, and this will cause a tangible change in technology acceptance to them.

3.6.6 Combined TAM and TPB (C-TAM-TPB)

Taylor and Todd developed this combined model in 1995 by combining the TPB model from social psychology field with TAM from information technology field to achieve a better use of TPB in technology acceptance (Wang et al., 2009). This model combines the predictors of TPB with perceived usefulness from TAM to provide a hybrid model (Taylor and Todd, 1995). TAM and TPB theories supposed that behaviour is determined by the intention to perform the behaviour. Intention itself is determined by the attitude towards behaviour. The constructs of TAM do not fully reflect the specific influences of technological and usage-context factor that may change user's acceptance (Taylor and Todd, 1995). Davis Jr (1986) noted that the future technology acceptance researches need to address how other variables affect usefulness, ease of use, and acceptance. It is applied in many fields (Pynoo et al., 2012).

3.6.7 Model of PC Utilization (MPCU)

Some technology acceptance theories such as TPB and TAM developed over the TAR concept in order to explain the individual usage behaviours (Triandis, 1979; Ajzen, 1985; Fishbein and Ajzen, 1975). TPB and TAM adopted TRA with the majority of its advantages and limitations. The research work of Triandis (1979) resulted a framework that described how the behaviour happened, and what are the variables that encourage the individual to do the behaviour while using the personal computer (PC).

3.6.8 Innovation Diffusion Theory (IDT)

IDT developed by Rogers in 1962 (Rogers Everett, 1995). This theory was a result of several diffusion studies which had been done in 1950s and focused on individuals' differences in innovativeness. Rogers Everett (1995) proposed four major factors for determining the behaviour: innovation, communication channels, time and social systems. Diffusion: is the process in which an innovation is communicated through certain channels over time among members of a social system. Innovation: is an idea, practice, or object that is perceived by an individual. Communication: is a process that leads to create and share information with others in order to get a common understanding. Rogers stated that there are five innovation attributes which effect on individuals' behaviours and explain the rate of innovation adoption. These attributes are: relative advantage, compatibility, complexity,trialability, and observability (Rogers, 2003). He suggested five stages of adoption process of a new technology. They are: innovators, early adopters, early majority, late majority and laggards (see the section 3.3 for more details).

3.6.9 The Motivational Model (MM)

Since 1940's, many theories have been resulted from motivation research. Self-Determination Theory (SDT) developed by Deci and Ryan (1985) is one of them. SDT proposed that self-determination is a human quality that involves the experience of choice, having choices and making choices (Deci and Ryan, 1985). Deci et al. (1991) mentioned that the regulatory process is choice when behaviour is self-determined, but when it is controlled, the regulatory process is compliance, or defiance in some cases.

3.6.10 Social Cognitive Theory (SCT)

SCT idea started in 1941 by Miller and Dollard with the name of Social Learning Theory (SLT) for the purpose of introducing the modelling into the principle of learning. In 1986, Bandura had developed SCT as a result of his continued work started in 1960s to expand SLT to become one of the most powerful theories of human behaviour (Bandura, 2001). The major feature of SCT is the social influence and its effect on external and internal social reinforcement. SCT also cares about the previous experiences of individuals. These previous experiences are influencing reinforcements and expectancies with no matter if the individual engages in a specific behaviour or not, and exposing the reasons why the individual engages in that behaviour. SCT believes that previous experiences create expectations of outcomes related to performing certain behaviour.

3.6.11 Unified theory of acceptance and use of technology (UTAUT)

The Unified Theory of Acceptance and Use of Technology integrates constructs across the eight models/theories (Zhou et al., 2010; Wang et al., 2009). The eight models/theories include TAM, TRA, TPB, C-TAM-TPB, IDT, SCT, MM, and MPCU. Although UTAUT has not been as widely used as TAM, it has gradually drawn researchers' attentions and has been recently applied to exploring user acceptance of mobile technologies (Carlsson, Carlsson, Hyvonen, Puhakainen, & Walden, 2006; Min, Ji, & Qu, 2008; Park, Yang, & Lehto, 2007).

UTAUT model is one of the most important models to understand the usage of ICT. It was strengthened from Technology Acceptance Model (TAM) (Muhammed Shaffril, 2012). It is a technology acceptance model formulated by Venkatesh and others in 'User acceptance of information technology: Toward a unified view' (Venkatesh et al., 2003). This model has four main variables. They are; performance expectancy, efficiency expectancy, social influence and facilitating condition. The performance expectancy and efficiency expectancy are used to integrate perceived usefulness and perceived ease of use in the original TAM model (Muhammed Shaffril, 2012). Apart from this, demographic factors (gender, age and experience) and voluntariness of use are included to mediate the impact of the main variables on usage intention (Venkatesh et al., 2003).

3.7 ICT: A General Purpose Technology

The term general-purpose technology (GPT) has been used extensively in recent literature which confirms about the role of technology in economic growth. It is usually reserved for showing the changes that transform both household and business life (Jo-

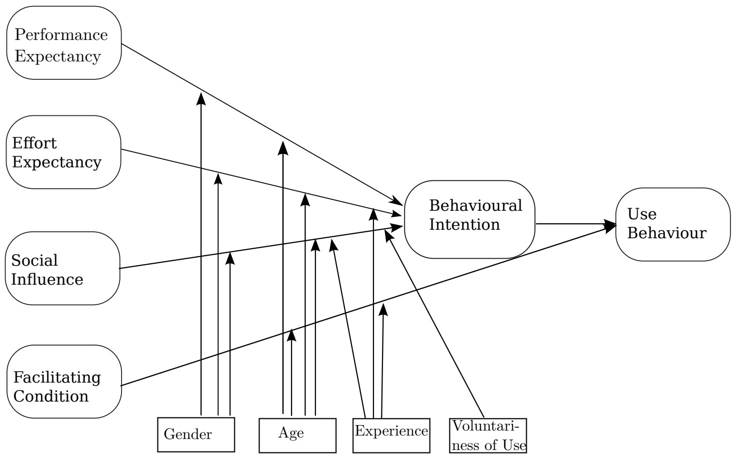


Figure 3.2: Hypothesised UTAUT model of Venkatesh et al. (2003)

vanovic and Rousseau, 2005). Some technologies are more important in the process of economic growth, while others and some new technologies may have only a small impact on the production process. Some technologies have only a very limited area of application. Thus, the term general purposive technologies has been coined to encompass these widely applicable technologies (Stoneman, 2002). GPT is a term coined to describe a new method of production and invention that is important enough to have a protracted aggregate impact. Electricity and information technology (IT) are the two most important GPTs (Jovanovic and Rousseau, 2005).

The concept of GPT was introduced by Bresnahan and Trajtenberg (1995), along with three key characteristics of such technologies, which are pervasiveness (should spread all sectors), technological dynamism (should get better over time) and innovational complementaries (make it easier to invent and produce new product or process).

ICT can be one of the best examples of GPT in this aspect. ICT revolution has contributed significantly to the whole economy by raising productivity. Many economists consider ICT as a general-purpose technology due to its pervasive character. It has already become an indispensable part of production of goods and services, irrespective of the industry (Erdil et al., 2009). Pohjola (2001) stated that ICT would need the development of complimentary inputs, infrastructure such as education, skills, telephones, and electricity connectivity etc., in order to reap the maximum benefit from the GPT. The literature has identified two important channels by which ICT applications have the effects on real economy which are production of ICT and the use of ICT (by other industries).

3.8 ICT and Diffusion Models

Researchers such as, Griliches (1957); Mansfield (1961); Ryan and Gross (1943) and Beal and Bohlen (1957) have observed the continuous process of a new technology adoption based on several depending factors over a period of time which provides ‘S’ shaped or sigmoid curve in the agriculture sector. Rogers Everett (1995); Stoneman (2002) and Geroski (2000) developed several diffusion theories of technology adoption to explain the characteristics of the S-shape applying any field of study. Hall and Khan (2003); Stoneman (2002) gave an empirical analysis of ‘S’ shape curve where they stated that the rank and the epidemic models are the dominant factors explaining the adoption of a new technology. Rank model depends on inter firm differences of adoption time, intensity, and profit, whereas epidemic model depends on the spread of information from users to non-users. Mahajan and Peterson (1985) provides major diffusion models such as; Gompertz, logistics and cumulative normal growth functions for mathematical optimization and prediction of the adoption processes of new technologies. Normally, any technology diffusion process is empirically tested with the help these models in any sectors. Following are some important studies of application of Gompertz, logistics and Bass model of ICT tools application in selected areas.

The following models; Gompertz, Logistic and Bass models are commonly used to investigate mobile telephony diffusion (Wu and Chu, 2010b).

Gompertz model

The Gompertz model is one of the most frequently used sigmoid models fitted to growth data and other data, perhaps only second to the logistic model. Researchers have fitted the Gompertz model to everything from plant growth, bird growth, fish growth, and growth of other animals, to tumour growth and bacterial growth (Tjørve and Tjørve, 2017). The

Gompertz model is expressed as

$$\frac{d_y}{d_t} = rNIn\frac{K}{N} \tag{3.3}$$

where N is the number of adopters at time t, r is the intrinsic growth rate, and K is the maximum (equilibrium) number of adopters. The solution for this first-order differential equation is

$$N(t) = Ke^{-e^{-r(t-m)}} \tag{3.4}$$

Logistic model

The logistic growth function is very similar to the exponential growth function, except that it levels off once it reaches a certain point. Model shows for a quantity that increases quickly at first and then more slowly as the quantity approaches an upper limit. This model is used for such phenomena as the increasing use of a new technology, spread of a disease, or saturation of a market (sales)(Mahajan and Peterson, 1985) (see 1.7.2 more details).

$$\frac{d_y}{d_t} = rN(1 - \frac{N}{K}) \tag{3.5}$$

where N is the number of adopters at time t, r is the intrinsic growth rate, and K is the maximum (equilibrium) number of adopters. The solution of this first-order differential equation is

$$N(t) = \frac{K}{1 + e^{-r(t-m)}} \tag{3.6}$$

Bass model

The Bass diffusion model was developed by Frank Bass and describes the process of how new products get adopted as an interaction between users and potential users. The model is widely used in forecasting, especially product forecasting and technology forecasting.

Mathematically, the basic Bass diffusion is a Riccati equation with constant coefficients (Dowling, 1980). The Bass model classifies adopters into two categories, innovators and imitators, which are expressed as

$$\frac{f(t)}{1 - Ft} = p + qF(t) \tag{3.7}$$

where $f(t)$ is the likelihood of adoption at time t; $F(t)$ is the fraction of the ultimate potential adopted by time t, p is the innovation coefficient, and q is the imitation coefficient. Eq.3.9 can be rewritten as

$$\frac{dN}{dt}K - N = p + q\frac{N}{K} \tag{3.8}$$

where K is maximum (equilibrium) adoption potential, and N, which equals $KF(t)$, is the total number of adopters in the interval $(0, t)$. The solution for N is

$$N(t) = K\frac{1 - e^{(p+q)}t}{1 + \frac{q}{p}e^{-(p+q)t}} \tag{3.9}$$

Gupta and Jain (2012) used three important epidemic models of diffusion to study the spread of mobile phone in India. The Bass, Logistics, and Gompertz are the three models that they used to test its spread and for predicting the diffusion. They found the exact fit of Gompertz diffusion curve rather than logistic, bass model in the Indian mobile phone dissemination and the fitted curve traced 'S' shape. The study also found that tariff, fixed line telephony and communication with other people are the three major determining factors of adoption of mobile phone in India. Completion among service providers and government intervention are the major factors for spread of diffusion of mobile phones in India.

Singh (2008) estimated future trends with the help of Gompertz diffusion model and analysed the pattern and rate of adoption of mobile phones among the fishermen in India. For that, he used the 'S' shaped growth curve model. He found that mobile density in India would be 71% in 2015-16 and mobile subscribers would be 900 million. The reasons cited low tariff as result of competition of mobile companies, and increase in average income of people led to demand more mobile phones in India.

Botelho and Pinto (2004) estimated the rate of adoption of mobile phones in Portugal. They used 'S' shaped logistics function model to predict the number of cellular phones subscribers and found that it was growing at the rate of 18% per quarter. They also used the Gompertz model to describe a sigmoid diffusion curve. But logistic function fitted only adequately for mobile phone diffusion in Portugal.

Michalakelis et al. (2008) studied about diffusion models such as, logistics, Gompertz, bass, and fish pry models for data fitting and forecasting performance of 2G mobile telephone subscribers in Greece. All models of diffusion was well applied on mobile phone subscribers and forecasted their logistic shape. The study found that a saturation level of adoption of mobile phone was greater than 100% due to interaction between the groups and non-adopters.

Kwon and Stoneman (1995) theoretically and empirically tested the impact of technology adoption on firm output and productivity with the help of Cobb Douglas production function. Three versions of the model with varying degrees of endogenous was applied and then tested upon a data set relating to the adoption of five different process of technologies by 217 firms in the UK engineering industry over a period from 1981 to 1990. They found that technology adoption has a positive impact on output and productivity.

Many studies applied all the models of diffusion for measuring the level and characteristics of the diffusion curve in many field including agriculture and industry. Very limited studies have been conducted in the Indian communication industry and yet fewer studied the diffusion level of a technology (Mobile phone). But, no studies were conducted in Kerala for measuring the diffusion level of any new technologies, especially in agriculture sector. A systematic measurement of ICT tools by any basic growth models reveals economic and social development of the state. The present study measures the diffusion level of ICT tools in fisheries sector of Kerala with the help of logistic growth function. The following Table 3.3 shows the logistic growth model fits well (denoted as ✓) for measuring the Information Communication and Technology.

Table 3.3
Studies of diffusion models of ICTs and their application

Author	Area & Region	Logistics	Gompertz	Bass
Gruber and Verboven (2001)	Telecommunication in Eurpean union	✓	×	-
Botelho and Pinto (2004)	Cellular phone in Portugal	✓	×	-
Frank (2004)	Wirleless communication in Finland	✓	-	-
Lee and Cho (2007)	Mobile telecommunication - Korea	✓	-	-
Michalakelis et al. (2008)	Mobile communication - Greece	✓	✓	×
Singh (2008)	Mobile phone - India	✓	×	-
Gamboa and Otero (2009)	Mobile communication - Colombia	✓	-	-
Syamsuddin and Hwang (2009)	Mobile telephone - Vietnam	✓	×	×
Wu and Chu (2010a)	Mobile telephone - Taiwan	✓	×	×

Source: Compiled by researcher

3.9 Summary

Technology innovation and diffusion are the main factors of economic development and growth. Diffusion is an essential part in the process of technological change. Economic theories concentrated on various approaches of diffusion, explains the process of diffusion and individual adoption decision. The theoretical analyses suggest that, technology diffusion is based on both the supply and demand factors. Some firms tend to adopt innovations earlier than the others, since spreading information is important for them. Diffusion takes place in different ways for different technologies and industries. The speed of diffusion and the shape of the diffusion curve depends both on the distribution of benefits and on the rate at which its dissemination takes place. However, the Logistic growth model is analogous to the Epidemic model which gives S shape for the adoption of a new technology and fitted successfully its shape in the sector, than other models.

Chapter 4

MARINE FISHERIES SECTOR: A BROAD PERSPECTIVE

In this chapter, the overall fish production in the world is discussed. Present fish landings of maritime countries and their comparison with India and Kerala are presented. The demographic profile of fisherfolk of India and Kerala are also discussed and analysed. Also, this chapter discusses the evolution of technological development in the Kerala fisheries sector from the early 1950s to 2010. The role of Information Communication Technologies and its importance in the fisheries sector of Kerala is also discussed in here.

4.1 Introduction

The fisheries sector is a sunrise sector of Indian economy. It's role in increasing food supply, generating job opportunities, raising food security and nutritional level and earning foreign exchange has been made an important contribution to the world. Growing urbanization, globalization, social structures and policies and the high demand for fish have become a major structure in the country. Furthermore, information technology (IT), waste reduction, motorization of traditional craft, use of low-cost fish aggregation devices (FADs), species and stock enhancement, improvisations in gears and nets, design of equipments for post-harvest technologies to avoid imports, tuna hunting, and identification of new items for export are some of the new opportunities that have been identified in the marine sector (Mruthyunjaya, 2004). In this context, the present study compares the basic features of Kerala fish production and status of fisher population with other Indian states based on various marine censuses and report of CMFRI and National and State Department reports.

4.2 World Fish Production

Fisheries and aquaculture provide livelihood to an estimated 540 million people or 8% of the world population (Food and Organization, 2013). Fisheries and aquaculture[1] remain important sources of food, nutrition, income and livelihoods for hundreds of millions of people around the world. World per capita fish supply reached a new record high of 20 kg in 2014 FAO (2016b). Moreover, fish continues to be one of the most-traded food commodities worldwide with more than half of the fish exports by value, originating in developing countries. Recent reports by various experts tell that fisheries sector contribute significantly to food security by providing adequate nutrition for a global population, expected to reach 9.7 billion by 2050. However, presently FAO (2016a) confirms a stable situation of total marine fish production at the global level. The Table 4.1 and Figure 4.1 show fish production in the world in ten years period. Total Global total fish production reached 167.2 MT in 2014. While marine fish production has remained around 93.4 MT since 2014, aquaculture fish production has continued to show strong growth, increasing at an average annual growth rate of 5.8% from 44.3 MT in 2005 to 78.8 MT in 2014. For marine fisheries production, China remained the major producer followed by Indonesia, and the United States of America, whereas India holds fourth place in marine fish production. India also holds the second rank in aquaculture fish production after China (45.5 MT) in the world (FAO, 2016a).

Table 4.1

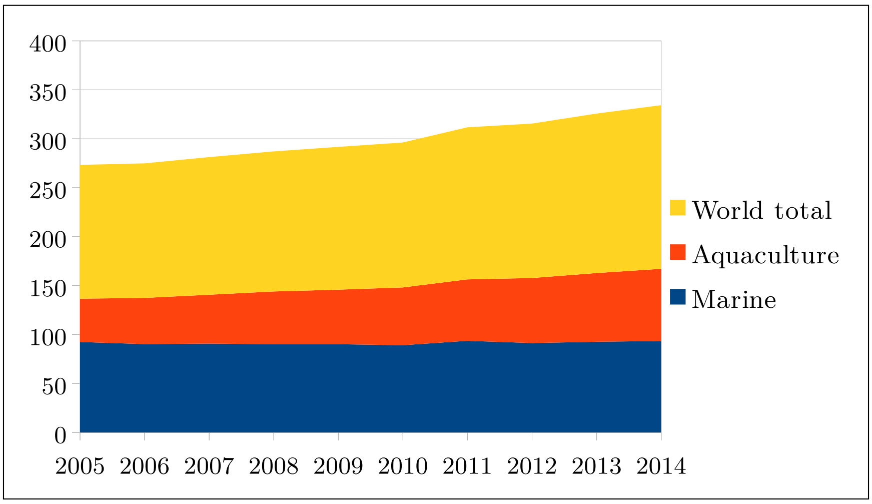
World marine fish production in ten years during 2005-2014 (in Million Tonne)

Sectors	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Inland capture	9.4	9.8	10	10.2	10.4	11.2	11	11.6	11.7	11.8
Marine capture (excluding anchevota)	NA	NA	NA	72.5	72.7	73.8	74.2	75	75.2	78.3
Anchevota	10.2	7	7.6	7.6	7.4	7	4.2	8.3	5.7	3.2
Marine capture	83	80.4	80.7	79.9	79.7	77.8	82.5	79.7	80.9	81.5
World total	**92.4**	**90.2**	**90.7**	**90.1**	**90.1**	**89.1**	**93.6**	**91.3**	**92.6**	**93.4**

Source: Various Fisheries and Aquaculture statistics reports, FAO.

Fish and fishery products represent one of the most-traded segments of the world food sector, with about 78% of seafood products estimated to be exposed to international trade

[1]The inland fisheries in India include both capture and culture fisheries



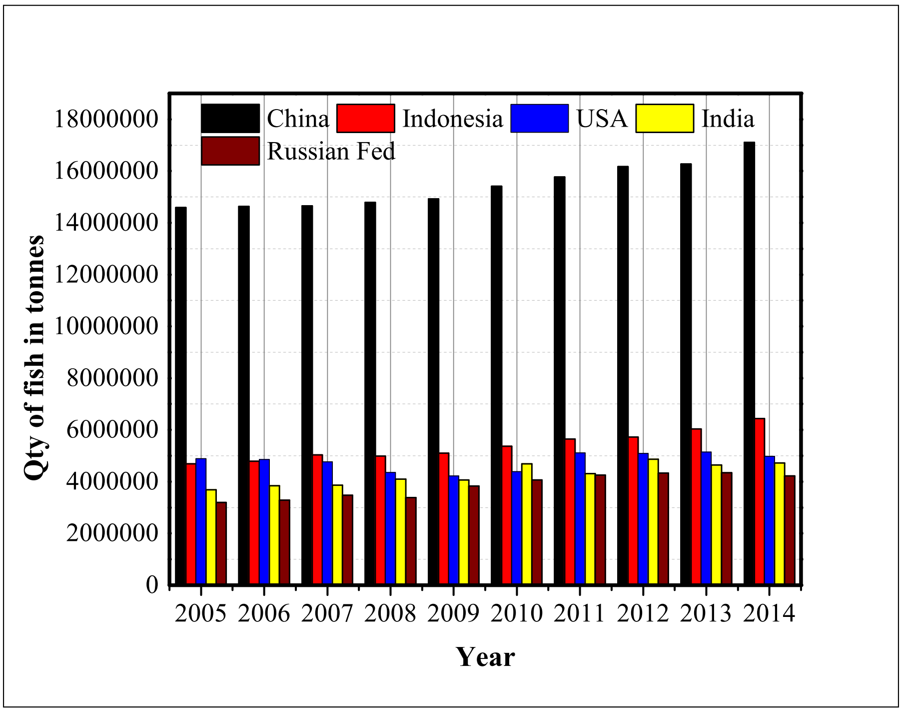
Source: Various Fisheries and Aquaculture statistics reports, FAO

Figure 4.1: World trend in fish production during 2005-2014

competition. About 36% of fish production enters into the international market in the year 2014. World exports of fish and fish products reached $148 billion in the year 2014 which is more than 6 percent over 2013. During the period 1976-2014, fish trade has grown at an annual growth rate of 8% in nominal terms and 4.6% in real terms. In 2010, about 76% of total fisheries imports in value were in developed countries, with the United States of America and Japan together accounting for about 27% of the total. Imports by the European Union (EU) represented a share of 40% of total world imports. However, if intraregional trade among EU countries is excluded, the share declines to 26% of world imports. This still makes the EU the largest market in the world. China is the main exporter of fish and fishery products, followed by Norway, Vietnam, and Thailand since 2015 (FAO, 2016b).

Fishery trade represents a significant source of foreign currency earnings for many developing countries, in addition to its important role in income generation, employment, food security and nutrition. Developing countries play a major role in exports with the top ten exporters accounting for 77% of the total value in 2014. In 2014, fishery exports from developing countries were valued at $80 billion, and their fishery net-export revenues (exports minus imports) reached $42 billion, higher than other major agricultural commodities (such as meat, tobacco, rice, and sugar) combined.

In the year 2014, about 87% (146 MT) of total fisheries production was used for direct



Source: Various Fisheries and Aquaculture statistics reports, FAO

Figure 4.2: Top five countries in marine fish production in the World during 2005-2014

human consumption (FAO, 2016b). The remaining 13% (21 Mt) was used for non-food products, mainly for the manufacture of fish meal and fish oil. About 46% used for human consumption was in live and fresh form. In 2013, global per capita consumption of fish was estimated at 19.7 kg, with fish accounting for about 17% of the global population's intake of animal proteins and 6.6% of all proteins consumed (FAO, 2016b). Globally, fish provides almost 20% of their average per capita intake of animal proteins to more than 3.1 billion people. Preliminary estimates for 2014 indicate a further growth in per capita consumption of about 20 kg, with the share of aquaculture production in total food supply overtaking that of the capture fisheries for the first time (FAO, 2016b).

4.3 India's Share in World Fish Production

The fisheries sector plays a vital role in the Indian economy. In the year 2016, India was the fourth largest major fishing country in the world in terms of quantity, after China, Indonesia, and the United States of America (Table 4.2). India contributes a significant rate of 42.29% of marine fish production and has a comparatively higher marine fisheries resources. India produces a good amount of fish resource comprising a coastal self of 6,068 km passing through 3,388 fishing villages and 1,511 landing centres across nine coastal states and two union territories. About 38% of marine fisher-folk were engaged in active fishing in which 85% are having full-time engagement (Shyam et al., 2014). There is no doubt that the fisheries sector in India has a strategic role in food and nutritional security, international trade, employment generation, and socio-economic status of fishing communities. With the changing consumption pattern, emerging market forces and technological developments, more importantly, have assumed added importance to the development of fisheries sector in India.

The share of agriculture and allied activities in the GDP is constantly declining. The agriculture sector is also diversifying towards high- value enterprises, including fisheries. The contribution of the fisheries sector to the GDP has gone up from 0.46% in 1950-51 to 1% in 2005 and it continued in 2016 (Table 4.4). The share of fisheries in agricultural GDP (AgGDP) has impressively increased during this period from a mere 0.84% to 4.9% and it continued even in 2016. In fact, the fisheries sector is booming and contributing increasingly to the economic growth of the nation.

4.3.1 India's Fish Production

World fish production has increased to 31 MT from 2005 to 2014. In a similar fashion the total fish production, from India has grown up to around 10 MT in 2016 from 6 MT in 2005, whereas marine fish production in India has increased from a mere 50,000 tonnes in 1950 to 3.94 million tonnes in 2012 (CMFRI, 2013). Aquaculture production has reached around 6.5 MT in 2016 which was almost nil in 1950 (Sathianandan et al., 2012). The global and Indian fish production during the last 10 years is presented in Table 4.2. The share of India in global fish production has grown gradually, from about 4.4% during the 2005 to 5.5% in 2015 and however, it was stagnant from 2008 to 2015, due to the various geographical and seasonal variation in the states. It showed that growth in fish production in India has been at a faster rate than that in the world, mainly due to the increasing contributions from inland fisheries (Kumar et al., 2003).

Figure 4.3 shows the fish production in India for over ten years which shows a positive trend. This is the only because of management policies and improvements in the fisheries catch in the inland sector rather than the marine sector. The production in the inland fisheries sector crossed the marine sector in the year 2000 and the marine fisheries sector is now sustainability. This reduced catch of marine fish in the inshore waters forces the fishermen to go to the deep sea, with the help of new information technologies. Large-scale fishing crafts used the advanced technologies during 2000 whereas and small-scale motorised sector faced the adoption of new technologies during the same year. A large number of adoption of ICT tools and its responsible use helped the fishermen to go deep sea and helped them to earn more income.

Composed of about 200 commercially important species, the marine fisheries resources were exploited by a variety of gears of fishing all along the coastline as well as in the inland (James, 2007). Fish production in various states from 2005 to 2016 is shown in Table 4.3. Andhra Pradesh, West Bengal, Gujarat, Kerala, and Tamil Nadu were the top five fish producing states in India during 2005-2016. West Bengal fisheries sector had the highest fish production from 1 MT in 2005 to 1.5 MT in 2010-11 followed by Andhra Pradesh with 1.3 MT in 2010-11. Kerala stands at the fourth place with 6.8 lakh tonnes, after Gujarat. In 2015 (provisional) data shows that Andhra Pradesh, West Bengal, Gujarat, Kerala, and Tamil Nadu produce 1.9 MT, 1.6 MT, 0.8 MT, 0.6 MT, and 0.6 MT respectively. The overall growth in fish production is gradually improving, due to some positive improve wants in aquaculture in the country (Table 4.3).

4.3.2 Contribution to Indian Economy

The Table 4.4 shows the total contribution of the fisheries sector to Gross Domestic Product from 2005 to 2016. Fisheries sector contributes to the national income, exports, food and nutritional security and employment generation. It is a principal source of livelihood for a large section of the economically underprivileged population of the country, especially in the coastal areas. The share of agriculture and allied activities in the GDP is constantly declining. The agriculture sector is also diversifying towards high-value enterprises, including fisheries. The contribution of the fisheries sector to the gross domestic

Table 4.2
Total fish production in India and the World, 2005-2015 (in Million Tonne)

	World			India			
Year	Total	Marine	Inland	Total	Marine	Inland	India's share (%)
2005	142.7	103.4	39.3	6.7	2.9	3.7	4.7
2006	143.7	101.9	41.7	7.0	3.2	3.9	4.9
2007	140.0	96.7	43.3	6.9	3.1	3.9	4.9
2008	142.5	96.3	46.2	7.9	3.4	4.6	5.6
2009	144.6	96.2	48.4	7.8	3.3	4.6	5.4
2010	148.0	95.2	52.1	7.9	3.1	4.9	5.4
2011	156.2	101.2	55.0	8.2	3.8	4.9	5.2
2012	157.8	91.3	66.4	8.9	3.9	5.6	5.2
2013	162.9	92.6	70.2	9.0	3.8	5.2	5.2
2014	167.2	93.4	73.7	9.6	3.6	6.1	5.4
2015	NA	NA	NA	10.0	3.4	6.5	5.4

Source: Fisheries Statistics, 2012, FAO Handbook on Fisheries Statistics, 2016, GoI, 2012, and CMFRI, various annual reports. India's share was manually compiled

product (GDP) has been increasing over the years, as indicated by the rising share of the fisheries sector in the GDP. On an average, the fisheries sector contributed approximately 1% of the GDP during the period 2001-2014. The average annual growth rate of the fisheries sector, estimated at 18% per annum, exceeds the average annual growth rate of GDP, estimated at 14% per annum.

The share of fisheries in agricultural GDP (AgGDP) has also shown a stagnant position with 4%. In fact, the fisheries sector is booming and contributing increasingly to the economic growth of the nation. The role of fisheries in the agricultural economy of almost all the states has been increasing as is evident from its enhancing share in the agricultural State Gross Domestic product (AgGDP). The present share of the fisheries sector to total GDP is 0.9%. Interestingly, this share has increased more prominently in the non-traditional fisheries states like Bihar, Haryana, Punjab, Madhya Pradesh, Uttar Pradesh, etc.

4.3.3 Fish Production: Structure and Trend

The fish production in India during the 1950s was more pronounced in marine fisheries, which remained the major contributor till the early 1990s. Its share in the total fish pro-

Table 4.3

Fish production in India from 2004-05 to 2014-15 ('000 tonne)

Sl.No.	States/UTs	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15(Prov)
1	Andhra Pradesh	891.09	856.93	1010.09	1252.78	1305.86	1368.2	1603.2	1808.077	2018.42	1964.4
2	Arunachal Pradesh	2.77	2.83	2.88	2.65	2.65	3.15	3.3	3.71	0.61	4
3	Assam	188.01	181.48	190.32	206.15	218.82	227.24	228.62	254.27	266.7	282.7
4	Bihar	279.53	267.03	319.1	300.65	297.4	299.91	344.47	400.14	432.3	479.8
5	Goa	104.95	102.4	33.43	86.21	85.36	93.27	89.96	77.879	114.06	117.847
6	Gujarat	733.82	747.33	721.91	765.9	771.51	774.9	783.72	788.49	793.42	809.932
7	Haryana	48.2	60.08	67.24	76.29	100.46	96.19	106	111.48	116.9	111.203
8	Himachal Pradesh	7.3	6.89	7.85	7.79	7.85	7.38	8.04	8.561	9.83	20.3
9	Jammu &Kashmir	19.15	19.2	17.33	19.27	19.3	19.7	19.85	19.95	19.98	203
10	Karnataka	297.57	292.46	297.67	361.85	420.06	526.58	546.44	525.566	555.31	613.241
11	Kerala	636.89	677.63	667.33	685.99	698.86	681.61	693.21	679.736	708.65	632.256
12	Madhya Pradesh	61.07	62.04	63.89	68.47	66.12	56.45	75.41	85.165	96.26	109.121
13	Maharashtra	580.54	595.94	556.45	523.1	550.36	595.25	578.79	586.374	602.68	548.746
14	Manipur	18.22	18.16	18.6	18.8	19.2	20.2	22.22	24.502	28.54	30.5
15	Meghalaya	4.12	5.49	4	3.96	4.33	4.56	4.77	5.417	5.75	5.863
16	Mizoram	3.75	3.76	3.76	2.89	3.25	2.9	2.93	5.43	5.94	6.387
17	Nagaland	5.5	5.8	5.8	6.18	6.36	6.59	6.84	7.13	7.47	7.835
18	Odisha	325.45	342.04	349.48	374.82	382.55	386.19	381.83	410.143	413.79	439.856
19	Punjab	85.64	86.7	78.73	86.21	122.86	97.04	97.62	99.13	104.02	114.77
20	Rajasthan	18.5	22.2	25.7	24.1	26.91	28.2	47.85	55.16	35.1	46.314
21	Sikkim	0.15	0.15	0.18	0.17	0.17	0.18	0.28	0.49	0.42	440
22	Tamil Nadu	463.03	542.28	559.36	534.17	582.93	614.81	611.49	620.397	624.3	697.612
23	Tripura	23.87	28.63	36.25	36	42.28	49.23	53.33	57.46	61.95	635.6
24	Uttar Pradesh	289.58	306.73	325.95	349.27	392.93	417.48	429.72	449.75	464.48	494.265
25	Wet Bengal	1250	1359.1	1447.26	1484	1517.01	1443.26	1472.05	1490.016	1580.65	1617.319
26	A & N Islands	12.1	28.69	28.69	32.49	33.16	33.92	35.26	36.62	36.95	39.36
27	Chandigarh	0.09	0.17	0.21	0.24	0.24	0.24	0.09	0.046	0.11	0.118
28	Dadra and Nagar Haveli	0.05	0.05	0.05	0.05	0.05		0.05	0.05	0.05	0
29	Hamn & Diu	17.79	16.41	26.36	14.14	15.88	16.97	17.43	19.012	19.01	37.177
30	Delhi	0.7	0.61	0.61	0.72	0.71	0.82	0.74	0.69	0.88	0.675
31	Lakshadweep	11.96	11.75	11.04	12.59	12.37	12.37	12.37	12.372	18.72	13.186
32	Puducherry	21.45	39.67	39.01	40.3	41.95	41.95	42.4	41.066	42.08	73.505
33	Chhattisgarh	131.75	137.75	139.37	158.7	174.25	228.21	250.69	255.611	284.96	314.164
34	Uttarakhand	2.79	3	3.09	3.16	3.49	3.82	3.83	3.847	3.89	3.936
35	Jharkhand	2.79	3	3.09	3.16	3.49	3.82	91.68	96.6	104.82	106.43
	India	**6571.63**	**6869.05**	**7126.83**	**7616.09**	**7997.99**	**8230.71**	**8666.71**	**9040.337**	**9578.97**	**1007.24**

Source: Handbook on Fisheries Statistics, 2012, 2013, 2014,2015 & 2016, DAHFS

duction was more than 70% during the 1960s, but started declining thereafter and came down to about 62 per cent during 1970s and to 59 per cent during 1980s. In the 1990s it seemed that marine fisheries production has reached a maximum and, at best it can register only a marginal increase in the near future (60 per cent). Inland fish production had been on the constant rise from 2011 and it showed a declining trend (Figure 4.3). Figure 4.3 shows a trend of fish production in India during 2005-2014. On the other hand, the share of marine fisheries sector showed a declining trend up to the year 2000 and then increased in the year 2010-11 with higher contribution than inland, a source of fish production to the state.

Inland fishing is divided into two types namely, capture and culture fish production. The share of culture fisheries out of total inland fish production has also increased from 28% to 66% in 2015. The capture fisheries have been the major source of inland fish production till the mid-1980s. Capture fisheries has declined from over 0.59 to 0.40 MT

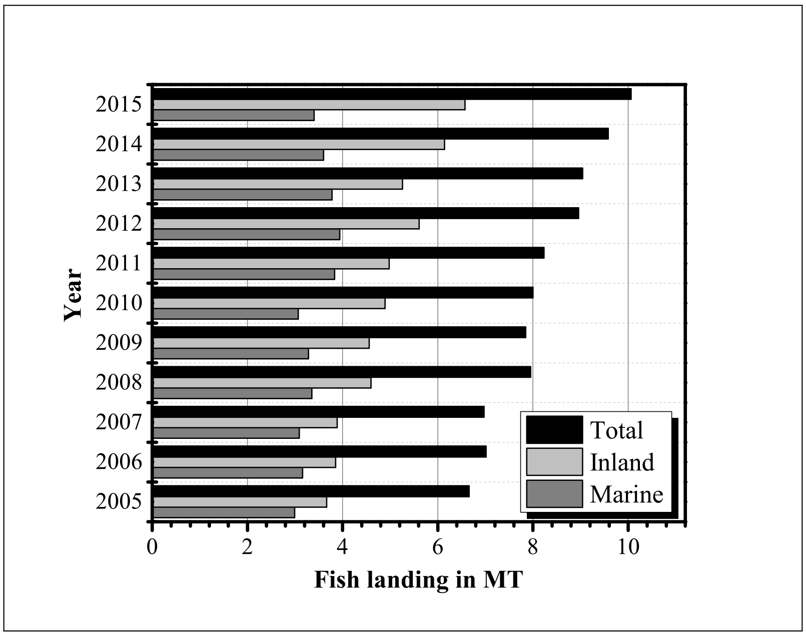
Table 4.4
Contribution of fisheries sector at current price 2004-05

Year	Total GDP-fc	GDP from agri, forestry & fishing	GDP from fisheries	Total GDP from fisheries (%)	GDP from agri, forestry & fishing (%)
2005-06	3390503	637772	31699	0.93	4.97
2006-07	3953276	722984	35182	0.89	4.87
2007-08	4582086	836518	38931	0.85	4.67
2008-09	5303567	943204	44073	0.82	4.65
2009-10	6108903	1083514	50370	0.82	4.65
2010-11	7266967	1306942	57369	0.79	4.39
2011-12	8832012	1499098	66862	0.80	4.46
2012-13	9280803	1644926	78053	0.80	4.75
2013-14	9921106	1881152	96824	0.92	4.60
2014-15	10656925	NA	NA	NA	NA

Source: Handbook on Fisheries Statistics, DAHFS, 2016 and GoI, 2012

(Modayil et al., 2006). But, fish production from natural waters such as rivers, and lakes followed a declining trend, primarily due to the proliferation of water control structures, indiscriminate fishing and habitat degradation (Katiha, 2001). The depleting resources of marine fish resources, the energy crisis in the marine sector, the high cost of fishing etc., have led to an increased realization of the potential and versatility of aquaculture as a sustainable and cost-effective alternative fishing. Figure 4.4 shows the decadal source of fish production in India. During the past one and a half decades, the production of inland aquacultural fish has increased from 0.51 to 2.38 MT. The percentage share of aquaculture has increased sharply from 46 to 86%, primarily because of 4.5 fold increase in freshwater aquaculture.

However, there is still ample scope for enhancing fish production in India. The growth rate analysis of fish production among states showed a significant growth except in Rajasthan. In some states, like Andhra Pradesh, Gujarat, Karnataka, Kerala, Maharashtra and Odisha, the growth of inland fisheries was found to be higher than that of marine fisheries. But in West Bengal and Tamil Nadu, marine fisheries growth was observed to be more than that of inland fisheries. The compound aggregate growth rate from 1984-2001 shows that Punjab had the highest growth rate even though there were no marine fisheries in the state. Among the marine states, Odisha has the highest CAGR (%) with 7.28 and Kerala had 4.34%.



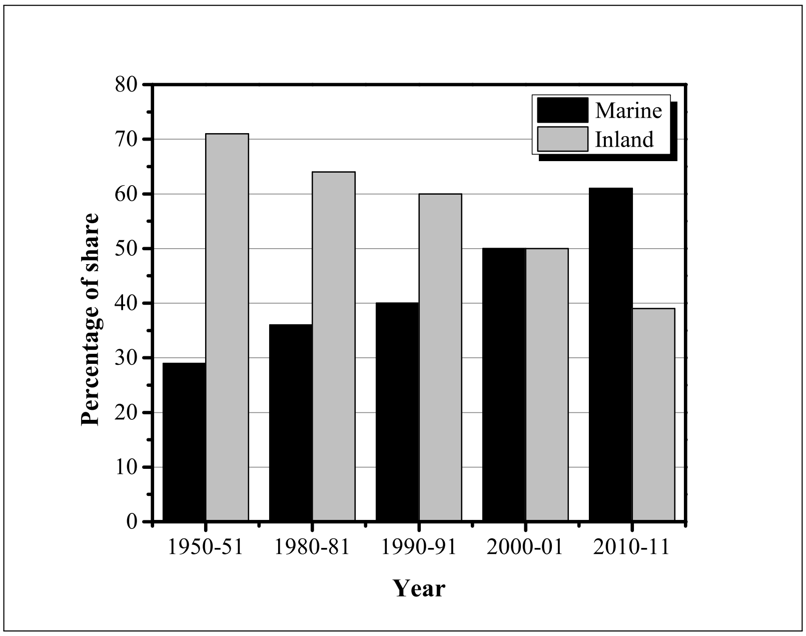
Source: Handbook on Fisheries Statistics, 2016 and GoI, 2012

Figure 4.3: Trend in fish production in India, during 2005-2014

4.3.4 Demographic Features of Marine Sector

According to Indian census report, 2011, total population rate of India is 1240 million. The total fisher-folk population of India was 13 million, where Bihar stood first in the fishermen population with around 5 million, followed by Jharkhand with 2 million. Marine fishers population of the country was 4 million, spread across 3432 fishing villages. Table 4.5 shows the present basic demographic features of the coastal states of India. Tamil Nadu holds the highest number of marine population (0.8 million), with less number of fishing villages (573), with where Odisha having the highest number of fishing villages (813). However, the marine population of Odisha (0.6 million) is less than that of Tamil Nadu (TN) (0.8 million). This is due to the better infrastructure facilities and more availability of the fish resource in Tamil Nadu. But, Kerala state has almost 0.6 million fisher population spread among 222 fishing villages, which shows a high density of fisher population.

Table 4.6 shows the fisher population of marine states of Kerala during the period from 1980 to 2010. Table 4.6 shows that the West Bengal has the highest number of fishermen population i.e., around 1.8 million, followed by Andra Pradesh with nine lakhs and Kerala



Source: FAO Handbook on Fisheries Statistics, 2016 and GoI, 2012

Figure 4.4: Decadal source of fish production

with 7.5 lakhs. In the year 2010, the total marine fisher population in the country was 400 million with Tamil Nadu, Kerala and Odisha accounting for 20.1%, 15.3% and 15.1% respectively (CMFRI, 2012).

During 1980s, Kerala had the highest number of marine fisher population in India. However, during the period from 2005 to 2010,Tamil Nadu replaced Kerala.

Kerala has seen remarkable achievements in its demographic transition. Lowest total fertility rate, lower birth rate and death rate, favourable sex ratio and increasing proportion of the aged are some of the demographic achievements of Kerala. Table 4.6 shows the state-wise fisher population size and its percentage in parenthesis for three decades. In 1980, the average family size is observed to be highest in Karnataka and lowest in Andhra Pradesh. The difference between these two State is almost three persons per household. From 1980 to 2010 the average number of the person in a household declined in all the states and union territories. But, in 2010, it showed an increase in Kerala, Tamil Nadu, and Goa. The highest decline was observed in Kerala which is from 6.4 to 5.1 (1980 to 2010), which is a proof of the increased socio-economic development of Kerala.

Table 4.5
Marine fisheries resource of India

State/Uts	App.length of coastal line(kms)	No. of landing centres	No. of fishing villages	No. of fishermen family	Fisher folk population
Andra Pradesh	974	353	555	163427	605428
Goa	104	33	39	2189	10545
Gujarat	1600	121	247	62231	336181
Karnataka	300	96	144	30713	167429
Kerala	590	187	222	118937	610165
Maharastra	720	152	456	81492	386259
Odisha	480	73	813	114238	605514
Tamil Nadu	1076	407	573	192697	802912
West Bengal	158	59	188	76981	380138
A& N	1912	16	134	4861	22188
Daman & Diu	27	5	11	7374	40016
Lakshadweep	132	10	10	5338	34811
Puduchery	45	25	40	14271	54627
Total	**8118**	**1537**	**3432**	**874749**	**4056213**

Source: Fisheries statistics, DAHFS, 2015

4.3.5 Occupational Profile

The share of fisherfolk occupation as a percentage of the total fishing population was observed as ranging between 25% and 64% from 2005 to 2010. Fisherfolk occupation of Kerala in 2005 and 2010 was 37 and 34.5% respectively. It implies that a major share of fisherfolk population in Kerala was a dependent one. According to Marine Census, 2005 and 2010, coastal districts of Tamil Nadu and Kerala occupied the first and second position respectively, in terms of active fishermen population in the sector. The share of active fishermen population in the country ranged from 18 to 27% across the states. The share of Kerala was 23.8% in the year 2010. However, the total size of active fishermen with the percentage of the size of total occupied fishermen varies from 39 to 72% across the states. Tamil Nadu occupied 72.4% of active fishermen followed by Kerala (69%). Table 4.8 shows the state-wide occupational profile of fishermen of Indian coastal states and its union territories.

4.3.6 Educational Profile

The literacy rate of the Indian fishermen is 56.5% at varying levels of education (CM-FRI, 2012). Table 4.9 shows the state-wise distribution of educated fisher population as

Table 4.6
State-wise distribution of no. of fishermen population & its per cent to total population (in parenthesis)

State	Fisher Population		
	1980	**2005**	**2010**
West Bengal	83561 (0.2)	269565 (0.3)	380138 (0.4)
Odisha	117144 (0.4)	450391 (1.2)	605514 (1.4)
Andra Pradesh	326304 (0.6)	509991 (0.7)	605428 (1.2)
Tamil Nadu	395903 (0.8)	790408 (1.3)	802912 (1.1)
Puduchery	25312 (NA)	43028 (NA)	54627 (1.6)
Kerala	639872 (2.5)	602234 (1.9)	610165 (1.8)
Karnataka	112893 (0.3)	170914 (0.3)	167429 (0.3)
Goa,	39912 (NA)	10668 (NA)	10545 (0.7)
Maharastra	NA	319397 (0.3)	386259 (0.3)
Gujarat	152015 (0.4)	323215 (0.6)	336181 (0.6)
Daman & Diu	NA	29305 (NA)	40016 (NA)
Total	**1892916 (0.3)**	**3519116 (0.3)**	**3999214 (0.9)**

Source: Computed from Marine Fisheries Census, 2005 and 2010, CMFRI
Computed from Census of India, 1981, 2001, and 2011, GoI

a percentage of total fishermen population. The table shows that the total educated fisher population was lower in Andra Pradesh in 1980, 2005 and 2010. Odisha had the second lowest educated fisher population in 1980, but 2005 to 2010 Gujarat became the second largest, replacing Odisha. Among the states, the highest percentage of educated fishermen was observed in Karnataka and in Kerala. In the year 2005, Kerala had the highest educated fisher population among the Indian states and became the second highest in 2010, after Goa.

4.3.7 Fishing Crafts and Gears

Introduction of mechanised fishing and motorisation of the country craft were the significant achievements, which gave more importance to the marine fish production of the country. Table 4.10 shows the state-wise distribution of fishing crafts and gears. It is clear from the table that there has been a very high growth in the number of motorised and mechanised crafts since 2010. The motorisation was started in the early eighties in Maharashtra and Gujarat. Later on, the process of motorisation was initiated in all the other maritime states including Kerala. As per the 1998 Marine Fisheries Census,

Table 4.7
State-wise distribution of average family size of fisher population

State	Family size		
	1980	2005	2010
Andra Pradesh	4.5	4.0	3.7
Gujarat	6.6	5.4	5.4
Karnataka	7.2	5.7	5.4
Kerala	6.4	5.0	5.1
Maharastra	NA	4.9	4.7
Odisha	5.8	5.2	5.3
Tamil Nadu	5.2	4.1	4.1
West Bengal	5.9	5.0	4.5
Goa	5.5	3.7	4.8
Pudichery	5.9	5.5	3.8
Daman & Diu	NA	4.0	5.4
Total	**5.7**	**4.7**	**4.6**

Source: Various Marine Fisheries Census reports, CMFRI.

there were 30,979 trawlers followed by gillnetters (9,968), dolnetters (5,538) and other crafts (81,033). But in 2010, it increased to 50,618 (Traditional), 71,313 (motorised), and 72,559 (mechanised). Figure 4.5 shows the share of total fishing crafts and gears in the country during 2010. It is clear from the Figure 4.5 that mechanised and motorised sectors have an equal contribution (37% each) to crafts and gear share in the country. In gear wise, trawlers are more (64%) in the sector. The maximum number of crafts was occupied by Tamil Nadu and Kerala. Gujarat has the number of mechanised boats followed by West Bengal in the country. Tamil Nadu had occupied more size of motorised boats followed by Kerala. Andhra Pradesh occupied first place in the size of the non-motorised crafts and gears in the country (Table 4.5).

4.3.8 Trade Performance

Fisheries sector in India has been one of the major contributors of foreign exchange earnings for the country. The data on different indicators of fisheries export, presented in Table 4.11, reveals that fisheries have been an important component of agricultural exports. India has been a net exporter of fish and fish products and the import of fish products constituted only a miniscule proportion of fisheries exports, both in terms of quantity

Table 4.8
State-wise occupational profile of fishermen in India

State	Occupation of Active fishermen (%)		Total Occupation of fisher population (%)	
	2005	2010	2005	2010
Andra Pradesh	46.2	49.9	58.9	49.9
Gujarat	49.4	59.6	52.2	41.3
Karnataka	41.4	51.0	53.1	47.7
Kerala	62.4	69.0	37.3	34.5
Maharastra	43.8	39.5	51.5	50.0
Odisha	41.9	62.4	64.2	43.0
Tamil Nadu	63.9	72.4	41.0	36.8
West Bengal	54.2	65.0	48.4	38.5
Goa,	39.3	46.4	59.9	48.4
Pondichery	46.7	62.6	51.4	38.5
Daman & Diu	77.0	51.8	25.7	36.1
Total	**51.4**	**59.4**	**49.1**	**41.7**

Source: Computed from Marine Fisheries Census, 2005 and 2010, CMFRI

and value (Table 4.11). During the mid-1990s, especially after the establishment of World Trade Organization (WTO) in 1995, import of fish product started showing improvements. In recent years, the value of imports of fisheries commodities as a percentage of export varied from 0.58 to 0.94 per cent. Furthermore, the fisheries sector has been substantially contributing to national earnings in terms of foreign exchange. During the financial year 2011-12, for the first time in the history of marine product exports, the export earnings crossed USD 3.5 billion. This is also the first time export has crossed all previous records in quantity, rupee value and USD terms. Exports aggregated to 862021 tonnes, valued at $3508.45 million. When compared to the previous year 2011, in the year 2012 seafood exports recorded a growth of 6.02% in quantity, 28.65% in value and 22.81% growth in USD earnings respectively (Sea Food Export Authority of India). The region wise analysis shows that the exports from India to the European Union have been continuously increasing from 2005 to 2009. However, export to Japan and the USA economy has seen a decline in the same period. However, the situation has completely changed since 2012 because of global economic fluctuations. Figure 4.6 shows the share of India's export of marine products to various foreign countries. South East Asia became the largest buyer of Indian marine products with a share of 37% in volume and 9% in US $ realization, got

Table 4.9
State-wise distribution of educated fishermen as a percentage to total fishermen population

State (%)	1980	2005	2010
Andra Pradesh	7.5	32.5	30.9
Gujarat	19.0	40.9	38.1
Karnataka	25.1	69.6	58.5
Kerala	23.2	72.8	65.9
Maharastra	NA	67.0	63.6
Odisha	8.6	47.9	45.0
Tamil Nadu	19.2	66.7	57.6
West Bengal	22.5	45.6	53.1
Goa	25.9	61.2	79.3
Puduchery	25.9	63.2	61.9
Daman & Diu	NA	NA	60.5
Total	**18.6**	**56.2**	**51.6**

Source: Computed from Marine Fisheries Census, 1980, 2005 and 2010, CMFRI

into the second place with a share of 17% of India, export to European Union (EU), it has second place followed by China 10%, Japan 8%, and the Middle East 4% and other countries by 14% (Figure 4.6).

4.3.9 Potential of Fishery Resources in the Indian EEZ

India is the seventh largest country in the world covering an area of 3.28 million sq.kms. India is endowed with a long coastline of 8129 Kms. It has also 2.02 million sq.km of Exclusive Economic Zone and 1.2 million hectares of brackish water bodies, offering vast potential for development of fisheries. There are about 3288 marine fishing villages with a population of about 3.2 million people (CMFRI, 2012). These populations are completely dependent on 2.02 million sq.kms coastlines for their livelihood. The demand for fish and fishery products are increasing both in domestic and export fronts. About 3.9 million tonnes of fishery potential is estimated from the marine sector, out of which only 2.6 million tonnes are tapped now (Economic Survey, 2010). 93% of the fish production is contributed by artisanal, mechanised and motorised sector, remaining 7% is contributed by deep sea fishing. Silas Committee (2000) stated that able to harvest the potential of marine fishery resource in the EEZ has been estimated at about 3.9 million tonnes

Table 4.10
State-wise distribution of fishing crafts and gears during 2010

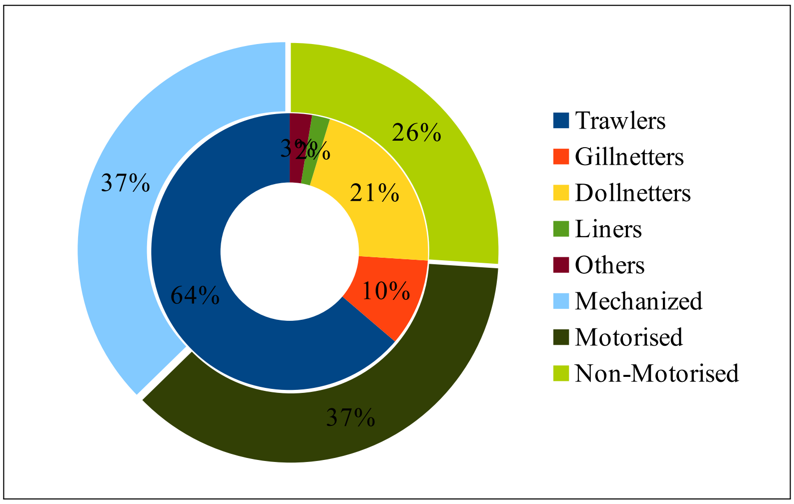
State	Mechanised	Motorised	Non-motorised	Total
Andra Pradesh	3167	10737	17837	31741
Gujarat	18278	8238	1884	28400
Karnataka	3643	7518	2862	14023
Kerala	4722	11175	5884	21781
Maharastra	13016	1563	2783	17362
Odisha	2248	3922	4656	10826
Tamil Nadu	10692	24942	10436	46070
West Bengal	14282	0	3066	17348
Goa	1142	1297	227	2666
Puduchery	369	1562	662	2593
Daman & Diu	1000	359	321	1680
Total	**72559**	**71313**	**50618**	**194490**

Source: Computed from Marine Fisheries Census, CMFRI, 19980, 2005 and 2010.

(Sathianadhan, 2013). An estimation of the depth-wise potential shows that about 58% of the resources are available at 0-50 meter depth, 35 per cent at 50-200 meter depth and 7.0 per cent at depths beyond 200 meters.

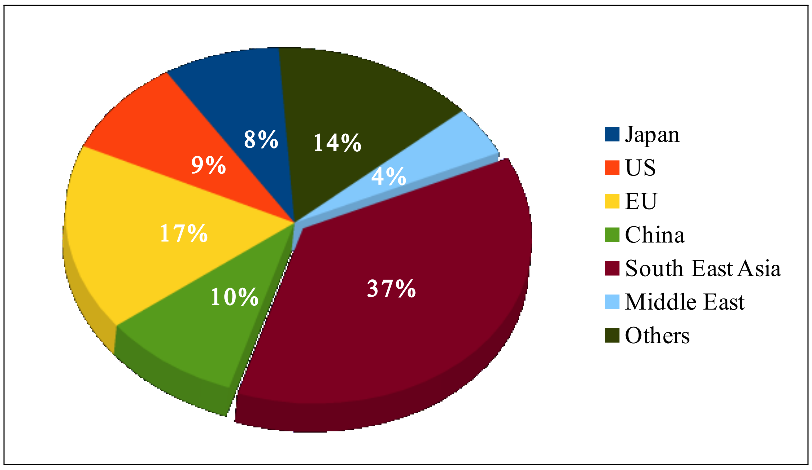
Present condition of Indian marine fishery

The marine fisheries sector in India has witnessed a phenomenal growth during the last five decades both quantitatively and qualitatively. Currently, the total production is about 3.4 million tonnes (CMFRI, 2016). This increase is the result of improvements in the harvesting methods, increase in the fishing effort and extension of fishing into relatively deeper regions. The increased effort over time and space is the consequence of the ever-increasing demand for marine food both from external and internal markets. This phenomenal growth also brought in imbalances in the exploitation across the regions and among the resources. Besides, with production levels for most of the commercially important resources showing signs of approaching saturation levels, intersectoral conflicts increased due to competition to exploit the common resource. Fleet size and operations underwent quantitative and qualitative changes. Traditional boats are being increasingly motorised and the mechanised sector operating with trawlers and gillnetters are resorting to multi-day fishing for their existence. The situation thus calls for an appraisal of the



Source: Annual report,CMFRI, 2015-16

Figure 4.5: Share of fishing crafts and gears in the Indian marine sector



Source: Annual report,MPEDA, 2015-16

Figure 4.6: Share of exports of marine products to foreign countries druing 2012-13

status of the resources on a regional and all India basis, taking into consideration the scientific database developed over a period of about half a century to enable and formulate suitable strategies for exploitation and management of fish resources.

4.4 Kerala

Kerala is a small maritime state situated at the South Western end of the Indian peninsula. It has a coastline of about 590 km (Economic Survey, 2010), which is about 10% of

Table 4.11
Export trend of marine products in India during 2005-2015

Year	Qty in tonnes	Value(in crore)	Annual growth rate	
			Qty	value
2005-06	512163	7245.73	11.02	9.01
2006-07	612643	8363.52	19.62	15.43
2007-08	541701	7620.93	-11.58	-8.88
2008-09	602834	8607.95	11.29	12.95
2009-10	678436	10048.53	12.54	16.74
2010-11	813091	12901.46	19.85	28.39
2011-12	862021	16597.23	6.02	28.65
2012-13	928215	18856.26	7.68	13.61
2013-14	983756	30213.26	5.98	60.23
2014-15	1051243	33441.61	6.86	10.69

Source: Handbook of Fisheries Statistics, 2014, DAH& F
Annual report,MPEDA, 2015-16

the total mainland coastline in India (Kurien and Paul, 2001). The Exclusive Economic Zone (EEZ) lying adjacent to Kerala coast is spread over 36,000 sq. km which is almost equivalent to the land area of the state (GoK, 2007). At the same time, Kerala is endowed with rich inland water bodies consisting of 44 rivers (estimated 0.85 lakh ha), 30 major reservoirs (0.30 lakh ha), fresh ponds and tanks (0.25 lakh ha), 45 backwater bodies and extensive brackish water area (2.43 lakh ha) (Dhanuraj, 2004). With these abundant water resources, fisheries play an important role in Kerala's economy. More than one million of its population is, directly and indirectly, engaged in fishing sector (GoK, 2013), with about two hundred thousand active fishermen (CMFRI, 2012). Basic demographic features of Kerala coastal state is shown in the Table 4.12.

Kerala is the fourth largest fish producing state in India contributing 9% of the total fish resource. The Figures 4.7 and 4.8 show the trend of fish production in Kerala in comparison with India's production. The Figure 4.8 shows the trend of marine fish production for ten years. The total marine fish landings from the mainland of Kerala for the year 2012 is 0.841 MT against 0.74 MT in 2011, and it was the highest landings in marine fishing in the history. But, total marine fish landings in Kerala was 0.48 MT in 2015 registering a decline of 16% compared to the previous year. It was 19.2% increase in the fish landings when compared to the previous year (CMFRI, 2013). The maximum contribution of marine fish was from Kerala (61%), followed by Karnataka (34%) during 2012 (CMFRI,

Table 4.12
Demographic features of Kerala during 2005 & 2010

Demographic features	**2005**	**2010**
EEZ	2185369 sq.km	-
Continental Shelf	39139	-
Coastline (km)	590	590
Landing centres	178	187
No. of fishing villages	222	222
No. of fisher families	1,20486	118937
Fisher folk population	6,02234	610165
Active fishermen	1,40222	145396
Full time fishermen	1,24103	130922
Part time fishermen	10488	20418
Occasional fishermen	5631	NA
Catchable Resource Potential	-	7.5 lakh MT

Source: Economic Review, (GoK, 2016)

2013) (South West Coastal states). The maximum contribution of marine fish landing in 2015 was from the South Eastern states (Tamil Nadu, Andhra Pradesh, and Puducherry). The contribution of mechanized, motorized, and artisanal sectors of Kerala were 68.2%, 30.3% and 1.5% respectively (CMFRI, 2013).

Economic significance of fisheries sector

The Gross State Domestic Product has increased by about 60 percent during the period from 2005-06 to 2011-12, and the share of the fisheries sector in the State Domestic Product has declined from 1.3 to 0.9 percent in the same period. However, it increased to 1.12% in 2012 and decline to 1.04% in 2015. The share of the Primary Sector to GSDP declined from 17.1% to 9.5% during 2005-12. The share of the primary sector to GSVA also declined from 15% to 11% during 2012-16. The contribution of the fisheries sector to GSDP during 2005-12 is given in Table 4.13 and the contribution of the fisheries sector to GSVA during 2011-16 is given in Table 4.14.

Table 4.13
Contribution of fisheries sector to GSDP of Kerala (at constant price 2004-05) (₹in crores)

Year	GSDP	Fishing	Share of fisheries sector in GSDP	Share Primary sector in GSDP	% share of primary sector in GSDP
2005-06	131293.9	1704.80	1.30	22466.88	17.11
2006-07	141666.7	1800.24	1.27	31038.10	14.85
2007-08	154092.7	1795.44	1.17	20802.16	13.50
2008-09	162659.2	1784.03	1.10	21256.50	13.07
2009-10	177571.4	1886.81	1.06	21140.55	11.91
2010-11(P)	191866.7	1794.13	0.94	20071.67	10.46
2011-12(Q)	210107.2	1792.67	0.85	19924.89	09.48

Source: Economic Review, GoK (2016)

Table 4.14
Contribution of fisheries sector to GSVA of Kerala [at base year 2011-12] (₹in crores)

Year	Gross State Value Added	Fishing & Aquaculture	Share of fisheries sector in GSVA	Primary sector	Share of primary sector in GSVA (%)
2011-12	336293.11	3773.63	1.12	51100.77	15.20
2012-13	356354.73	3764.19	1.06	51357.60	14.41
2013-14	371651.47	3978.45	1.07	49409.05	13.29
2014-15(P)	395721.90	4313.64	1.09	50249.76	12.70
2015-16(Q)	424791.11	4402.14	1.04	49206.30	11.58

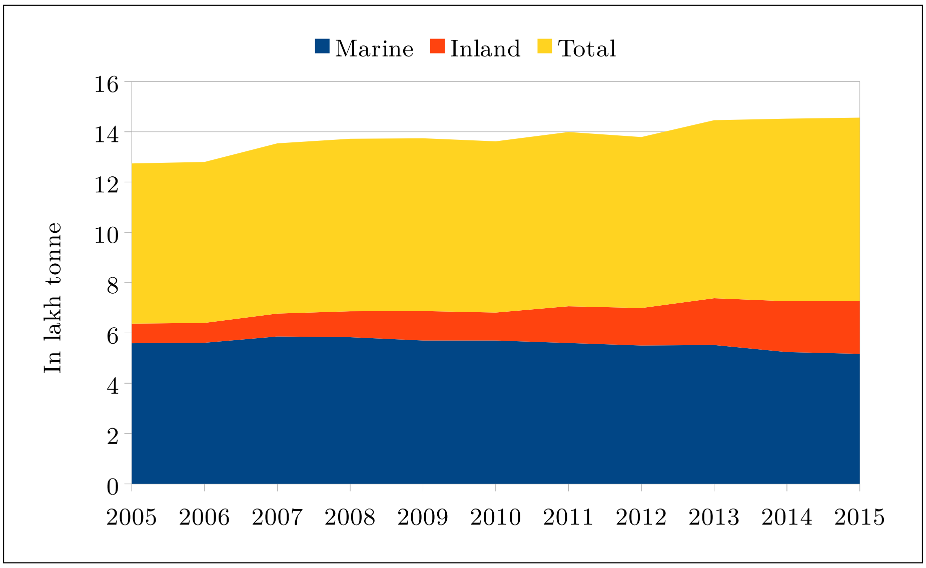
Source: Economic Review, GoK (2016)

4.4.1 Marine Fish Landings in Kerala

The overall fish production curve and its trend are shown in Figure 4.8. It shows the annual fish landings of Kerala and India during a period of ten years. The Gross Marine Fish Landings in Kerala show an increasing trend from 2005 to 2015 (GoK, 2005-2015). This was due to technological advancements in fishing methods, increased utilisation of extended fishing area and an increase in the number of fishing fleets (Sathiadhas, 2005). The growth of fish landings is stagnant to 5 lakh tonnes during the period.

District wise analysis

Kerala consists of fourteen districts out of which only nine districts are situated in the coastal belt. Table 4.15 shows the district wise marine fish production of the state during the last ten years. According to the Statistics Division of Fishery Department, overall marine fish landings of Kerala show constant growth in the last ten years. However, in



Source: Various annual reports of Fisheries Department of Kerala, 2005 - 2015

Figure 4.7: Share of marine fish production of India and Kerala, 2005-2015

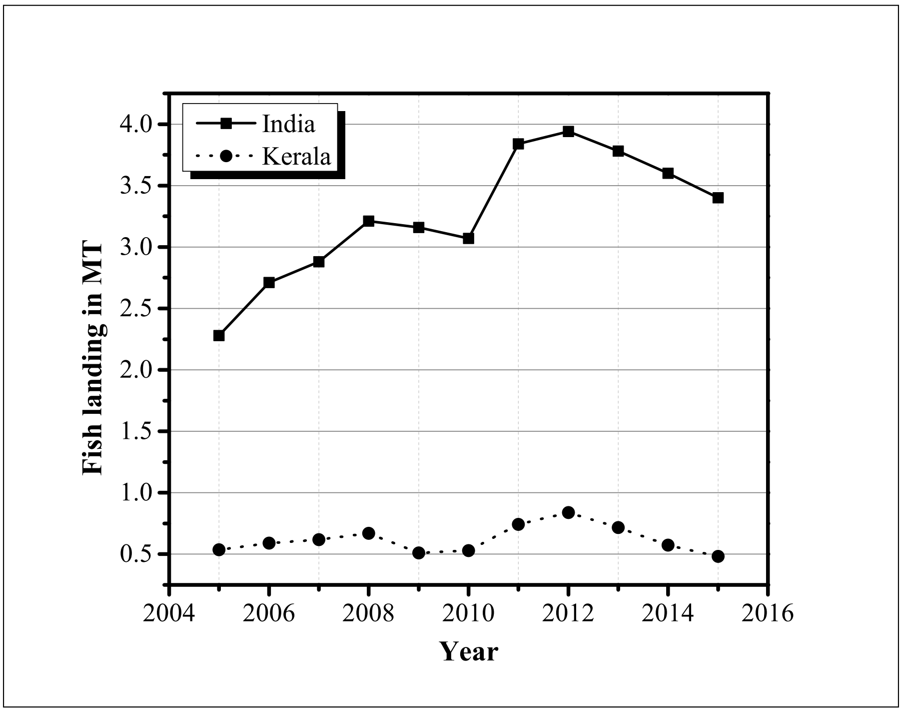
2005, the total fish landings in the state is 6 LT (lakh tonne) and it decreased to 5 LT in 2015. This was due to the various changes of nature of ecology, heterogeneous nature of fishery sector and population parameters. District wise fish landings show that Kollam and Alappuzha (except in 2015) occupied a top position from 2005 to 2015. District wise production in 2012 shows that Alappuzha ranked first with 22.4% of total fish production of the state, followed by Kollam (15.1%), Kozhikode (14.6%), Thrissur (14.0%), Ernakulam (10.7%), Thiruvananthapuram (10.0%), Malappuram (6.7%), Kannur (4.2%), and Kasaragod (2.2%) (CMFRI, 2013).

Table 4.15

District wise Marine Fish Landings (MT) of Kerala during 2005-2015

District	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
TVM	50367	44895	48289	47299	47055	45930	45121	44310	41836	33308	63518
KLM	123546	113784	121922	119516	118859	116030	114031	112085	105009	72270	108686
ALP	150003	127612	137971	134905	134313	131588	129321	127385	116159	108312	44388
EKM	56587	54805	58408	57333	57000	55429	54502	53972	51997	95023	80394
TCR	66644	65566	69484	68283	67887	66648	65623	64995	63905	31164	21057
MLPM	29361	27468	29200	28679	28530	27908	27479	27328	25155	20004	59920
KKD	85214	84048	89743	87952	87440	85337	83798	82937	80050	94740	93443
KNR	22817	23669	24958	24546	24389	23859	23491	23247	22320	43121	23254
KSD	17324	17066	18082	17773	17677	17284	17032	16918	15877	26526	22085
TOTAL	**601863**	**558313**	**598057**	**586286**	**583150**	**570013**	**560398**	**553177**	**52230**	**524468**	**516745**

Source: Various years of Kerala Fishery Statistics at a glance, Dept. of Fisheries, Kerala.



Source: Various annual reports, CMFRI

Figure 4.8: Trend of marine fish production of India and Kerala, 2005-2015

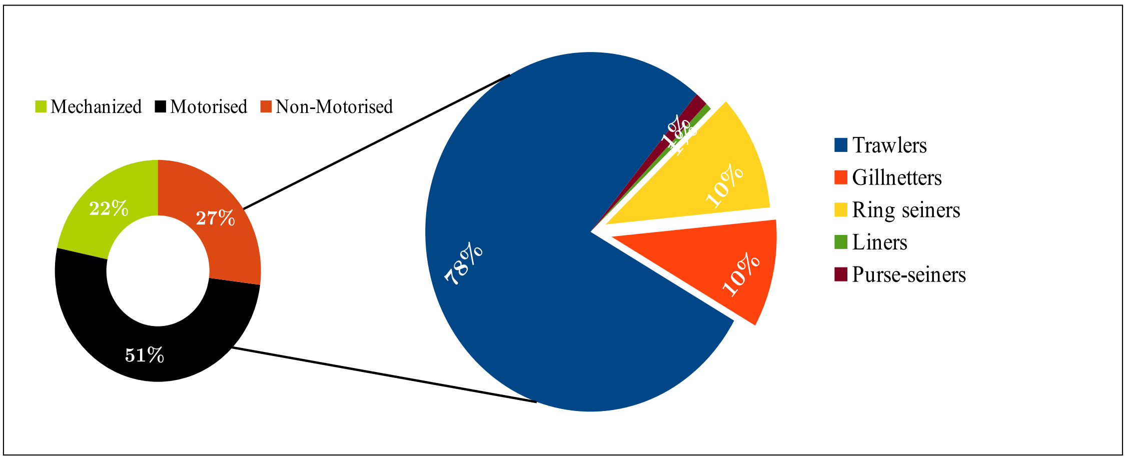
4.4.2 Fishing Crafts and Gears

Introduction of mechanised fishing and motorisation of country craft are the significant events which gave a good boost to the marine fish production in India. The motorisation started in the early eighties all over Kerala and its adoption increased when multiday fishing began during 2000s. Table 4.16 and Figure 4.9 show the state-wise distribution of fishing crafts and gears in the year 2010. The table 4.16 shows a decreasing rate of motorised and mechanised crafts in 2010 compared to 2005. The Figure 4.9 shows the decreasing rate of gears compared to last census year, 2005. It is clear from Figure 4.9 that share of motorised crafts (51%) is more than the mechanised (22%) and non-mechanised (27%) in the state. In gear wise, trawlers (78%) are more, followed by gillnetters and ring seiners at 10% each. A maximum number of motorised crafts are used in the district of Thiruvananthapuram (26%), followed by Kasaragod (16%) and Alappuzha (13%).

Table 4.16
District wise fishing crafts of Kerala during 2005-2010

State	2005			2010		
	Mechanised	Motorised	Non-motorised	Mechanised	Motorised	Non-motorised
TVM	55	3063	5005	0	2880	2304
KLM	1272	605	425	993	546	299
ALPZ	136	3947	1010	38	1503	1980
ERN	1898	1104	1190	1588	531	146
THR	259	456	306	195	670	217
MLPR	441	1607	361	353	1571	186
KZD	1034	1976	641	1065	1831	260
Kannur	226	503	290	325	542	97
KSKD	183	890	294	165	1101	395
Total	**5504**	**14151**	**9522**	**4722**	**11175**	**5884**

Source: Marine Census report 2005 & 2010, CMFRI



Source: Marine Fisheries census of CMFRI, 2010

Figure 4.9: Craft and gear wise distribution of Kerala, 2010

4.4.3 Catch Per Unit Analysis

Table 4.17 shows sector wise Catch Per Unit analysis over three decades from 1980 to 2012. There is a definite decline in the number of non-mechanised boats in recent years. As non-mechanised fleets are decreasing, there is a clear increase in motorised and mechanised boats due to their better technical efficiency and comparative economic advantage. In the mechanised sector itself, the growth rate of trawlers is increasing at a faster rate, especially boats with 15 meter overall length (OAL) and more, which are capable of multi-day fishing (Sathiadhas, 2006). The per capita annual catch (kg) per unit of fishing over the years is proof of the reducing fish stocks and overcapitalisation in the fishing sectors (Table 4.17). Compared to 1980, the annual CPU of mechanised sector declined from 138 to 70 tonnes, but total marine fish production increased due to a large number of registration of mechanised crafts in the state.

Table 4.17

Sector wise per capita Annual Catch Per Unit over the years

Indicators	1980	1990	2000	2010	2012
Mechanised					
Number of Units	983	3742	5504	4722	4722
Production in tonnes	135305	231572	285890	328600	570646
Per capita Annual Catch Per Unit[2]	138	62	52	70	121
Motorised					
Number Of Units	NA	11374	14151	11175	11175
Production in tonnes	NA	388624	242345	169600	251756
Percapita Annual Catch Per Unit	NA	34	17	15	23
Non-Mechanised					
Number of Units	26271	26137	26137	5884	5884
Production in tonnes	144238	42694	42694	53000	12588
Per capita Annual Catch Per Unit	5490	1633	1638	9	2

Source: Compiled from Sathiadhas, 2016, Marine Fisheries Census reports, CMFRI, 2005& 2010.

4.4.4 Socio-Economic Features of Fisher Folk

The coast of Kerala extends to 590 km spreading over nine coastal districts, the maximum coastline of 82 km equally being shared by Alappuzha and Kannur. As per the Marine Fisheries Census Report, 2010, the fisherfolk population in Kerala is 6.1 lakh CMFRI (2012) and 6.1 lakh fisher population is spread over 222 coastal villages of Kerala. Table 4.18 shows district wise distribution of fisher families and fisher population in nine coastal districts of Kerala. The table 4.18 shows that Thiruvananthapuram district has maximum fishing villages (42) and Kannur has minimum (11) number of landing centres. Average fisher households per village in the state is 536 and it is highest in Thiruvananthapuram (743) and lowest is Kasaragod (290). According to Kerala Marine Statistics 2010, the total marine fishermen population in Thiruvananthapuram has the highest fishermen population with 1.86 lakh, followed by Alappuzha (1.22 lakh) and Kozhikode (1.1 lakh).

34% of fisher population of the state is illiterate due to various socio-economic reasons. 43% of fisher population belongs to the Christian religion and 29% and 28% of fisher population belong to Hindu and Muslim communities. The ratio of Landing centres and the ratio of co-operative societies of Kerala coast with total coastal villages of the state is 0.8 and 0.6 respectively. This shows that not every coastal village has enough landing centre facilities and presence of fisheries societies. The overall basic demographic features of Kerala marine sector is shown in Table 4.12.

Table 4.18
Basic demographic features of nine coastal districts of Kerala in 2010

Distritcts	**TVM**	**KLM**	**ALPZ**	**ERN**	**THR**	**MLPR**	**KZD**	**KNR**	**KSKD**	**Total**
Fishing Villages	42	26	30	21	18	23	35	11	16	222
Fisherfolk Population	146326	63300	92033	42083	27572	98120	82129	27949	30653	610165
Adult-Male	52548	22767	34832	16323	10924	32213	29611	10113	11271	220602
Primary Edtn- Male	19098	6573	17509	8682	4458	12474	13509	6178	5099	93580
Higher Secondary Edtn- Male	18191	11961	19542	8045	5753	8057	15872	4372	3971	95764
Unschooled (<5Ys)	27132	7938	3422	1682	2165	22965	6143	1477	4311	77235
Actual Fishermen	33876	14405	23239	8900	5698	22152	20180	5389	7665	141504
Active Fishermen	35314	16677	23256	8934	5704	22238	20200	5404	7669	145396
Total Occupied	58484	23341	35795	13386	7446	28292	23550	8291	11911	210496
Hindus	608	3924	8187	4464	3645	421	7577	2220	3463	34509
Christian	27944	7019	11076	4218	31	3	12	387	30	50720
Muslim	4788	1545	1015	636	1772	14516	6568	1724	1144	33708
Members in the Co-operatives	30618	11307	23797	9210	5649	13979	17461	5265	7685	124971
Community centres	56	12	17	15	11	4	14	13	11	153
Fish Landing centres	51	18	16	20	21	11	19	12	19	187

Source: Compiled from CMFRI (2012).

Districts-wise distribution of active fishermen

According to Marine fisheries census 2005 and 2010, the active fishermen of the state is 1.4 lakh and 1.45 respectively. The highest number of active fishermen is in Thiruvananthapuram with 35314, followed by Alappuzha with 23256 and Malappuram with 22238. The district wise distribution of employment pattern of active fishers over the two marine fisheries census years is presented in Table 4.19. It shows that the number of active fishermen is increasing with increasing number of crafts and gear in the state. Active fishermen in the state have increased to 3.5% in 2010 when compared to 2005. Kollam, Malappuram, and Kozhikode were reported to have number of active fishermen in the year 2010 than 2005. All other remaining coastal districts reported a declining rate of active fishermen in 2010, compared to 2005.

Table 4.19

Districts wise active fishermen of Kerala during 2005 & 2010

Districts	**2005**	**2010**
	Active fishermen	Active fishermen
Thiruvananthapuram	38805	35314
Kollam	8665	16677
Alappuzha	25255	23256
Ernakulam	9713	8934
Thrissur	7054	5704
Malappuram	16422	22238
Kozhikode	20119	20200
Kannur	6470	5404
Kasaragod	7719	7669
Total	**140222**	**145396**

Source: Marine Fisheries Census, CMFRI, 2005; CMFRI, 2012

Educational status of fisher folk in Kerala

Even though Kerala with 94% literacy rate is the most literate state in India, the literacy rate of fisher folk of Kerala is only 73% which is more than the average literacy rate of fisher population (56.6%) of India. The literacy rate of fisher population in Kerala varies from 53% in Malappuram to 86% in Ernakulam. Among the the total educated fisher folk 39% received primary education only, 50% were educated upto secondary level and 11% of the fishermen upto secondary education. Table 4.20 shows the education status of fisher population of Kerala and Table 4.21 shows the changes in the educational trend over the decades 1080 - 2010.

Table 4.20

Education status of fisher population in Kerala in 2010

District	**Primary**	**Secondary**	**Above secondary**	**Total**	**Literacy rate**
Thiruvananthapuram	37429	16674	8716	62819	65
Kollam	12241	11500	5122	28863	80
Alappuzha	34449	17885	6029	58363	83
Ernakulam	17132	7250	3395	27777	86
Thrissur	8761	4886	1568	15215	78
Malappuram	24739	8155	1409	34303	53
Kozhikode	25543	15916	4488	45947	77
Kannur	11684	4405	1852	17941	80
Kasaragod	10203	3811	1254	15268	71
Total	**182181**	**90482**	**33833**	**306496**	**73**

Source: Marine Fisheries Census report, CMFRI (2012).

Table 4.21 shows a decrease (65%) in illiterate rate among the fishermen population of Kerala from 1980 to 2010. Primary and secondary education of this community also improved over the decades. Kerala had brought about tremendous faced various changes in political and socio-economic conditions since the 1990s. This was the main reasons for the declining of illiteracy of fisherfolk population. However, there was a slight decline in higher education achievers in 2010, compared to 2005.

Table 4.21
Change in the education status over the years (1980-2010)

Parameters	1980		2005		2010	
	No.	% of total	No.	% of total	No.	% of total
Illiteracy	491218	77	163567	27	152580	27
Primary	119823	18	171470	23	182181	33
Secondary	23514	4	218704	36	186246	34
Above secondary	5317	1	484493	8	33833	6

Source: Marine Fisheries Census Reports, CMFRI (2012); CMFRI (2005).

Occupational status

Occupational status is a component of socioeconomic status, which summarizes the power, income and educational requirements associated with various positions in the occupational structure. Table 4.22 shows the occupational profile of the fisher population of Kerala in 2010. There are 2,10,496 people employed in marine fishery sector of which 69% are in active fishing, 26% in secondary activities and 0.05% in the tertiary sector. The dependency ratio in 2005 is different from the ratio of 2010. The overall dependency ratio in 2005 is 1:3 which varies from 1:2 in Thiruvananthapuram district to 1:4 in Kannur district, whereas, the overall dependency ratio of 2010 is constant at 1:3, except in Thrissur (1:4). The dependency ratio reveals that most fisherpeople have to involve in one or other activity in their younger age itself. This is one of the major reasons for the drastic decline in an educational level beyond secondary education. Also, Thrissur district occupied first place in using the most motorised crafts for fishing. Therefore, the dependency ratio of Thrissur is more.

Table 4.22
Occupational structure of fisher population of Kerala (2010)

Districtcts	**Occupational Status**				**Dependency ratio**	
	Active fishermen	Secondary	Teritiary	Total	2005	2010
Thiruvananthapuram	35314	21040	2130	58484	2	3
Kollam	16677	6028	636	23341	3	3
Alappuzha	23256	8931	3608	35795	3	3
Ernakulam	8934	4048	404	13386	3	3
Thrissur	5704	1420	322	7446	3	4
Malappuram	22238	4995	1059	28292	3	3
Kozhikode	20200	2228	1122	23550	3	3
Kannur	5404	1552	1335	8291	4	3
Kasaragod	7669	4165	77	11911	3	3
Total	**145396**	**54407**	**10693**	**210496**	**3**	**3**

Source: Compiled from Marine Fisheries Census report, CMFRI, 2005 & 2010.

Ownership of land

The density of population in the coastal area of Kerala is around 2,168 (person/km^2) whereas for the whole state is 860. Possession of land among the fisherfolk is a critical problem due to the negligence of land reforms (HDRFF, 2009). In the state, about 8.25% of the fisher population owns land whereas it is 9% in the marine sector. Majority of the fisher population (60%) have land less than five cents[3]. Very fewer households own more than 10 cents of land.

Household amenities of fisher folk

Kerala is one of the main hubs of information technology in the country. Majority of the household use the mobile phone (91%) for communication purposes. The Indian Telecom industry has experienced an amazing growth and development, particularly in mobile communications sector during the last decade. The overall teledensity in Kerala is 107 and the percentage of wireless is 98 and wire-line is nine (NCAER, 2013). A

[3] 1 cent = 436 sqft

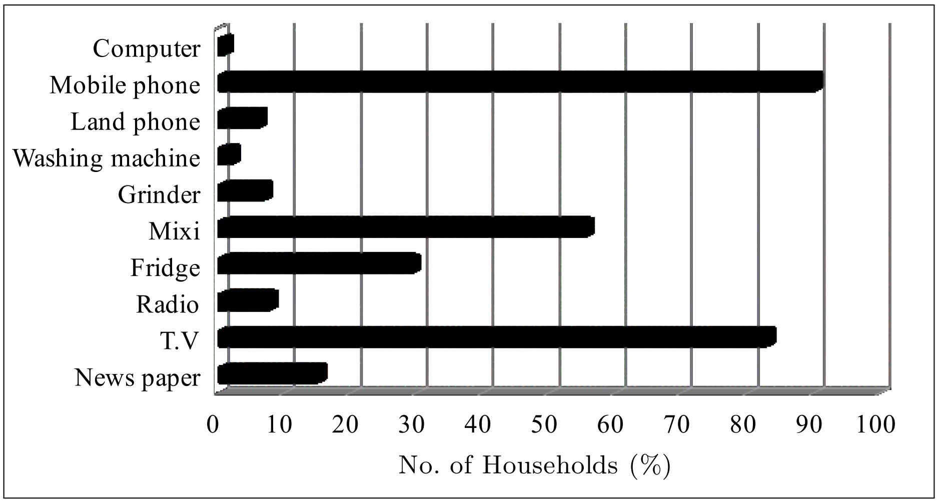
Table 4.23

Possession of land by the marine fisher households in Kerala, 2015

Category(in cent)	No of Households	Per cent
0	12850	9.11
1-5	84730	60.08
6-10	30422	21.57
11-50	12895	9.14
51-100	82	0.06
101-500	34	0.02
Above 500	17	0.01
Total	**141030**	**100**

Source: Compiled by the researcher from Socio-economic survey of fisher folk of Kerala, 2013, Department of fisheries, Thiruvananthapuram, GoK.

very less (1.39%) percentage of the household use computers. Figure 4.10 shows various electronic and ICT gadgets used by the marine households of the state.



Source: Various annual reports of Department of Fisheries, GoK.

Figure 4.10: Possession of various household goods used by marine fisher folk of Kerala

Monthly income and expenditure of the marine households in the state

Fishing and related activities of the household are the main sources of their expenses. Table 4.24 shows the monthly income and expenditure of the households. This shows that the majority of the marine household earn an average monthly income of ₹5,000-₹10,000 and in the same range at each month. A very less number of households earn or spent more than ₹20,000 per month.

Table 4.24
Monthly income and expenditure of the marine households of Kerala

Income categories	**Monthly Income**		**Monthly expenditure**	
(in ₹)	No. of households	%	No. of households	%
Below 5000	31599	22.41	36273	25.72
5000-10000	75836	53.77	73138	51.86
10001-20000	27565	19.55	26096	18.5
20001-50000	5580	3.96	5231	3.71
50001-100000	414	0.29	189	0.13
Above 100000	36	0.03	103	0.07
Total	**141030**	**100**	**141030**	**100**

Source: Socio-economic survey of fisher folk, 2013, Dept. of Fisheries, GoK, 2016.

Debt status of the marine households in the state

Many people (31%) in the fishermen community depend upon private financial institutions to meet their urgent needs such as daily expenses, hospital expenses, and other expenditure. Most of the people take loans from financial institutions for (12%) house construction and the marriage of their children. Moreover, they also depend on private banks and or their friends and relatives for various expenditures. Table 4.25 shows the institution wise loan taken by the fisher population in the state.

Table 4.25
Debt status of the marine households in Kerala (in %)

Purpose	**Mastyafed**	**Housing board**	**Bank**	**Co-operative society**	**SHG✶**	**Private finance**	**Others**	**Total**
Buying fisheries equipments	8	0	0.7	2.1	0.1	2.3	0	13.2
Marriage of children	1.5	0.1	2.1	6.5	0.1	7.2	0.3	17.8
Education	1	0.1	0.8	1.1	0.1	2.6	0.4	6
House construction	7.6	0.6	6.7	15.7	0.6	11.9	1	44.2
Repairing fisheries equipment	0.7	0	0	0.3	0.1	0.5	0	1.6
Treatment	0.9	0	0.6	1.1	0.1	4.4	0.1	7.2
Others	3.3	0	1	2.1	0.2	2.9	0.4	10
Total	**23**	**0.9**	**12**	**28.9**	**1.3**	**31.7**	**2.2**	**100**

✶Note: Self Help Group

Source: Socio-economic survey of fisher folk, 2013, Dept. of Fisheries, GoK, 2016.

4.5 Technology Development of Kerala Marine Sector: From Mechanisation to ICT tools

Kerala has an enduring tradition in marine fishing. The evidence of marine fishing and its availability in Kerala can be found in the songs from the *Sangam Age* to later centuries (Kurien, 1985). It is observed that the Arab traders and Europeans were attracted to Kerala by the flora and fauna and for the scientific value of ichthyology. This abundance and diversity of fish resources in Kerala's inshore sea is the result of unique geographical but different oceanographic features (Kurien, 1985). Along with this, the Arabian Sea estuaries nourished by 41 rivers originating in the Western Ghats, provide fresh water and it gets the right mix of salt and nutrients for all forms of marine resources to grow. The two monsoon cycles, occurring every year in the Kerala coast enrich the sea with oxygen and fresh water.

Fishermen were using traditional skills for fishing till the late-1960s. According to scholars, the Southern region, generally known as Tamilakam, which includes almost the entire region south of Deccan- was divided into five geographical segments. The people who inhabited the coasts, known as Neithal, were described as Meenavar or Paravar in Sangam literature. The Sangam texts refer to a variety of fishing operations and also mentioned about fishes like ayala (salmon) and sravu (shark), which is popular even now in these regions. They speak of *marakkalam*, a wooden vessel that floats on the water and uses of those vessels were later known as 'Marakkars', a seafaring community in the south. Traditional fisherfolk of Kerala were divided into different groups based on their castes. They are Mokayas, Mukkuvas, Valers, Nulayars, Arayas, Mokaveeras, Dheevaras and Kadakkoties. The nature of work of each group varies according to their caste and community. The present demographic patterns among fishing communities in South India remains unchanged for several decades. Muslims, Hindus and Christians are part of the coastal society. 27% of the fishing population in Kerala are from backward caste Hindus, 30% from Muslims, and 37% from Christians (CMFRI, 2012).

4.5.1 Emergence of Indigenous technologies

The fish catch in the marine fishing depends on; the *Crafts* they use, the *Gears* and its accessories apart from the *methods of fishing*. The fishing crafts in the marine sector can be categorized into three types namely, mechanized crafts, motorized crafts and non-motorized crafts. Trawlers, Gill nets and Purse seines come under the category of mechanized fishing crafts, where engine power is also used for fishing. The total number of mechanized boats operating in the State is 3,451 (CMFRI, 2012). Motorized crafts include Plywood canoes, which are used power only for propulsion through outboard motors (OBM) and Inboard engine fitted crafts (inboard vallam) (Harikumar and Rajendran, 2007).

Traditional Crafts

Craft or boat provides a platform for fishing operations as well as, carrying the crew and the fishing gears. The instrument used for the fishing operation depends on the surf conditions, nature and availability of fish stock and the relative economic condition of fishermen. There are three main types of crafts used in the traditional fisheries sector of Kerala. They are named as Kattamaram, Dugout canoes, and Plank-built boats.

1. **Kattamaram**: Kattamarams are traditional crafts used by fishermen of Eastern coastal sides of India from Odisha to Kanyakumari. Later, it also spread to Thiruvananthapuram and Kollam districts of Kerala. 'Catamaram' is a keelless craft formed by tying together few logs of light wood with coir ropes. Two wooden supports called kattamarams are used for lashing them together (Mathur, 1977). Small gaps are purposefully left in-between the logs to allow the water to drain, thus reducing the impact of waves (Ram et al., 1991). According to their length, Kattamarams are two types, the big one 7.50 to 8.50 metres long and 0.80 metres wide, and the small one 4-5 metres long and 0.60 metres wide (Korakandy, 1994). The former accommodates three to four fishermen whereas latter accommodated only one or two. As per the current rate, the investments required for a new Kattamaram is around ₹25,000 - ₹30000 depending upon its size. The technical speciality of

Kattamaram is that it is a versatile craft and can be used in all seasons. The craft is very sturdy, reliable, and cheap (Iyengar, 1985).

2. **Dug-out Canoes**: The dugout canoes are made by scooping out the wood from a single log of mango tree or jungle jack tree. The keel portion is thicker than the sides. It is shaped by using teak panels if necessary. The dug-out canoes may be large or small depending on its usage. The large ones are 9.50 - 12.50 metres long, 0.90 - 1.50 metres wide and 0.75 - 0.90 metres deep. The small ones are 7.20 - 8.50 metres long 0.90 - 1.20 metres wide and 0.45 - 0.60 metres deep. Seven to eleven fishermen can work on large dug-out canoes whereas the smaller one can accommodate only three to six. The investment requirement on bigger dugout canoes is high. Dug-outs canoes are modified into high board dug-out by adding planks stitched on its sides.

3. **Plank-built boats**: Plank-built canoes are constructed by seaming together planks of wood using coir ropes and copper nails (Bhushan, 1979). They are made with or without wood ribs on the sides. Black pitch coating is used to make them watertight. These undecked crafts are generally found in two sizes. The large ones measure 11-13 metres in length, 1 - 1.5 metres in width and 0.70-0.80 metres in depth (Korakandy, 1994). The small ones are 6 - 9.50 metres in length, about 0.90 meters in width and about 0.68 meters in depth. The large ones are operated by 12-15 fishermen while the small ones carry a crew of 4-6 people. The large ones are used during the months of July to October. The smaller ones are used from September to March and April.

Traditional Gears

Gears are the instruments used for catching fish. In the traditional sector, numerous fishing gears are used by fishermen. Traditional fishermen used various types of crafts and gears for fishing. The gears have been evolved from the long experience of the catching and feeding habits of each species of fish. These gears are used differently with the crafts depending upon the seasons, availability of fish, and biological characteristics of fish species. The important gears in use in Kerala coast are;

1. **Gillnets**: Gillnets are single-walled nets and are of different types. They are set, floating or drifting depending upon their usage (Kurien and Willmann, 1982). Set gillnets are used for stationery crafts and can be set either at the surface or at the bottom. Floating gillnets are suspended in water with anchors at the bottom and hence floats on the top. When a floating gill net tied to a craft is allowed to drift with ocean current, it is known as drift net (Bhushan, 1979). Fish gets caught in the gillnet when they swim into it and their gills get entangled in the mesh of the net. The gill nets with different mesh sizes catch different species like mackerel, seers, eel, catfish, skates, ray, sharks etc. Gillnets are used widely in Kerala Coast. They can be operated with a crew of two persons as a catamaram, or as many as twelve as a canoe, depending upon the length and weight of the net. Besides these nets, stake nets, Chinese nets and cast nets are also used for fishing.

2. **Boat Seines**: Boat Seines are a kind of encircling nets (Sainsbury, 1971). They are conical, bell-shaped or bag-shaped nets made from cotton, hemp or nylon. The open end of the boat seines normally has larger meshes which decrease in size towards the closed-end. It is operated with the help of two boats, canoes or catamarams which helps to pull the ends of the two wings of the net while fishing. This keeps the mouth of the net open and the fish swim into the narrower end. In this process, scaring devices made of coconut leaves or wood are often used to produce sound in the water, which drive the fishes into the month of the net. Depending upon the size of the net and the craft used, a boat seine can be operated by as few as five to as many as twenty people. Boat seines are generally used to fish pelagic and mid-water shoaling species. It is generally used at a depth of 10 to 20 fathoms of the sea.

3. **Shore seines**: The Shore seines are bag-shaped nets operated from the shore with the help of a canoe. The working of the shore seine is such that one wing of the net remains on the beach, and the other wing is taken out in the canoe, drawing it in a semi-circular manner and finally bringing the other end to the shore. After the net has been laid, the two ends are simultaneously and gradually pulled in by the fishermen (Kurien, 1978). A canoe with a crew of six to eight persons is used to

place the net in the sea and twenty-five to forty people are employed to pull in the net. Shore seines are used all along the coast of Kerala. It is used for six months during calmer seasons between November and March-April. It is the pelagic and shoaling fishes that get caught within (Korakandy, 1994). The use of shore seines is fast falling in coastal Kerala at present.

4. **Hook and lines**: The hook and line fishing is the most common method of fishing. Kerala fishermen have been using this method of fishing from time immemorial (Bhushan, 1979). This method is generally used in deep sea fishing for mainly catching sharks, eels and seer fish. The type of fish caught using hook and lines depends on the depth to which the line is sunk as well as the size of the hooks. Three types of fishing lines are used by Kerala fishermen namely, hand lines, long lines and chain lines. The hand-line represents the simplest method of fishing and are generally cast from anchored canoes in shallow as well as deep waters of the sea (Kurien, 1978). The number of hooks attached depends on the length of the line and it varies according to seasons. The chain lines are used for catching sharks and use strong hook-lines (Mathur, 1979).

Emergence of mechanisation in Kerala

The approach to fisheries development in Kerala was radically different in nature. The states fisheries policy in the first decade of planned development during 1956 to 1966 period was increased fishing effort. The policy was applied by the artisanal fishermen using their traditional non-mechanised craft and a wide array of fishing gear and tackle (Kurien and Achari, 1990). This approach did not last long. During the mid-1960s modernisation had crept into the fisheries sector of Kerala, by the introduction of growth-oriented model (Thankappan Achari, 1986). Kerala is the richest resources for penaeid prawns as revealed by an exploratory survey conducted by Travancore Government in collaboration with the Saurashtra Government in 1949-1950. During the same time, increased demand for prawns in the international market caused mechanization of crafts in 1953 with the help of Indo-Norwegian Project (INP) (Balan, 1958; Kurien, 1985). The export market started to grow powerfully which led to *pink gold rush* in the 1970s. With the help of Indo-Norwegian Project (INP) mechanised boats of 32 feet size were constructed in its yard and fishermen were trained to use the trawl nets. The craft, Purse-seines was also introduced in Kollam and later on in Kochi (Iyengar, 1985). The overall trend of fish production showed positive growth till the mid-1970s, primarily because of rapid changes from cotton to nylon nets and mechanisation of boats. This situation has changed in 1975, with the level of fish catch and the availability of prawns beginning to fall. The trawler fleet of the stock continued to increase. To improve deep sea fishing Purse-seiners were introduced, to harvest oil sardines and mackerels, whose production was steadily declining by them. The artisanal fishermen of Kerala were the most affected people of modernization which led to a various protest in different occurred, particularly to demand regulations on unsuitable methods of gears and crafts. Fish resources were affected badly because of mechanisation (Iyengar, 1985). The number of artisanal fishermen, craft, and gear they operated continued to increase. From a peak of 448,000 MT of fish in 1973, it fell to 332,000 MT in 1980. Prawns catch also dropped from 86,000 MT to 41,000 MT (Thankappan Achari, 1986). Economic marginalization of traditional fishermen was forced to unite. There were scattered unions among the fisherfolk which were formed mainly under the initiative of the church, named *Latin Catholic Fishermen's Federation (LCFF)* in 1977. They protested against the government to put regulations on mechanised boats. During 1978 the LCFF changed their name to Kerala Swatantra Matsya Thozhilali Federation (KSMTF). Kerala witnessed organised struggles of the traditional fishermen to demand exclusive fishing zones for traditional fishing crafts, a total ban of purse-seiners and night-trawling, banning of bottom trawling during the monsoon months etc. Thus, the enactment of Kerala Marine Fishing Regulation Act (KMFR act) 1980, has empowered fishermen to conserve the fish wealth and by protecting the interests of the traditional fishermen. From 1988 onwards, the trawling ban was introduced in Kerala during monsoon seasons.

Emergence of motorisation

Motorisation of the traditional crafts was another major step of the technological development in the Kerala marine sector and it began in 1980 (Kurien, 1985; Kurien and Willmann, 1982; Kurien and Vijayan, 1995; Balan et al., 1989). Motorisation of the boats means fitting outboard or inboard engines to plywood or fibreglass boats used only for the propulsion. Motorisation helped the traditional fishermen to go deeper into the sea and more fish.

Motorisation and new gear designs have resulted in large-scale capital investment in traditional fishing units (Jacob et al., 1987). In 1970, under the Indo-Belgium Fisheries Project about 100 boats were fitted with the outboard engine at Muttom in Kanyakumari district (John Kurien and Jayakumar 1980). In 1974, the Marinand fisheries co-operative society in Trivandrum district initiated a similar experiment (Gillet, 1981). The successful trials carried out at the fishing village Mannamaly (Ernakulam) during 1979-80 attracted the fishermen of this region. Motorization programme picked up acceleration in Kerala, and fishermen of Alleppey, Ernakulam and Quilon districts were credited for the initiative and large-scale adoption. From about 50 outboards (OBM)engines during 1979-80, the number has gone up to about 10000 in 1988 (Balan et al., 1989). Presently, the cost of a motorised craft (single day) is around ₹3-5 lakhs and multi-day Outboard Motorised (OBM MD) boats cost ₹10-15 lakh. Trip cost of motorised crafts also increased tremendously due to factors like inflation, more hours and days of fishing and hike in the oil price, forcing the fishermen into continuous indebtedness to middlemen.

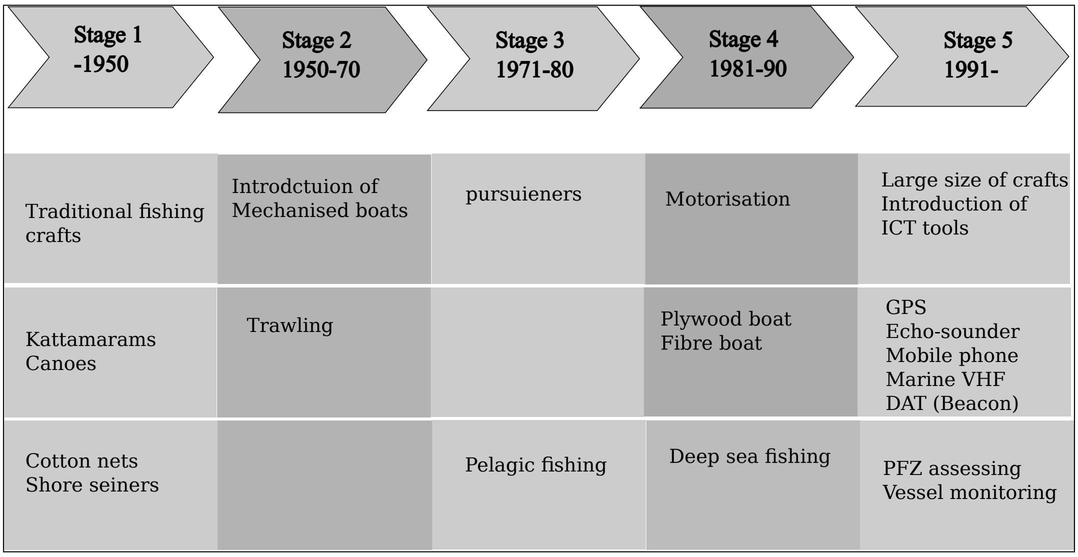
After the advent of motorisation, the traditional sector witnessed a series of further technological changes. This included the introduction of plywood boats in 1982, construction of Artificial Fish Habitats (AFHs) in 1983/84, the introduction of mono-filament gillnet (Kangoose vala), trammet net (discovala), mini trawl net, ring seine (Thanguval and Ranivala) in the mid 1980s, and fish attracting lanterns in 1987 (Rajan, 2002). Fish-attracting lanterns were introduced in almost all the units in Thiruvananthapuram district (Rajan, 1993). Usage of advanced electronic instruments for finding fish habitats in Marianad village and use of winch for ring-seine operation in Ernakulam district and Alappuzha district are examples of modern technology adoption in fisheries sector of Kerala (Rajan, 2002). The mechanisation of fishing craft, the introduction of mechanized boats of new designs, use of improved gear materials and gear designs, adoption of modern techniques are all contributing to the development of fishing industry on scientific lines and thereby in bringing about increased catch (Rajasenan and Sankaranarayanan, 1987).

Table 4.26

Technological progress in Kerala marine fisheries sector

Year	Historical trend
1917	First cooperative society for fishermen
1953	Indo-Norwegian project
1958	Establishment of CIFT in Kochi
1962	Exploratory and experimental fishing by INP and introduction of new craft designed by Central Institute of Fisheries Technology (CIFT) Introduction of nylon nets (Singapore nets) in Kerala Shrimp trawling
1963	Central Institute of Fisheries Nautical and Engineering Training (CIFNET)
1971	CMFRI HQ at Kochi
1974	Motorised boats (OBM) from Marinad coastal area
1976	Introduction of purse-seine in north Kerala
1979	Fisheries college, commercial purse seine nets fishing nets
1980	Motorisation programme adopted by fishermen of Alappuzha, Ernakulam and Kollam Promulgation of the Kerala Marine Fishing Regulation Act 1980 (KMFRA-1980) by Govt. of Kerala MFR Acts Manson trawl ban Diffusion of motorised boats in other coastal regions
1981	Outboard motor (OBM) in Kerala
1982	Plywood canoe in Thiruvananthapuram
1983	Artificial reef in Thiruvananthapuram
1985	Outboard ring seiners Mini-trawling boats
1988	Introduction of ban on trawling during the monsoon period
1996	Introduction of multi- day fishing voyage
1999	Conversion of small trawlers for deep sea prawn fishing
1997	Introduction of inboard ring seiners
2007	Conversion of shrimp trawlers for tuna long line Mobile phone was introduced
2010	Introduction of Wireless set
2012	Introduction of Beacon Distress Alert Transmitter (DAT)

Source: (Jensen, 2007; Sabu and Shaijumon, 2016)



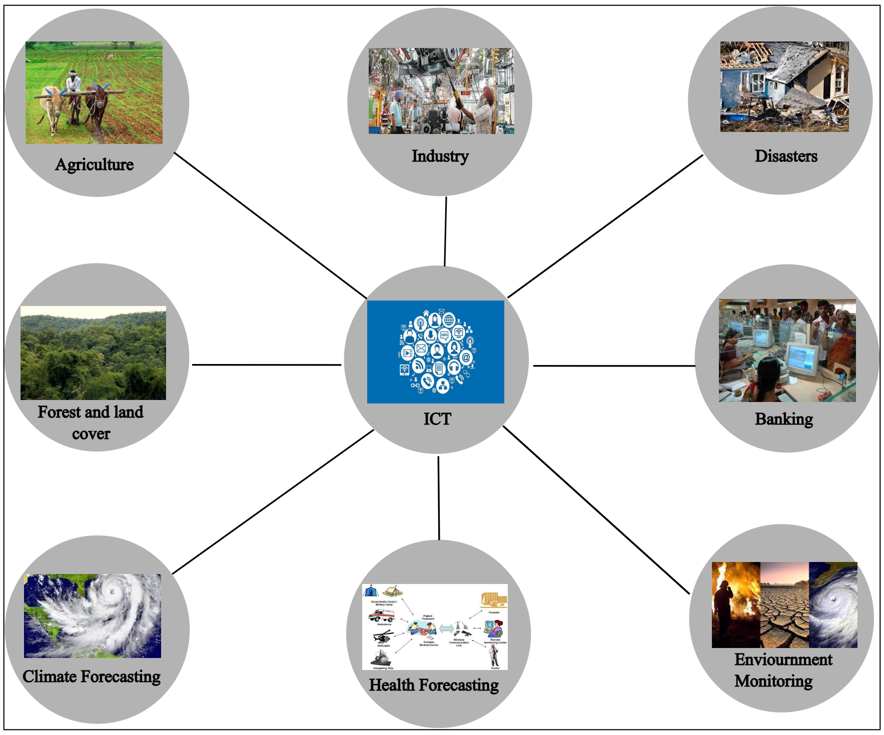
Source: Compiled by the researcher

Figure 4.11: Five phases of technology development in Kerala coast

In Kerala, five phases could be observed in the development of fishing technology. The first phase constitutes the year up to 1950, during which fishing was done by means of indigenous (traditional) fishing crafts like kattamarams, canoes and cotton gears. Propulsion of crafts during this period was done by oars and occasionally by sails. The second phase (1950-70) witnessed mechanisation of boats and trawling system. Third phase (1971-80) witnessed the introduction of purse seiners and their pelagic fishing methods. Fourth phase (1980-90) witnessed the motorisation of plywood boats, and fifth phase (1990-) the emergence of new Information and Communication Technology (ICT) tools and their extensive use in fishing and related activities. The detail observations of technology development in Kerala over these periods are shown in Table 4.26 and Figure 4.11.

4.6 Advance Technology: ICT

Recent advanced The world is undergoing Information and Communication Technology (ICT) revolution, one that has enormous socio-economic implications for the developed and developing countries. Information and Communication Technology (ICT) plays a different role in different industries or sectors. ICT development has led to an increase in its importance over the past 30 years. Mobile communications, the Internet have revolutionised economic activity across all industries in the economy (EMCC, 2003). The use of



Source: Compiled by the researcher

Figure 4.12: Role of ICT in various sectors and its application

electronic computers, telecommunication infrastructure and software to convert, process, transmit and retrieve information from anywhere, any time, to achieve strategic goals all comes under the role of ICT. ICT is an umbrella term which includes any communication or application with the help of radio, cellular phones, computer and network hardware. Figure 4.12 shows the role of ICT in various sectors and its application in India.

In the fisheries sector, it includes radio, mobile phone, GPS, sonar, echo-sounder, marine VHF-radio and Distress Alert Transmitter (DAT). Except for radio, other technologies are called New Information Communication and Technology (FAO, 2007). But in the fishing industry, the impact of new ICT has been more gradual in terms of communication and information dissemination. They have recently been evolving into a valuable tool for the fisheries industry (EMCC, 2003).

4.6.1 ICT in Fisheries Sector

Information Communication Technology (ICT) plays a vital role in the development of the status of agriculture and allied areas in our country. New information and communications technologies (ICTs) are being used across the fisheries sector, from resource assessment, capture or culture to processing and commercialization. ICTs range from advanced modern technologies, such as GPS navigation, satellite communication, and wireless connectivity, to older technologies such as radio and television (FAO, 2007). During the last two decades, the fishing industry of the country has been used various Information Communication Technologies (ICT) in a number of operational areas. The diverse nature of the fishing sector and lack of knowledge sharing across it brings out the problem of the diffusion of technology. Information and Communication Technology in fisheries ranges from advanced modern technologies, such as GPS navigation, satellite communication, and wireless connectivity, to traditional technologies such as radio and television (FAO, 2007). However, the rural people still have difficulties in accessing critical information and understanding them in order to make timely decisions. New information and communication technologies are generating possibilities to solve problems of rural people and also to promote the agricultural production by providing scientific information to the farmers. Figure 4.13 explains how the ICT tools are helping fishermen for various fishing activities.

The role of ICT in changing the fisheries sector is important. It helps in every stage of the fishing process; from catch to commercialisation of fish. Technology has been used to manage change in terms of fisheries and catch management as well as to anticipate change by remodelling the way in which the industry operates. The process of the fish catch and its operation of satellite technologies in the fisheries sector are explained in Figure 4.13.

Figure 4.14 shows the framework on how ICT tools help the fishermen and how it affects the fisheries sector. The framework shows a social, economic and organisational change in the industry. The fisheries sector has undergone major technological change during past decades. Functions of the new technologies have been reassessed by the expert scientist. Until then, ICT will provide the mechanism to ensure that fishing activities are managed efficiently and effectively on a broad scale (EMCC, 2003).

The fishing sector comprises various types of boats with a spectrum of sophistication. At one end lone fishermen operating in coastal waters needing minimal assistance from ICT. At the other end, a fleet of ships fishing in deep water using the latest technologies

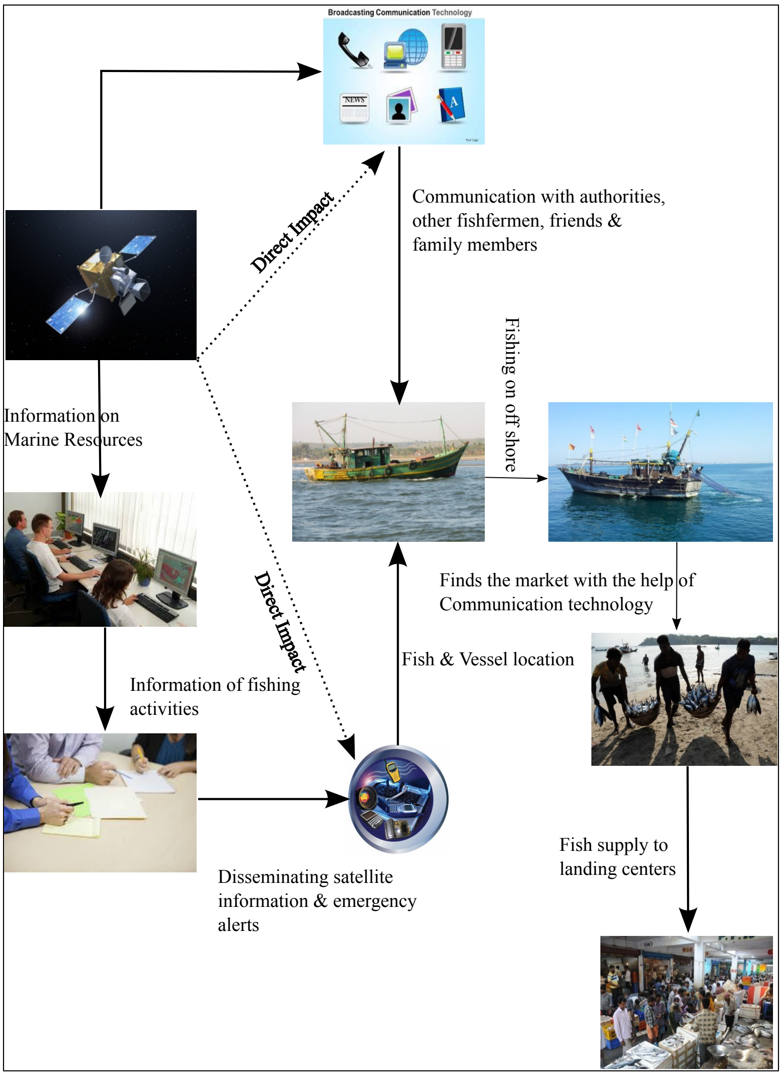


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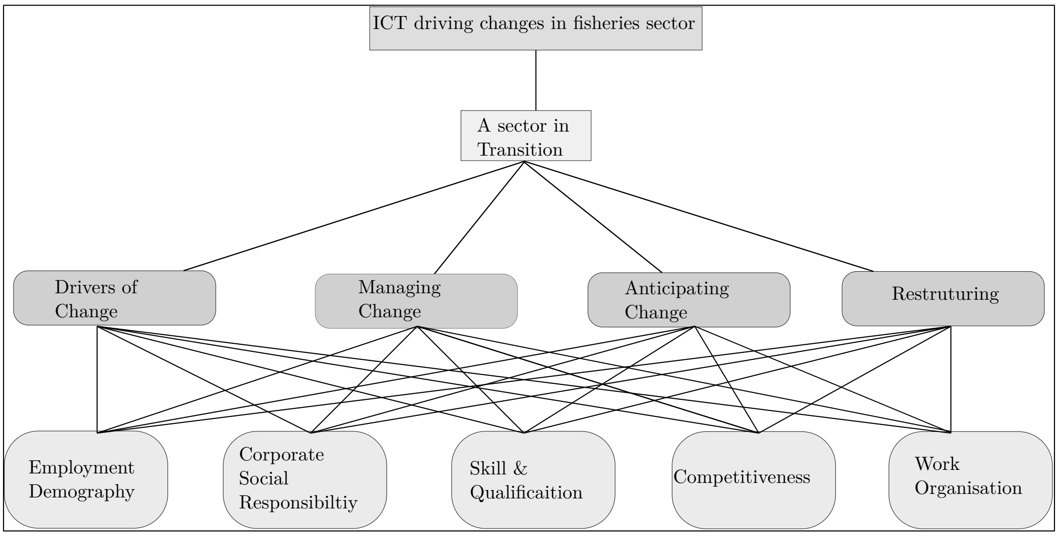
Figure 4.13: Working model of ICT tools in Marine fisheries sector



Source: Compiled by the researcher from (EMCC, 2003)

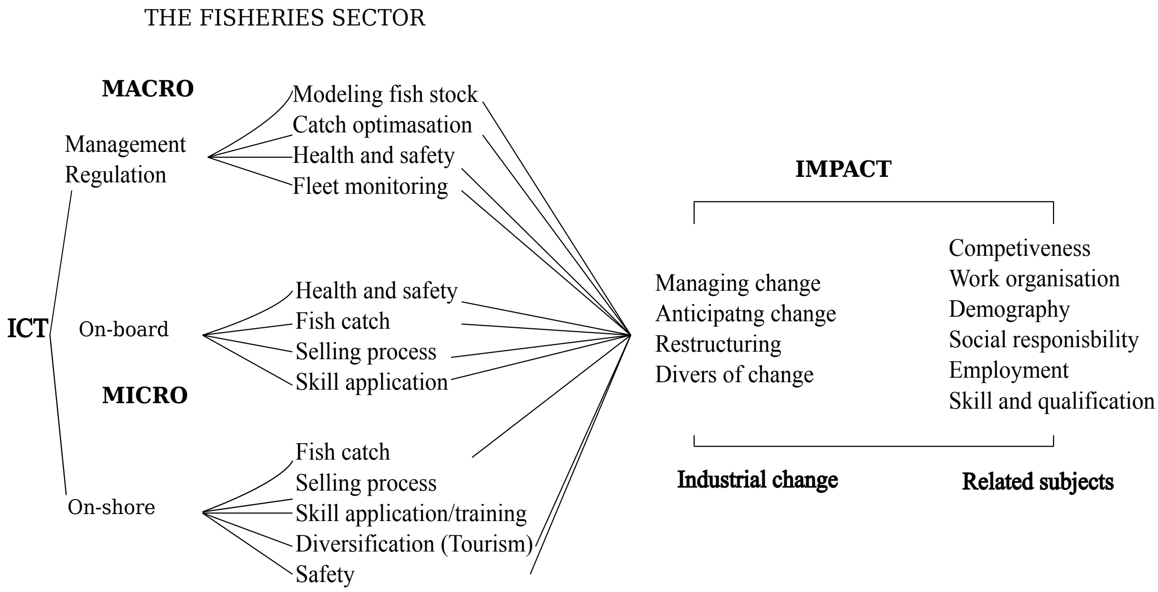
Figure 4.14: ICT and major changes in the fisheries sector

to direct them to rich fishing grounds. However, ICT has not driven any changes in a uniform way across the whole sector. The fishing industry has undergone major changes during the past decades and this will continue in future periods. The situation will be reassessed only if there is a scientific evidence that fishing activities have stabilised and technologies are used effectively. Until then, ICT provides the mechanism to ensure that fishing activities are managed efficiently and effectively on a broad scale.

The study by the European Monitoring Centre on Change (EMCC, 2003) categorised the use of ICT in the fishing sector into three areas:

- Macro technologies: It covers satellite remote sensing and satellite communication systems. Application of these technologies are; pinpoint and monitoring the crafts. This function shows that ICT provides information on weather, environment and the opportunity to monitor and manage fishing grounds and fleets. The use of ICT at this macro-level has been a strong driver of change in the fishing industry since these technologies monitor the status of fishing grounds and alert regulators of overfishing or illegal fishing activity. Thus, the industry is forced to adopt more responsible fishing practices. As a result, ICT becomes essential for managing fisheries and in supporting policymakers and the industry to achieve long-term sustainability.

- Micro technologies on-ship: It includes the use of echo sounder & sonar, sensors



Source: Compiled by the researcher from (EMCC, 2003)

Figure 4.15: ICT driven changes in the fisheries sector

and other IT systems. It helps in understanding the depth of the sea. Improvements in navigation have enhanced many aspects of the fisheries activity. Navigational technologies like GPS guide vessels along precise routes avoiding easily known obstacles and allowing them to return to well-charted and characterised fishing grounds. It supports fisheries management and sustainability, increase safety, increase efficiency and need less crew size.

- Micro technologies on shore: It includes IT systems which help for e-Commerce (including e-Auction, mobile telephony etc.). Mobile telephony has had a limited impact aboard vessels because fishers can only use it when close to shore (at a distance no greater than 10km off-shore). It offers support for the supply chain and marketing of fish resources. It also assesses how the Internet has provided opportunities to diversify or supplement existing activities. The Internet has further revolutionised this and, in recent years, progress in developing e-Commerce activities has created a new market and operational opportunities. It enhances market efficiency, increase competition, and supports fisheries sustainable management. Figure 4.15 shows a schematic view of how technologies have enabled change in the fishing sector.

Table 4.27
Functions of ICT tools and their benefits in fishing and its related activities

ICT tools	Usage/benefits
GPS	It helps to locate the spots of the fish location, it aids the fishermen to come back accurately to the spotted location whether its daylight or dark. It Improves the safety aspects for the fishermen and helps them to,return to the jetty even in bad weather or at night where vision is restricted, can be an assistance to the fishermen due to its ability to warn them if they are close to the border or dangerous coral reef, Information such as latitude, longitude, altitude, surface speed, sunrise and sunset.
Echo-Sounder	It uses to get the accurate fishing area, density, depth movement, species and size of the fish shoal.
Wireless set	Intensifies safety aspects of the fishermen. In case of emergency, wireless set help the fishermen to communicate either with other vessels or and related agencies, so that immediate action can be taken. On the top of it, they can instantly share information regarding the fishing spots with the others. Moreover, through wireless set they can deal a better price with dealer even when they are still on the sea.
Mobile	To search, distribute and share fisheries related information such as market price, online applications, weather conditions, professional advices, loan service, business opportunity etc among or between colleague and related agencies.
Beacon	Distress Alert Transmitter (Beacon) that operates with the INSAT satellite, for the use of fisherman going deep in to sea. Marine VHF radios can be used for a wide variety of purposes, including summoning rescue services and communicating with other vessels or users.,.

ICT Tools and its Functions

Information and Communication Technologies are used for the purpose of fishing and fisheries related activities. The uses of ICT for development go beyond direct support for income-generating activities. ICT helps the knowledge sharing, training and education, and social inclusion (Ejiogu-Okereke et al., 2016). Table 4.27 shows the various ICT tools and functions of each tool in fishing and its related activities. Figure 4.17 shows images of ICT tools of various coastal districts of Kerala. The role of each ICT tools varies according to its nature and usage. They are classified as the tools for specialist and general applications.

General Application Technology

General Purpose Technology (GPT) has penetrated all sectors of the economy and entailed large potentials of technological improvements and innovation complementarities within firms. In this regard, the diffusion of ICT as a GPT is of a high overall economic importance since it may contribute to a substantial rise of productivity in various industries and thereby increase the growth potentials of the economy as a whole (Hempell, 2006). ICT is a general purpose technology (GPT), which is usually characterized as an enabling technology that induces further innovations and is adopted in a widely across all sectors of the economy (Liao et al., 2016). Bresnahan and Trajtenberg (1995) argue that a GPT contains three main characteristics: pervasiveness, improvement, and innovation spawning. In the fisheries sector, following technologies are being used as general purposive technologies;

1. Global Positioning System (GPS)
2. Mobile phones
3. VHF radios

Specialist Application Technology

1. Remote Sensing Technology
2. Vessel Monitoring System
3. Advanced Eco-Sounders and Sonars
4. Beacon

1. **Global Positioning System**: Global Positioning System (GPS) is a radio navigation system that allows land, sea and ariborne users to determine their exact location, velocity and time 24 hours a day, in all weather conditions, anywhere in the world. This technology works with the help of satellite and helps in monitoring fishing vessels. GPS helps the fishermen to locate better fishing grounds and in turn can avoid fishing in protected areas. Now, the advanced GPS navigation or tracking device is equipped with a camera. It takes'geotagged' photographs which have GPS data including latitude and longitude and possibly compass bearings attached to the images (FAO, 2012). It saves time and fuel and helps in safe return (FAO, 2007).

2. **Remote Sensing Technology**: Any technology which obtains information about objects or areas from a distance, typically from aircraft or satellites. The remote sensing

technology helps the fishermen to catch more with less difficulty in searching the fishes by sending Fish Potential Zone (FPZ). FPZ data are sent to fishermen with the help of various NGO in their local language. The Indian Space Research Organization (ISRO) has developed this method for fishermen to increase their catch and make fishing an important occupation. Through satellite remote sensing application, sea surface temperature (SST) and chlorophyll images can be generated from the data provided by Ocean Colour Monitor (OCM). On superimposing the colour information over the thermal gradients, the areas of denser fish distribution can be identified at thermal fronts in the areas of high Chlorophyll concentration. Based on the strength of colour and thermal features, the Potential Fishing Zones can be identified. Fishery Survey of India (FSI) [4] collaborates with Space Application Centre, Ahmedabad and INCOIS, Hyderabad for the development of FPZ algorithm and the validation process (FSI, Mumbai).

3. **Eco-Sounders and Sonars**: These instruments display measurements of reflected sound on a graphical display, allowing operators to interpret information to locate schools of fish, underwater debris, and the sea bottom (FAO, 2012). They may also be integrated with GPS navigation systems. This also helps to lessen the problem of unwanted fish catch which has no market value. The efficiency of total catch improves includes considerably and there will be a substantial profit increase.

4. **Vessel Monitoring System (VMS)**: VMS is used in commercial fishing to allow environmental and fisheries regulatory organizations to track and monitor the activities of the fish and is used for communication between the ships and various stakeholders in the shore. This system has been widely using in various Common Wealth countries. Recently, Kerala fisheries sector has been using the device increasingly. It helps the fishermen to position the vessels to determine better catch prospects. The operation of VMS takes the help of GPS. Those fitted GPS can generate more benefit for a wide spectrum of sea fishing activity which increases the product and the profit.

5. **Mobile Phones**: Mobile phone is a portable telephone that an make and receive calls over a radio frequency link while the user is moving within a telephone service area. The application of the mobile phone has no limit. In the fishery sector, mobile phone

[4] FSI is the nodal fishery institute in India with the primary responsibility of survey and assessment of fishery resources in India.

plays an important role in communication purposes. The fishermen can communicate among themselves from offshore to inshore waters with others. This technology can readily relieve their condition by talking to family and friends onshore, who must have this instrument ready. Mobile Phones are a ready reckoner in the marketing arena, from catch to processing.

6. **Marine VHF radios**: A marine VHF set a is combination of transmitter and receiver and only operates on standard international frequencies knowns as channels. Marine VHF radio is installed on all large and small boats and is used for various purposes, including summoning rescue services and communicating with other vessels, harbours, other users etc.

7. **Beacon**: The beacon with the size of a police wireless set, is a small part of a complex yet simple global satellite-based system that ISRO involved in. Once the lost fishermen activate the beacon, the distress signals are picked up by a satellite, in this case the INSAT 3A, and transmitted to its tracking centres at Lucknow and Bangalore. Once the signal is received, a telefax is automatically sent to the nearest rescue coordinator - the Coast Guard or Indian Air Force (IAF), which can send teams to look for them.

In general, the motivation behind the introduction of ICT tools in the fisheries sector can be summarised as follows:

- To increase productivity
- To enhance operating capacity
- To reduce cost,
- To improve product quality
- To enhancing safety and working conditions of fisher population.

However there are some barriers to the uptake of new technology and/or development of existing services, that include:

- *Lack of knowledge*: It includes complexity of technology, unfamiliarity with technology options, and need for external consultancy/service provider.

- *Culture*: It includes distrust of technology, central government and other regulatory bodies

- *Size of the industry*: Large number of SMEs and lack of coordination among them are other barriers for technology adoption in the sector .

- *Level of investment*: Also existence of continuous limits on budgets, other investment priorities, and lack of appropriate government support do not promote more adoption of new technologies.

4.7 ICT tools in Kerala Marine Sector

There is a tremendous change in the pattern of adoption of technology in Kerala marine fisheries sector in the last three decades. Communication among the fishermen was very limited and fishing was done with the help of traditional knowledge during the 1980s (e.g., looking at different stars in the sky to reach seashore). Since the 1990s, Kerala marine fisheries sector has experienced a phenomenal change in the introduction of technology (Mary, 2011). The main features during the period are the emergence of several technologies like Information Communication and Space Technology (ICST) or New Information and Communication Technology (NICT). The New Information and Communication Technologies (NICT) includes devices like echo-sounder, Global Positioning System (GPS), mobile phone, wireless set, echo-sounder and beacon. The States of Tamil Nadu, Andhra Pradesh and Maharashtra came to the forefront in the adoption of these technologies (Mary, 2011). The good result of the adoption of this advanced technology in the neighbouring states made Kerala fishermen adopt the same. This kind of diffusion of a new innovation is called as ‘epidemic model’ of diffusion (Stoneman, 2002). Mobile was introduced in 1997 among the Kerala fishermen (Jensen, 2007) and GPS, Echo-sounder, Wireless set, beacon were introduced in motorised boats during 2000 (Sabu and Shaijumon, 2016). The proper use of such advanced technology (ICT) helped the motorised fishermen to achieve more efficiency and income.

The present usage level of ICT gadgets in Kerala is more compared to the previous marine census, 2005. Also, the Marine Census Report, 2010 report showed the detailed entry of each ICT tools like mobile and GPS. All other ICT tools like wireless set, beacon etc. are included in other ICT gadgets.

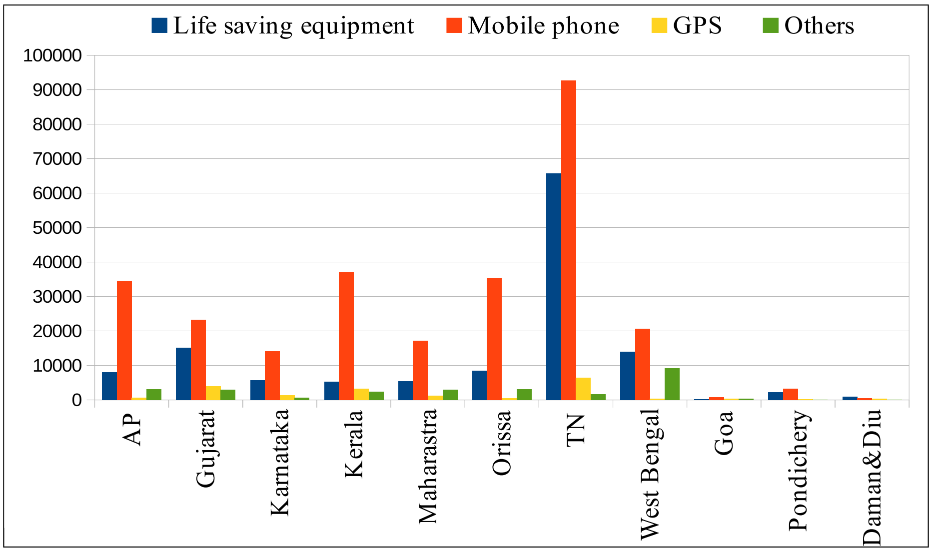
Figure 4.16 shows the state-wise contribution of ICT gadgets of India in 2010. Tamil Nadu holds the first position in using more new electronic and life safety tools (ICT tools), followed by Kerala among the states. Least number of ICT tools were reported in Karnataka and Goa compared to all other states in India. This is mainly due to the less number of fisher population in the two states (except UTs). Figure 4.16 shows that Kerala ranks the second position in the usage of mobile phone, 3^{rd} in GPS and 6^{th} in other ICTs respectively in India. CMFRI census report, 2010 indicates that the total number of boats using ICT in Kerala was; GPS - 3288, mobile - 36965 and other ICT tools - 2354 which is 13, 18 and 0.1 per cent of the nation, respectively.

CMFRI census report, 2005 shows that only 4,224 electronics gadgets (electronics gadgets are meant for a total number of ICT tools) were used by Kerala fishermen for fishing and communicating purposes during 2005. However, the 2010 Marine Census, systematic segregation of gadgets have been adopted. Before, 2010, all electronic ICT tools were considered as electronic gadgets in the census. District-wise distribution of new ICT tools of Kerala during 2005 and 2010 is shown in the Table 4.28. It shows that mobile phone is one of the largest used ICT tools in Kerala. An average number of mobile users/adopters are more compared to other ICT tools. It indicates that easily usable and low-cost technology would diffuse very fast. Use of wireless set, echo-sounder and beacon are included in other ICT tools and such technologies began to be extensively used after only 2010.

Table 4.28
Number of ICT tools in Kerala marine fisheries sector during 2005 and 2010

District	2005		2010				
	Electronics gadgets*	Active fishermen	Mobile phone	GPS	Other ICT tools	Total ICT tools	Active fishermen
Thiruvananthapuram	354	38805	5703	1851	820	8374	35314
Kollam	304	8665	5862	412	357	6631	16677
Alappuzha	191	25255	10454	221	547	11222	23256
Ernakulam	539	9713	2411	229	410	3050	8934
Thrissur	247	7054	1575	382	126	2083	5704
Malappuram	626	16422	3099	26	57	3182	22238
Kozhikode	770	20119	3435	112	36	3583	20200
Kannur	85	6470	1361	55	0	1416	5404
Kasaragod	108	7719	3065	0	1	3066	7669
Total	**4224**	**140222**	**36965**	**3288**	**2354**	**42607**	**145396**

Source: Marine Fisheries Census, 2005 and 2010, CMFRI
* Information technologies, such as; GPS and Echo-sounder.



Source: Marine Fisheries Census, 2010, CMFRI

Figure 4.16: Number of various ICT tools in Indian marine fisheries sector

The use of mobile phones in the fisheries sector of Kerala started in the year 2000. Presently, 2.8 lakh fishermen use mobile phone for communication. The second most useful electronic gadget for fishermen is GPS, 185,36 fishermen households own GPS for fishing. Among the marine fishermen households in India, 1,31,012 families were having life saving equipments (life jacket, beacon etc.) which is very low when compared to total fishing crafts (CMFRI, 2012).

Source: Compiled photos from field visits, 2014

Figure 4.17: Presently observed ICT tools in the coastal villages of Kerala

4.7.1 ICT programmes in the state

The success of India's socio-economic development and ICT- enabled business services in all the industries is by now well known. The impact of ICTs in supporting health, e-governance, and agricultural applications for rural populations has also simultaneously created new business opportunities (kuriyan2008). Indian Agriculture sector contributes almost 22% of our GDP and gives employment opportunity to approximately 60% of the Indian population (GoI, 2017a). Less contribution to the nation is the limiting factors of farmers in maximizing their incomes. For this purpose, they access new technologies to contact with government endeavour, resources, institutions and services. Figure 4.18 shows the various groups who use the ICT tools and its application for their agricultural activities. One of the main reasons for using new ICT tools is that expert scientific advice on crop production and marketing is not reaching the farming community in a timely manner. There is a concern that the gap between the information rich and information poor is widening. This is due to various reasons such as lack of proper usage of ICT, lack of sufficient extension workers, poor technological knowledge of farmers and village level extension personnel, and the economic problems of rural people. ICT can play a significant role in solving these problems. ICT can connect various technologies and processes to distribute and communicate the desired information to the targeted people. Now, at least fifty grass root projects in the agriculture sector are currently using modern ICT for development in India (Keniston, 2002).

The advancements in ICT can be utilised for providing accurate, timely, relevant information and services to the farmers, thereby facilitating an environment for more remunerative agriculture. Given the development scenario in Indian Agriculture, ICT movement is still evolving. However, all the ICT initiatives are not uniform. It shows disparities between regions in the level and quality of ICTs. Telecommunications and information facilities and different nature of demand of the farmers are different according to areas. While these initiatives are intended to address the needs of the farmers through ICT, their actual usage and their ability to bring significant impact on the farm productivity and socio-economic development of the intended beneficiaries is to be understood. It is relatively unknown as to whether the intended beneficiaries actually use the technology provided for them meaningfully or not. The common problems in adoption of ICT in rural segments are ICT illiteracy, non-availability of relevant and localized contents in their own languages, technology accessibility and other issues such as lack awareness and willingness in the adoption of new technologies among the rural peoples. As seen in some of the initiatives of ICT introduction in rural areas, the critical aspect of the usage of ICTs for farmers and their groups is the involvement of human interface at the last mile indicating that there is a human dependency in the transmission of information/knowledge to farmers. Thus, we need to understand how far the ICT initiatives are able to address the farmer's needs so that better solutions can be developed to address those unmet needs. We need to understand some past and present major ICT initiatives in agriculture, especially fisheries sector in India.

Source: Compiled by the researcher

Figure 4.18: Profile of ICT using agriculture workforce

Various ICT projects were implemented successfully in the agriculture sector of India.

The programmes such as Akashganga, Bhoomi,ITC e-chaupal, TARAhaat, Gyandoot, Kisan Call Centers (KCCs), AGMARKNET, Bellandur Gram Panchayat Computer System, Boodikote Jagruthi Resource Center, eSeva APOnline Centers, M.S.Swaminathan Research Foundation InfoVillage Knowledge Centers, HP iCommunity in Kuppam, Wired Warana Village Project, mKRISHI®Fisheries, Fisher Friend, Byrraju Foundation's v-Agri, and ISRO/INCOIS are the major important ICT projects of the country. The aims and objectives of each project vary between states and the programmes. But the broad aim of all the ICT projects is to reduce digital gap in India and to make people computer-literate. In Kerala programmes such as Akshaya, KISSAN Kerala, E-Krishi Kerala, FISHNET, Fish Market Intelligence System (F-MIS) are important ICT oriented programmes to empower the people especially, farmers electronically (Radhakumari, 2006; Kukreja and Chakrabarti, 2013; CIPS, 2017).

4.7.2 Major Challenges of Kerala Marine Sector

The fishery resource is a natural one and subject to variations due to natural reasons. The total changes taking place in the weather throughout the world, such as global warming, are definitely going to affect the fish population. Together with this, the water body where the fish life is getting polluted highly because of human interference. Oil spills from tankers due to various reasons are reported regularly. Large-scale industrialization in the coastal areas without proper waste disposal mechanism is definitely affecting the ecosystem of the sea, making it unfit for the survival of the fish and other organisms. Using illegal methods, destructive (bottom trawling) fishing, and irresponsible use of ICTs are other major problems of the fisheries sector. Kerala Perspective Plan 2030 (KPP) shows some challenges and concerns of the marine sector and provides various ways of approach to be implemented to become a better and sustainable sector in the country GoK (2015). They are;

Declining marine fish resources: Decline in marine fishing since 2006-07 is a major problem of the sector (Bhathal, 2014). Within the short period from 2012-2016, fish production had declined by over 6%. The world has been facing a global fishing crisis in unprecedented proportions. Marine ecosystems are on the decline worldwide. According to the U.N. Food and Agriculture Organization (FAO), 70 per cent of the world's commercially important marine fish stocks is fully fished, overexploited, or depleted(FAO, 2016a). The main reasons for this scenario are unsustainable fishing practices (intrusions by trawlers into artisanal zone, illegal operation of nets during high tide, use of smaller sized gillnets to catch juveniles, dominance of foreign and domestic trawling ships and migration of other state non-fisher to the field), inappropriate incentives, high demand for limited resources, poverty, inadequate knowledge, ineffective governance, and interactions between fishery sector and other aspects of the environment(GoI, 2012; GoK, 2015).

Environmental issues: The health of marine fisheries is intrinsically linked with various natural phenomena(Libini et al., 2018). Environmental hazards that are encountered have also had adversely affected marine stock in Kerala over the years. Loss of marine biodiversity due to overfishing, water pollution and emission of effluents and damage to marine habitats and organisms living on the sea floor by dredging and trawling are the some of them (GoI, 2017b).

Inadequate fish processing: Fish processing in India is done almost entirely for export. Open sun-dried fish and fish meal are the only major exceptions. The total fish processing and storage facility in Kerala is grossly inadequate compared to the potential for fish production and processing. Most exports are in the form of frozen fish. Also, the Indian brand does not exist in advanced countries' markets. Even at the national level, barely five per cent of India's seafood exports are in processed form. In fact, more than 60% of India's exports to South East Asia are re-exported after processing. Vietnam, a small country, has created vast capacity in fish processing and is importing raw material to re-export it after processing (GoI, 2017b).

Maladaptive capacity of new technologies: Various forms of adoption of new technologies in the marine sector is very important. The rate of adoption of any new technology usually starts low, accelerates until about 50% of the community has adopted the technology, then decelerates, eventually approaching zero, as nearly everyone in the community has adopted the technology. Always the poor section of the society is motorised fishermen become conservative or sceptic of adoption of new technology in the sector.

They face lack of leadership/support for innovation, lack of understanding and ability to implement, difficulty/non-availability of time for training, resistance to learning new technology, work stress/overload, cost, proof of value, the reliability of technology, less user acceptance and less knowledge on technology performance. The gap or barrier between adopters and non-adopters exists in the sector. A proper dissemination of innovation of new technology and timely distribution of information about the technology and awareness about the functioning of new technology, proper infrastructure in the landing centres help minority section of the society to increase the adaptive capacity of the fishermen and brings holistic development of the sector.

Ineffective supply chain management of fish resources: Ineffective selling and supply of marine fish resource are the other major challenge of this sector (Hameri and Pálsson, 2003). Even though Kerala faces a technology boom in all the other sectors, the marine sector, still lacks the maximum usage of the technology in the present market system due to inability of fishermen in using new technologies like mobile phone and its various applications, and lack of infrastructure facilities to provided internet facilities in the inshore waters of the sea. There various innovative uses of mobile and internet applications are made use of by marine research institutions at present. However, making these new applications useful in the sector is very difficult since most of the fishermen are either illiterate or less educated (GoI, 2017b).

Co-operative societies: Worsening livelihood situation of Kerala's fishermen due to decreasing fish catches led to massive unrest among the fishermen in the 1970s. Social and religious activists in several coastal localities motivated the creation of fishermen's cooperatives and unions, in an effort to direct the people's anger into organized actions to defend their interests (Steyn and Das, 2015). The Kerala Government created Matsyafed to protect the fisheries' community of the state. The structure of the federation was envisaged in a way that each marine village would have a Cooperative Society to represent in the apex body. However, the issues such as lack of infrastructure, safety and protection of fishermen, coastal poverty, competition between traditional and trawler fishermen, and digital divide remain the same (GoI, 2017b).

State also presents an integrated approach to the effective use and management of fisheries resource. They are the institutional approach, technological approach, and human capital approach. The institutional approach addresses various concerns of the local fishermen and to safeguard their religious, cultural and natural practices associated with fishing. In technological approach, the use of acoustics, light or any other additional stimuli to enhance encounters by target species within the catching zone of trawl nets and use of electronic seabed mapping tools and integrated global navigation satellite tools reduce fishing effort and fuel consumption. Human capital approach focus on educating the traditional fishermen about the modern, eco and environmentally friendly fishing techniques/methods through the Governmental and Non-Governmental organisation.

4.8 Summary

Fisheries sector in India has been one of the major contributors of employment, income and foreign exchange earnings through exports. Fisheries sector both inland and marine are showing competing nature in the economy. The contribution of inland is more than the marine sector in recent years. However, the marine sector never showed a negative trend in its growth. Upgrading of technology in the fisheries sector in the form of a new craft and gear and Information and Communication Technology can help the fisheries to increase its share in world fish production. Kerala marine fisheries sector has faced the technology progress from the 1950s and the sector achieved growth since the three decades. Availability of large quantity of penaeid prawns and related fish caused for the introduction of mechanisation of boats in the sector. A large investment of mechanisation and lack of necessary skill to adopt technology have created many problems for the traditional fishermen. Motorisation of the crafts was introduced in the 1980s to improve the products, productivity and living standards of traditional fishermen. The new technology adoption has helped the fishermen in improving their communication, safety and landing. The technological progress in the sector made substantial changes in Kerala marine sector and benefited both the mechanised and traditional small-scale fishermen in various ways.

Chapter 5

ADOPTION OF ICT TOOLS AMONG MOTORISED FISHING CRAFTS IN KERALA: AN EMPIRICAL ANALYSIS

In this chapter, the results of primary data that are collected from six coastal districts of Kerala namely Thiruvananthapuram, Kollam, Alappuzha, Ernakulam, Malappuram, and Kozhikode are qualitatively and quantitatively analysed. Data analyses are presented on the basis of the objectives of the study. Out of five research objectives, four are discussed coastal district wise and the last one analysed as a whole to get a general picture of the influencing variables in the state. All the procedures and methods of data analysis of each research objectives are reviewed in detail.

5.1 Introduction

The primary data was collected from the 500 traditional motorised fishermen of the selected regions of Kerala by using a well structured questionnaire (see Appendix). The purpose of this study is to examine the role of ICT tools and its impact on the marine fisheries sector of Kerala. The study further examined the socio-economic factors influencing the adoption of ICT tools in the sector. Each study objective is analysed and explained both quantitatively and qualitatively. Demographic features of fishermen and crafts and usage level of ICT tools were analysed by statistical values like mean, standard deviation and line graph. Fitting the recalled primary data to 'sigmoid shape' was executed by logistic growth function. Determinants of ICT tools adoption is explained with the help of non-parametric test, called Principal Component Analysis (PCA) and socio-economic influencing factors are measured by crosstabs, chi-square test, and binomial logistic regression model. The summary of this chapter shows the potential for merging theoretical views and practice (real data).

This chapter is divided into six sections. Section 5.2 deals with the basic demographic feature of fishermen and the details of the fishing crafts they use. Section 5.3 explains the level of ICT tools adoption in the sector. Section 5.4 shows an 'S' shaped fitted logistic curve in the study areas. Section 5.5 presents the major determinants of the ICT tools in Kerala marine sector. Section 5.6 carries out the influence of socio-economic factors and type of craft factors for adoption of ICT tools. Section 5.7 comprises the relationship between the income and the adoption level of ICT tools.

5.2 Socio-economic features of Fishermen and Profile of their Crafts

It is necessary to study the social and economic factors of fishermen which helps to understand how both factors influence the adoption of ICT tools in the sector. The socio-economic features of the fishermen are looked upon in terms of age, family size, religion, marital status, and education in Kerala. The basic profile of the motorised crafts is analysed in terms of boat size, crew size, initial cost of boat, use of ICT tools, time duration of usage of ICT tools, days per trip, fuel of craft, total cost, and total revenue per trip in Kerala.

This section is divided into three sub-sections. Sub-section 1 explains the socio-economic conditions of Northern Kerala. Sub-section 2 shows the socio-economic profile of Central Kerala. Sub-section 3 discusses the socio-economic status of Southern coastal districts of Kerala.

5.2.1 Northern Coastal Districts - Kozhikode and Malappuram

On the basis of geography, the state's districts are generally grouped into three parts; the Northern Kerala districts of Kozhikode and Malappuram; the Central Kerala districts of Ernakulam and Alappuzha, Southern Kerala districts; Kollam and Thiruvananthapuram. The Northern coastal districts; Kozhikode (formerly known as Calicut) and Malappuram were historically significant and politically important districts of the state and shares almost fifty percentage of coastal villages and fisher population to the total of the Northern region (see the map of the study 1.1).

Table 5.1 shows the basic socio-economic features of coastal districts of Kozhikode and Malappuram. It shows that, single day (SD) fishermen from Malappuram district belong to the age group of 43 and the mean age of fishermen work in multi-day (MD)fishing is 36. The results show that, MD fishing is dominated by younger fishermen in Malappuram. Fishermen in Kozhikode belong to the age group of 40 for SD and 43 for MD. The majority of fishermen (66%) from Kozhikode belong to Christianity compared to Muslim (99%) community in Malappuram. Kerala Marine Census, 2010, shows that only 0.2% of Christian population lives in Kozhikode. The reason for the higher Christian fishermen population in Kozhikode is migration of the fishermen from South and Central Kerala as well as the presence of better infrastructure facilities for landing, supply, and selling of fish. The mean years of schooling in Kozhikode is 5.0 and in Malappuram is 4.5 which are under the stipulated 12^{th} standard of schooling[1]. This implies that the majority of the fishermen (95%) from the northern region have only primary education and the majority of the fishermen are married. Also, illiteracy rate in the northern region is high compared to other regions of the state. Illiteracy rate of Kozhikode is 14% for SD and 32% for MD fishermen and illiteracy rate of Malappuram is 14% for SD and 24% for MD fishermen. Thus, uneducated fishermen in the both the coastal regions are high compared to other study regions. The number of young and bachelor fishermen are very less in this coastal region [2]. The average size of northern SD is 8.5-9 Overall length (L_{OA}) and MD OBM fishing craft is 9-10L_{OA}. The initial cost of craft, gears, and electronic gadgets of SD is ₹500 thousand in 2015 whereas initial investment to buy MD craft in the region is one million rupees. The average crew size on both the crafts is four. The average fishing distance of SD fishermen of Kozhikode is 40 nautical miles (nm) when compared to the 30 nautical mile in Malappuram. The average days of fishing by MD outboard motorised (OBM) is four in Kozhikode and it is three days in Malappuram.

[1]The average year of schooling has been calculated on the basis of equation $\frac{Pn \times 4 + UPn \times 7 + Sn \times 10 + HSn \times 12}{N}$, where, Pn = Primary education no., UPn = Upper primary education no., Sn = Secondary education no., HSn = Higher secondary education no., and N = Total number of fishermen (GoK, 2009).

[2]It is the average of two weights i.e., 1 = Unmarried fisherman and 2 = Married fisherman

The average operating revenue per trip of SD fishermen in Kozhikode is ₹12,051.91 and the average revenue of MD fishermen is ₹18,729.39, which shows more than SD (₹ 3166.67) and MD (₹14,904.08) fishermen's revenue of Malappuram. 70-80 litres of Kerosene (with 5 litres of petrol) is used by SD fibre (FRP) of 9-10 m L_{OA} for a trip that covers 45-50 km in Kozhikode. The total expenditure for this craft per trip is ₹7,500. Fishermen of Malappuram go around 20-25 km in the 9-10 m L_{OA} size of craft with the cost of ₹3,450 per trip. The study shows that operational revenue and profit of Malappuram fishing crafts are less compared to Kozhikode fishing crafts due to less distance of fishing zone. The majority of the fishermen in Malappuram are active fishermen with the experience of 16-20 years and it is less for MD fishermen, where the fishermen have only the working experience of 10-15 years. Whereas, fishing experience of both the SD and MD fishermen of Kozhikode is 16-20 years. This is due to the reason that, MD fishing method was adopted by Kozhikode fishermen much before Malappuram fishermen.

The present study states that the SD FRP craft of 9 m L_{OA} with the outboard engine of 9-11 hp with 70-80 litres of fuel covers 30-40 km at the cost of ₹3,000 - ₹7,000 per trip. MD FRP craft of 10 m L_{OA} with the outboard engine of 9-11 hp with 150-200 litres of fuel covers 50-60 km with the cost of ₹12,000 - ₹19,000 per trip. Multi-day fishing needs more energy and health compared to single day fishing, because of its long days of stay at sea. But, a previous study of Jeeva et al. (2012) stated that the FRP craft of 9 m L_{OA} with the outboard engine of 9-11 hp with 10-15 litres of fuel covers 20 km with the cost of ₹500 per trip only.

Table 5.1

Socio-economic status of the fishermen in the Northern study areas ($n = 195$)

Sl.No.	Variables	Kozhikode ($n = 105$)						Malappuram ($n = 90$)					
		Single day (SD)		Multi day (MD)				Single day (SD)		Multi day (MD)			
		OBM		OBM		IBM		OBM		OBM		IBM	
		Mean	Std.D	Mean	Std.D	Mean	Std.D	Mean	Std.D	Mean	Std.D	Mean	Std.D
1	Age	40.56	7.27	43.68	12.78	37.36	13.71	43.38	9.82	35.98	10.34	34.43	16.03
2	Family size (N)	5.13	1.3	5.43	1.94	5.09	1.30	5.71	1.88	1.00	0.00	1.00	0.00
3	Religion (%)	CH-47.7, H-13.6, M - 38.6		CH-45.3, H-25.7, M - 30.0		CH-100		M-100		M-100		M-88, H-12	
4	Marital Status (%)	95	0.29	1.89	0.31	1.73	0.47	100.00	0.00	1.88	0.33	1.57	0.53
5	Education (score)*	1.47	1.1	1.32	1.20	1.27	1.19	1.09	0.62	1.33	1.05	1.86	1.21
6	Illiteracy (%)	14	1.1	24.00	4.50	8.00	5.60	14.00	0.62	22.00		2.00	
7	Boat size (ft)	29.95	2.25	32.81	3.65	44.27	4.29	27.33	2.63	31.52	2.21	30.57	2.23
8	Crew size (ns)	4.37	1.34	4.30	1.22	6.55	1.81	3.19	0.40	4.14	1.07	3.57	0.79
9	Cost of C,G, E (in lakh)	5.56	2.31	10.27	4.38	27.45	11.54	6.23	2.16	9.57	2.30	35.5	2.23
10	Cost of Mobile (₹)	2724.42	1426.5	1798.65	783.20	1672.73	911.14	1561.90	538.95	1490.24	304.80	1514.29	357.90
11	Cost of GPS (₹)	11058.82	2762.75	11385.71	3994.93	15181.82	404.52	14000.00	6957.01	10958.06	3416.80	11800.00	3033.15
12	Cost of Echo-sounder (₹)	NA		NA		49000.00	6678.32	NA		15000.00	3456.23	15000.00	5678.41
13	Cost of Wireless set (₹)	12000	0	14722.22	751.90	15545.45	1213.56	NA	NA	17444.44	4096.07	10000.00	1500.00
14	Fishing distance (nm)	43.12	13.54	64.22	32.36	381.82	141.90	35.23	14.44	55.67	21.21	150	13.67
15	Fishing experience (ys)	16-20	4.12	20-25	2.00	11-15	2.01	14-20	1.82	11-15	1.47	11-15	2.27
16	Days per trip	1	0	4.27	1.68	8.82	5.38	1.00	0.00	3.55	1.11	2.86	1.86
17	Diesel/trip (litre)					1081.82	1300.44			455	100.7	650	234.5
18	Petrol/trip (litre)	5.74	3.09	16.29	14.05			4.86	1.42				
19	Kerosene/trip (litre)	83.95	34.54	224.46	105.46			74.76	41.51	192.38	60.38	145.00	43.87
20	Savings of GPS tools (₹)	1206.9	575.05	1569.70	1110.60	1954.55	1588.31	250.00	70.71	716.67	424.61		
21	Average Monthly Income (₹)	7964.29	4241.76	8554.05	4432.81	23454.55	4058.66	4976.19	5568.83	6187.18	3899.13	5642.86	4269.21
22	Total operating cost (₹)	7341.9	5507.29	19812.50	13189.33	10363.66	96981.72	3452.38	2018.07	12857.14	6886.08	38714.29	2058.66
23	Total Revenue (₹)	19393.81	24073.27	38541.89	35419.38	254090.91	176320.99	6619.05	5951.69	29411.90	30407.17	137140.29	4644.51
24	Adoption value	1.7	0	2.5		3.45		1.4		2		3.5	
25	Active fishermen (N)	44		50		11		40		48		2	

Note: ₹= Rupees, N = Total Number, yrs = in Year, ft = in Feet size, nm = nautical mile distance, CH = Christians, M = Muslim, H = Hindu

*The average year of schooling has been calculated on the basis of equation, $\frac{P_n \times 4 + UP_n \times 7 + S_n \times 10 HS_n \times 12}{N}$ where, Pn = Primary education no., UPn = Upper primary, Education no., Sn = Secondary education no., HSn = Higher secondary education no., and N = Total number of fishermen (GoK, 2009).

Source: Primary survey, 2015-16

Average age of MD IBM fishermen (35) in all the regions are low compared to MD OBM fishermen (43). Illiteracy rate (5%) is also low among MD IBM due to the participation of youngest fishermen in the crafts. The size of the MD IBM crafts (35-40 feet) is more compared to MD OBM. The initial cost of gear, craft, and electronic gadgets of MD OBM (₹1 million) is very less compared to MD IBM (₹3.5 million) in the sector. Average fishing days in the sea is more for MD IBM (10) than MD OBM (3) due to large craft and crews sizes. Obviously, operating cost (10000) and revenue per trip of MD IBM is more than the MD OBM. Operating cost of MD OBM is ₹10,000 and it is ₹35,000 for MD IBM crafts. MD OBM crafts use fuel petrol for starting engines and kerosene for propulsion purpose, whereas MD IBM use only diesel for starting and propulsion of the vessel in the sea. Fishing experience of MD IBM is less compared to MD OBM. This is due to the reason that, more youngest fishermen are concentrated in this type of crafts. Fishing area and fishing distance from the seashore of MD IBM (150 NM) is more than the MD OBM (60) in the region. In Malappuram region, no fishermen are interested to go in MD IBM crafts due to its long distance of fishing and more risk of life than the Kozhikode region. It is happening in the Kozhikode due to the migrant fishermen of southern Kerala with their MD IBM crafts.

5.2.2 Central Coastal Districts - Ernakulam and Alappuzha

The marine fishermen population of Kerala are not uniformly distributed across the districts. Their concentration varies according to their religion, community and also in the nature of fishing. These differences reflect in their respective socio-economic features. Table 5.2 shows the socio-economic features and the features of crafts in the central marine districts, viz, Ernakulam and Alappuzha of Kerala. The fishermen of Ernakulam uses MD OBM, MD IBM and SD plywood crafts. However, all the fishing boats of Alappuzha district are single day OBM plywood/Fibre boats. The mean age of multi-day IBM fishermen is 39 in Ernakulam and mean of single day OBM fishermen is 45 in Alappuzha. The family size of the fishermen in both the districts is five, which is high compared to the national and state averages[3]. The average years of schooling are calculated by taking

[3] Average family size in India is 4.8 and it is 4.2 in Kerala (CMFRI, 2012)

the education level to the higher secondary school. Results reveal that, mean years of schooling of secondary school. The reason for less education rate in Ernakulam is the of migration of active fishermen from the Southern Kerala (i.e. Kollam and Thiruvananthapuram) and Tamil Nadu (Thuthoor and Kullachal) districts. The influence of Government Adult Education Programme of 1990 had a positive impact on in the coastal belt, making them to read and write (Focus Group Discussion). Uneducated fishermen in Alappuzha is also very low compared to Ernakulam and other coastal districts in the State. The illiteracy rate among fishermen population of Alappuzha is only 3% whereas it is 19% for Ernakulam. Majority of the fishermen belong to Christian community in central Kerala.

The average size of MD IBM crafts in Ernakulam is 17 m L_{OA} and Alappuzha OBM boat fishermen use crafts size of 8.5 - 9 m L_{OA}. Crew size (labourers) and an initial investment of motorised crafts vary according to the size of the crafts. The initial investment for 17 m L_{OA} size IBM crafts is 5.0-6.0 million rupees and investment for 8.5 - 9 m L_{OA} size crafts is 1.0 -1.2 million rupees. The initial cost includes the cost for crafts, gillnets, hook and line, electronic gadgets; such as mobile phone, GPS, wireless set, beacon etc. The average fishing days of IBM craft in the region is 10-15. The per capita investment per active fishermen in mechanised units is 3,22092 and it is 21,311 in motorised boats in 2005 (Sathiadhas, 2006). The maximum size of fishermen in MD IBM craft is 9-12 and the maximum fishermen in the SD OBM craft is four to six. The size of the crew varies according to the season, method of fishing, and fishing days (FGD). The average nautical mile of fishing of MD IBM craft is 150-450 NM in Ernakulam whereas it is 20-30 NM for single day OBM in Alappuzha fishing craft.

The development of craft and gears had begun in 1950s in the central coastal regions and the use of new ICT tools in the sector started in the late the 1990s (FGD). This happened with the help of the local fishermen employees union. The fishermen started using mobile phone for fishing purpose in 2006 in Ernakulam and the beginning of 2007 in Alappuzha, which supports the findings of Jensen (2007). Slowly the adoption of GPS was begun by MD IBM fishermen of Ernakulam in 1997, by observing the use of GPS by mechanised boats. Firstly GPS was used by mechanized fishing crafts and later it was adopted by inboard motorised boats - deep sea fishermen. Ernakulam coastal district is considered as the innovator of GPS for fishing purpose (FGD). IBM crafts fishermen in

Ernakulam began to use echo-sounder in late the 1990s. A large number of gulf migration of fishermen, fast development infrastructure and sound economic policies were the main reasons for the adoption of ICT tools.

The early adoption of both the GPS and echo-sounder in Ernakulam was in the year 1997. Alappuzha fishermen adopted the GPS very late, i.e., in the year 2010. This is due to long distance fishing in the region. No single day outboard motorised boat use echo-sounder for finding out fish shoals, because of lack of facilities in fishing crafts and high cost of the gadget. The cost of an echo-sounder is between ₹45,000 to ₹50,000 and it varies according to the brand. Most of the fishermen use Garmin GPS or Garmin/Furno[4] echo-sounder for finding out location, position of the craft, fish shoal, and reef. There are two sizes of GPS and wireless sets available in the market, such as Handy GPS & Wireless set and fixed GPS & Wireless set. Fixed tools are high cost but have more specification whereas handy tools are low cost with less specification. Most of the IBM crafts use high-cost gadget compared to OBM crafts. The cost of GPS used by IBM is between ₹18,000 to ₹20,000. Sometimes, they use the echo-sounder which can also be used as an alternative to GPS and fetches a high price. MD IBM fishing craft saves almost ₹5,000 to ₹6,000 through less fuel consumption due to the use of GPS compared to the earlier method of finding the fishing location[5]. Cost of wirelesses sets of multi-day IBM is between ₹18000 to ₹2000, which is attached to the top of the deck where the driver (shrank) sits. SD OBM fishing craft use handy GPS cost between ₹10,000 to ₹12,000 and they also use handy wireless set of ₹15,000 . The costs of GPS and wireless set are affordable for SD OBM motorized fishing crafts (FGD).

Fifty percent of multi-day IBM fishermen have 25-30 years of fishing experience and remaining has only about ten to twenty years of experience. It shows that the participation of the younger fishermen are necessary for multi-day IBM fishing crafts. IBM crafts use traditional gears of large size gill nets and hook and line, which need more manpower. Single day OBM crafts of Alappuzha are operated by only middle-aged fishermen for fishing which use only small size gill nets (FGD). This is due the to less distance of fishing zone and use of different types of gill nets. The total cost of a trip by MD IBM craft is

[4]Garmin and Furno are the names of two International technology companies.

[5]Traditional method of finding out the position of crafts either with the help of stars or geographical features

2 lakhs rupees which include fuel, food and maintenance cost. The cost per trip varies according to the days they spend on the sea. If they spend almost 20 to 25 days in the sea, the total expenditure will be around 3 to 5 lakh rupee for fuel, food and maintenance cost. Whereas, SD OBM spends ₹5000 to ₹6000 per trip for fuel, food, and maintenance cost. The average revenue per trip also shows a big difference between the districts. Multi-day IBM crafts earn almost 1-1.2 million rupees and it would increase if they spend 25 days and more. The SD OBM crafts in Alappuzha earn only ₹10,000 - ₹20,000 per trip. The differences in all the features of both the districts were due to the different types of crafts and different methods of fishing that the fishermen follow. In short, the study reveals that quality and quantity of fishes that the fishermen catch and the revenue of craft depends on fishing days, size of the craft and crew, usage of ICT tools, gears, and method of fishing.

Table 5.2
Socio-economic status of the fishermen in the Central regions ($n = 115$)

Variables	Ernakulam ($n = 30$)		Alappuzha ($n = 85$)	
	Multi day (MD) IBM		Single day (SD) OBM	
	Mean	Std.D.	Mean	Std.D.
Age	39.03	12.45	44.91	10.62
Family size (N)	4.97	1.694	4.48	1.22
Religion (%)	CH-100		CH-93, H-5, M - 2	
Marital Status(%)	90	0.39	95	0.19
Education (score)	5.2	1.07	6.6	1.66
Illiteracy (%)	19		2.9	
Size (in ft)	53.22	5.078	29.76	1.79
Crew size (N)	11.38	2.709	6.28	0.82
Cost of C,G & engine((₹) in lakh)	46	10	10	6
Cost of Mobile phone (₹)	4265.63	1717.95	1370.10	484.11
Cost of GPS (₹)	18046.9	5255.35	17344.90	6309.25
Cost of Echo-sounder (₹)	44937.5	13916.70	NA	
Cost of Wireless set (₹)	17677.4	3153.16	15000	
Nautical mile of fishing (nm)	396.72	242.994	25.29	6.4
No. of Mobile phone	2.1875	0.78	2	0
Saving due to GPS tools (₹)	6109.4	7661.9	431.3	196.2
Days per trip	14.38	7.17	1	0
Average catch of last trip (in Kg)	35.125	176.07	1-250	0
Diesel/kerosene in use of a trip (in litre)	2765.63	2201.12	80-100	0
Fishing experience (in Ys)	25-30	1.82	20-30	6.4
Operating cost/trip (₹)	2,68,125	-	6,810.78	-
Revenue/trip (₹)	11,09687	-	21,460	-
Adoption score	4	0	1.75	0.5
Active fishermen (N)	30		85	

Note: ₹= Rupees, N = Total Number, ys = in years, ft = in Feet size, nm = nautical mile distance, dash (-) = not being used

NB: Beacon is 100% subsidised tool

*The average year of schooling has been calculated on the basis of equation, $\frac{P_n \times 4 + UP_n \times 7 + S_n \times 10 HS_n \times 12}{N}$

Source: Primary survey, 2015-16

5.2.3 Southern Coastal Districts - Thiruvananthapuram and Kollam

Thiruvananthapuram and Kollam districts are the Southernmost districts of the coastal state of Kerala. Thiruvananthapuram has a large number of fishermen population engaged in fishing and allied activities. Most of the fishing villages in the district have their basis in small-scale fisheries, which account for a large percentage of the state's income.

Table 5.3 shows the detail socio-economic profile of Kollam and Thiruvananthapuram coastal districts. Mean age of the SD fishermen in Kollam and Thiruvananthapuram is 49 and 40, respectively, whereas the average age of MD fishermen in both regions are 37 & 39 only. The average size of the family members of motorised fishermen in south Kerala is 4.5. Fishermen population of these regions belong to Hindu, Christian and Muslim communities. The study shows that the majority of the motorised fishermen of south Kerala belongs to the Christian community and it supports the result of CMFRI census, 2010. The study shows that majority of the multi-day fishermen in Thiruvananthapuram and Kollam belong to Christianity and a few fishermen belong to other religions. Most of the fishermen in both the regions are married. The education status shows that fishermen of both the coastal districts have a primary level education. MD fishermen from Thiruvananthapuram have education status value of 3.5. The education value up to four shows primary education. Meanwhile, almost 30% of the uneducated fishermen, (30% in TVM and 34% in KLM) work in Southern regions.

The size of the SD fishing motorised craft is 8.5-9m overall length (L_{OA}) and MD fishing is 10-11m L_{OA} in the south region. The average number of crews per trip in SD fishing is five and the average size of fishermen in MD fishing is six in both the regions. The initial investment of an SD fishing craft in both the regions is six lakhs (0.6 million) rupees and multi-day fishing crafts in these regions cost 16 to 20 lakh (1.6 to 2 million) rupees. The cost or initial investment includes the cost of craft, Suzuki[6] or Yamaha of 9.9 hp engine (90% of crafts are having two engines), gears (gillnet is the major gear with hook and line), and electronic gadgets of Information and Communication Technology tools such as GPS, echo-sounder, wireless set, mobile phone, and beacon. MD fishermen

[6]Mastyafed (Mastyathozhilali (local name for Fishermen Federation) is the sole importer and distributor of Suzuki engines to OBM fishermen in south India. It assesses the demand and supply of OBM to the traditional fisheries sector

also use other electronic gadgets like radio and Television at when in the sea. They use a basic mobile phone of MTS, Reliance mobile phone with inbuilt SIM and Nokia mobile phone with BSNL and another mobile phone with Idea network. The average cost of a mobile phone of SD fishermen in both the regions is between ₹2500 to ₹3000 and cost of mobile phone of MD fishermen is between ₹5000 to ₹10000. The average cost of GPS of SD fishing craft in the southern coastal regions is between ₹8000 to ₹10000 and the cost of GPS for MD fishing is between ₹15,000 to ₹20,000. Cost of a wireless set that is used for MD fishing is between ₹15000 to ₹18000 and SD fishermen of both the regions do not use wireless set for communication purpose. They instead use mobile phones. In the rough sea season, a distance of SD fishing per trip in southern regions is 15-20 NM and it increases up to 30 NM distance in the non-rough season.in the rough season, MD fishing craft of both the regions go upto 50 to 60 NM for fishing and they go upto 80 to 100 NM distance in the non rough season. The average days of spent on MD fishing is between five to six days. SD fishing crafts use five to ten litres of petrol and of 50-60 litre of kerosene per trip and it varies according to seasons. In the rough season, the amount of fuel consumption by SD fishing craft is less than 60 litre. A small number of IBM fishing craft is also working in the Kollam and Thiruvananthapuram coastal districts. IBM crafts of Kollam and Thiruvananthapuram use 1,000 to 1,500 litres of diesel per trip. The average cost per trip of SD fishing craft in both the regions is between ₹3000 to ₹4000 and MD OBM fishing crafts spend between ₹8000 to ₹10000 per trip. But, the average cost of an MD IBM fishing craft is more compared to MD OBM fishing gears (₹30000 to ₹35,000 per trip) due to more distance and days of fishing. The average revenue per trip of SD craft in the regions is between ₹ 8000 to ₹10,000, whereas, MD OBM crafts earns revenue between ₹15.0000 to ₹20,000. But, on an average, the revenue of MD-IBM fishing crafts per trip is between ₹60,000 to ₹70,000.

Table 5.3

Socio-economic status of the fishermen in the southern study areas ($n = 190$)

Sl.No.	Variables	Thiruvananthapuram ($n = 160$)						Kollam($n = 30$)					
		Single day (SD)		Multi-day (MD)				Single day (SD)		Multi day (MD)			
		OBM		OBM		IBM		OBM		OBM		IBM	
		Mean	Std.D	Mean	Std.D	Mean	Std.D	Mean	Std.D	Mean	Std.D	Mean	Std.D
1	Age	40	10.435	39.0	9.7	28.0	4.2	48.7	8.2	36.70	8.744	39.50	17.68
2	Family size (N)	4.6	1.23	4.4	1.4	5.5	2.1	4.6	1.1	4.30	1.34	6.00	1.41
3	Religion (%)	CH-99, H-1		CH-100		CH-100		CH-97.8 H-2.2,		CH-100		CH-100	
4	Marital Status (%)	95	0.31	1.9	0.3	1.5	0.7	100.0		1.80	0.42	2.0	0.0
5	Education (score)*	4.72	0.989	3.92	2.6	4.2	0.0	4.6	0.8	5.25	1.17	4.5	1.41
6	Illiteracy (%)	21	0.9	10.0		3.0		17.0	0.8	20.0	0.0	0.0	0.0
7	Boat size (ft)	28.66	2.889	35.0	2.8	58.5	4.9	30.3	2.5	34.50	2.014	53.50	2.121
8	Crew size (N)	4.96	1.288	5.8	0.8	10.0	0.0	4.6	1.1	5.50	.527	10.00	0.0
9	Cost of C,G, E (lakhs in ₹)	4.942	2.02	14.8	5.5	57.5	10.6	7.8	2.6	15.20	3.76	58.50	9.19
10	Cost of Mobile (₹)	2413.5	1043.23	2569.0	1303.8	2000.0	0.0	1377.78	482.9	1770.00	820.64	3500.00	0.000
11	Cost of GPS (₹)	12430.69	4627.65	14629.6	8419.1	22500.0	3535.5	11032.26	3191.0	13900.00	3754.99	32000.00	22627.42
12	Cost of Echo-sounder (₹)	0	0	9000.0		45000.0	26870.1	0.0	0.0	40000.00		25000.00	0.000
13	Cost of Wireless set (₹)	0	0	15272.1	3713.1	31000.0		0.0	0.0	17860.00	7474.876	22000.00	0.000
14	Fishing distance (nm)	14.11	5.667	87.5	76.5	600.0	424.3	23.6	8.3	79.70	1.64655	300.00	0.000
15	Fishing experience (Ys)	26-30	1.735	21-25	1.8	21-25	1.4	26-30		26-30		21-25	2.12
16	Days per trip	1	0	6.4	1.0	16.5	4.9	1.0	0.0	5.40	.843	12.50	3.53
17	Diesel/trip (litre)	0	0	3000.0		3250.0	2474.9					2750.00	353.5
18	Petrol/trip (litre)	10.50	9.35	34.7	8.5	35.0		10.3	8.3	46.11	27.588		
19	Kerosene/trip (litre)	50.42	24.322	291.4	67.6	250.0		63.5	22.8	304.44	77.19		
20	Savings of GPS tools	267.33	131.99	1458.6	917.5	3000.0	0.0	416.7	277.5	1571.43	534.52	3000.00	2828.43
21	Average Monthly Income	6693.07	5389.78	14192.9		25000.0		6361.0	1002.1	12777.78	3767.552	20000.00	7071.068
22	Total cost (₹)	3933.66	2582.77	27900.0	21805.7	200000.0	0.0	4875.0	3392.0	30666.67	5049.76	200000.00	0.000
23	Total Revenue (₹)	8749.8	10217.23	75659.7	65909.3	300000.0		9011.1	7938.7	106666.67	90932.67	382500.00	116672.61
24	Adoption value	2.009	0.17	2.98		2.9		1.861	0.35	3.25		3.4	
25	Active fishermen (N)	85		73		2		20		8		2	

Note: ₹= Rupees, N = Total Number, yrs = in Year, ft = in Feet size, nm = nautical mile distance, CH = Christians, M = Muslim, H = Hindu

*The average year of schooling has been calculated on the basis of equation, $\frac{P_n \times 4 + UP_n \times 7 + S_n \times 10 HS_n \times 12}{N}$ where, Pn = Primary education no., UPn = Upper primary, Education no., Sn = Secondary education no., HSn = Higher secondary education no., and N = Total number of fishermen (GoK, 2009).

Source: Primary survey, 2015-16

The study shows that participation of younger fishermen is more in Multi-day (MD) fishing boats than single day (SD) fishing boats. This is due to the reason that, MD fishing crafts and gears need more physical work than SD motorised fishing crafts in the sector. Most of the fishermen engaged in small-scale motorised fishing crafts belonged to Christian (73%) community. The educational status of Christian fishermen in the Southern districts are shown higher than the state average. Uneducated fishermen (43%) are more in the northern coastal region than other regions, but, the average uneducated fishermen in Kerala is only 7%. Fishing experience of the Northern fishermen is also less compared to the other two regions, with the former having only less than 20 years of experience. SD fishermen use less priced mobile phone than MD fishermen for communication purpose. Fishermen use mobile phone for gaining information on when to land, and not where to land. This finding of the study shows a contradiction with the study of Jensen (2007). The study also reveals that MD fishermen use mobile phone not only for communicating with other fishermen but also for entrainment purposes when they are at deep sea. Use of GPS helps the SD fishermen to save ₹500 and helps MD fishermen to save ₹1500 which shows a 15% reduction in the fuel consumption. GPS also helps to save fish searching time and ensures safety of fishermen in the sea. All these reasons urged the fishermen to prefer GPS most among all the available ICT tools. Days spend for MD fishing is more in southern regions than other regions. Normally, five days are spent for MD fishing by southern small-scale fishermen. Therefore, cost per trip in the south is more compared to other coastal districts of the state. But, the cost of SD fishing is high in Alappuzha than other regions. This is due to more time being spent in fishing activities. Region-wise, the cost of SD fishing is high in Southern Kerala because of more spending on food and beverages items along the trip. Number of use of ICT tools is less in Northern regions, because of difference in fishing method; less fishing distance, and less dedication. Use of new ICT tools in fishing by small-scale fishermen of SD and MD motorised boats helped to compete with other types of crafts in the sector and improved their standard of living and welfare.

Average age of MD IBM and MD OBM are almost the same in the southern region (38) except MD IBM of Thiruvananthapuram. Illiteracy rate (3%) is also very low among MD IBM than the MD OBM fishers. The size of the MD IBM crafts (55 feet) is more compared to MD OBM (35 feet). The initial cost of gear, craft, and electronic gadgets of MD OBM (₹1.5 million) is very less compared to MD IBM (₹5.5 million) in the sector. Cost of crafts varies with the other regions due to its size and material of crafts built. Average fishing days in the sea is more for MD IBM (15-20) than MD OBM (4-5) due to large craft and crews sizes. Operating cost per trip of MD IBM is ₹100 thousand to ₹200 thousand and most of the time, revenue per trip of MD IBM is more than its cost of operation. Operating cost per trip of MD OBM is ₹35, 000 and fishermen gets an income of ₹10,000 - ₹15,000 on an average per month. MD IBM use ₹2,000- ₹3,000 of diesel for fishing. MD IBM of Thiruvananthapuram regions uses more fuel for fishing due to its long distance of fishing area. MD IBM may also cross 200 NM of distance in the sea for fishing in off-season months. Fishing experience of MD IBM and MD OBM fishermen is almost the same which shows that southern region fishermen entirely depend on fishing and related activities for several decades. Most of the fishermen in the southern region know the pulses of the sea and they observe all the changes of the sea and the sector and adjust their fishing method and technology accordingly. The adoption value of ICT tools in southern regions is more compared to other regions of Kerala.

5.3 Trend Analysis of Adopted ICT Tools in Kerala

Trend line analysis is one of the most important concepts in quantitative research analysis for both trend identification and confirmation of any data. Technically it is the movement of highs and lows of several points that form a trend. This study has also used this analysis to identify the trend of ICT tools usage and confirm its 'sigmoid shape'. This analysis is important to understand the adaptive capacity of new technologies among the motorised fishermen of Kerala. The rate of adoption of ICT tools also shows the general implications of technological development in the fisheries sector.

Section 5.3 deals with the degree of adoption of ICT tools among motorised fishermen in the state and it is presented into three sub-sections according to each region.

5.3.1 Northern Kerala Coastal regions: Kozhikode and Malappuram

Trend analysis of adopted ICT tools in Northern districts was constructed with the help of the recall data; where the fishermen were asked the adopted year of each ICT tools in the survey procedures. The recall data of adopted years of ICT tools helps to understand the nature of adoption trend in the coastal districts.

Table 5.4 and shows the rate and trend of adoption of ICT tools in the Kozhikode and Malappuram coastal districts. The rate of adoption of ICT tools is the relative speed with which it is adopted by members of the fishing community. Majority of the SD and MD fishermen in the two regions started using mobile phones during 2005-2010. Many of the mobile manufacturing companies and mobile network companies emerged during this period. Price of mobile phone was also reduced during this period. But, the majority of the SD & MD fishermen in Kozhikode was used GPS during the period of 2005-2010, but, the majority of Malappuram SD & MD fishermen adopted GPS only after 2010. Malappuram SD fishermen travelled more distance for fishing and the region showed an increased rate of multi-day fishing, intensively, after the year 2010. No SD fishermen in Malappuram used GPS in the same period whereas SD fishermen of Kozhikode had adopted GPS by this period. Though GPS technology began to be adopted by both the coastal districts in the same period, it diffused fast or in Kozhikode compared to Malappuram. This is due to more number of MD fishing crafts being registered in Kozhikode. Wireless set the most useful communication technology while fishing in deep sea, was adopted by Kozhikode fishermen much earlier than Malappuram. MD fishermen in Kozhikode used wireless set during 2007 and it was gained popularity in Malappuram only after 2010. A small percentage (2.3%) of SD fishermen in Kozhikode use wireless set while fishing and no such a case were seen in the Malappuram region. This was due to the reason that multi-day fishing (MD) with plywood OBM in Malappuram became popular from 2010 onwards. Beacon: the lifesaver in critical times, is a recently adopted technology, that started being used only since 2013 by the fishermen of both the regions.

Figure 5.1 shows diverse tendencies of ICT tools adoption in the Northern regions during 1998-2015. A large increase in adoption of mobile phone and GPS tools was observed during the period of 2005-2012, while adoption of wireless set showed a large improve-

Table 5.4
Degree of adoption of ICT tools in northern Kerala (rates of single day fishing crafts are in parenthesis)

	Malappuram (in %) ($n = 90$)				Kozhikode (in %) ($n = 105$)			
Year	**M. Phone**	**GPS**	**Wireless set**	**Beacon**	**M.Phone**	**GPS**	**Wireless set**	**Beacon**
2000		2.7 (0)				2.9 (5.9)		
2002		2.7 (0)				2.9 (5.9)		
2005	4.2 (9.5)	2.7 (16.7)			27.5 (20.9)	8.6 (23.5)		
2007	14.6 (38.1)	2.7 (0)			13.5 (27.9)	22.9 (2.9)	5.6 (0)	
2008	14.6 (19)	2.7 (0)			5.4 (11.6)	2.9 (14.7)	11.1 (0)	
2009	20.8 (0)	2.7 (0)			2.7 (0)	5.7 (11.8)	5.6 (0)	
2010	2.1 (28.6)	27 (50)	10.0		5.4 (14)	17.1 (17.6)	22.2 (0)	
2011	37.5 (0)	8.1 (0)	0.0 (0)		8.1 (2.3)	11.4 (0)	11.1 (2.3)	
2012	2.1 (0)	37.8 (16.7)	70.0		16.2 (9.3)	14.3 (5.9)	27.8 (0)	
2013	4.2 (0)	2.7 (16.7)	10.0	2 (0)	5.4 (4.7)	5.7 (5.9)	11.1 (0)	1 (0)
2014		5.4 (0)	10.0		2.7 (7)	5.7 (5.9)	5.6 (0)	

Source: Primary Survey, 2015-16

ment during 2010-2014. The ICT adoption rate of SD & MD fishermen in Kozhikode was much higher than, that of Malappuram, during the period 2002 - 2006 and 2004 - 2008. Figure 5.1 also shows that adoption of GPS by MD fishermen in Malappuram increased after 2009.

The two different Northern coastal districts displayed different trends in ICT tools adoption. This is due to different nature of geographical, cultural, infrastructural, types of gears and methods of fishing of both the coastal districts. The number for wireless set rose most dramatically in 2012 and show an increase in declining rate of all ICT tools in the regions. In the year 2000, only a few fishermen adopted the ICT tool in a particular time period; they are called as early adopters. The adoption curve begins to increase upward as more and more fishermen adopt the tools (they were called as early majority adopters) and the curve becomes constant when all the fishermen adopt each ICT tools.

Usage level of ICT tools

ICT tools are used for various purposes in fishing. No fishermen were found in Malappuram who uses mobile phone, GPS, wireless set and echo sounder (M+G+W+E) together in a trip for fishing. But, a few fishermen in Kozhikode are seen to use these together. No fishermen in Malappuram use echo-sounder, due to high cost and lack of unskilled labourers. A very less percentage of fishermen use mobile phone, GPS, wireless set and

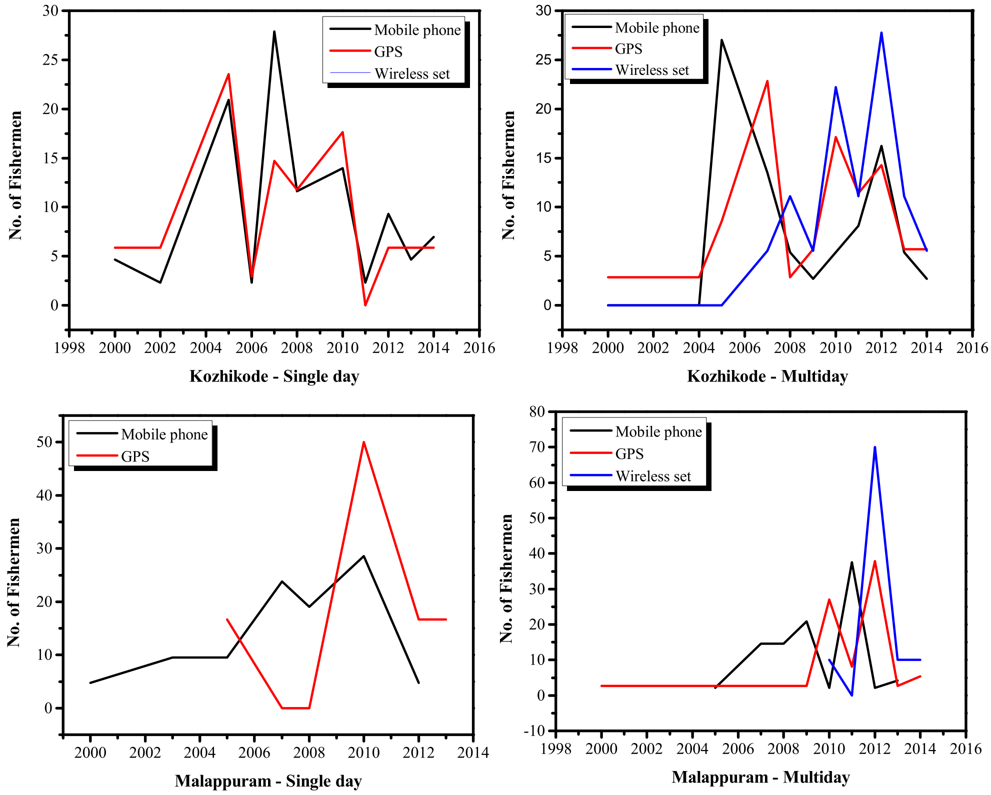


Figure 5.1: Trend curves of usage of ICT tools in Northern Kerala

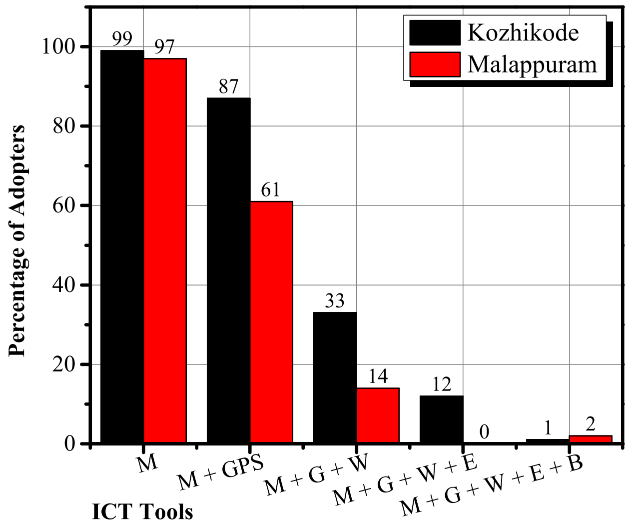


Figure 5.2: ICT tools usage level of both the coastal districts in Northern Kerala

beacon (M+G+W+B), together in a trip to the northern coastal regions.

Ranking of ICT tools

Ranking of ICT tools depends on its benefits on the marine fisheries sector. The fishermen were asked to rank numerically (i,e., 1,2,3 etc.) each ICT tools based on its benefits in fishing and related activities. Ranking of ICT tools was done only for presently using ICT tools by assuming other ICT tools which are not used by the fishermen will be ranked low.

Figure 5.3 shows the different ranks of each ICT tools by SD and MD fishermen of the study areas. It shows that GPS is the highest preferred technology compared to all other remaining technologies for fishing activities. It helps the fishermen to go to a specified location where they get more fish and save the time for more fishing. It is very user-friendly when compared to other tools. Malappuram SD fishermen prefer both GPS and mobile phone equally, because of less distance of fishing. Thus, they use GPS only for finding previous fish locations. They use mobile phone to communicate fish price deals and to know landing information. In usage wise, both the tools are equally helpful to SD fishermen. SD fishermen of Kozhikode give second preference to mobile phone and the third to wireless set. Kozhikode MD motorised fishermen give almost equal importance to wireless sets and mobile phone in fishing and related activities, but they preferred mobile phone as second best ICT tool. The fishermen of Kozhikode go for fishing more distance than the Malappuram fishermen. They use a wireless set, efficiently, when they are at the sea and use mobile phone, effectively, when they are near the seashore.

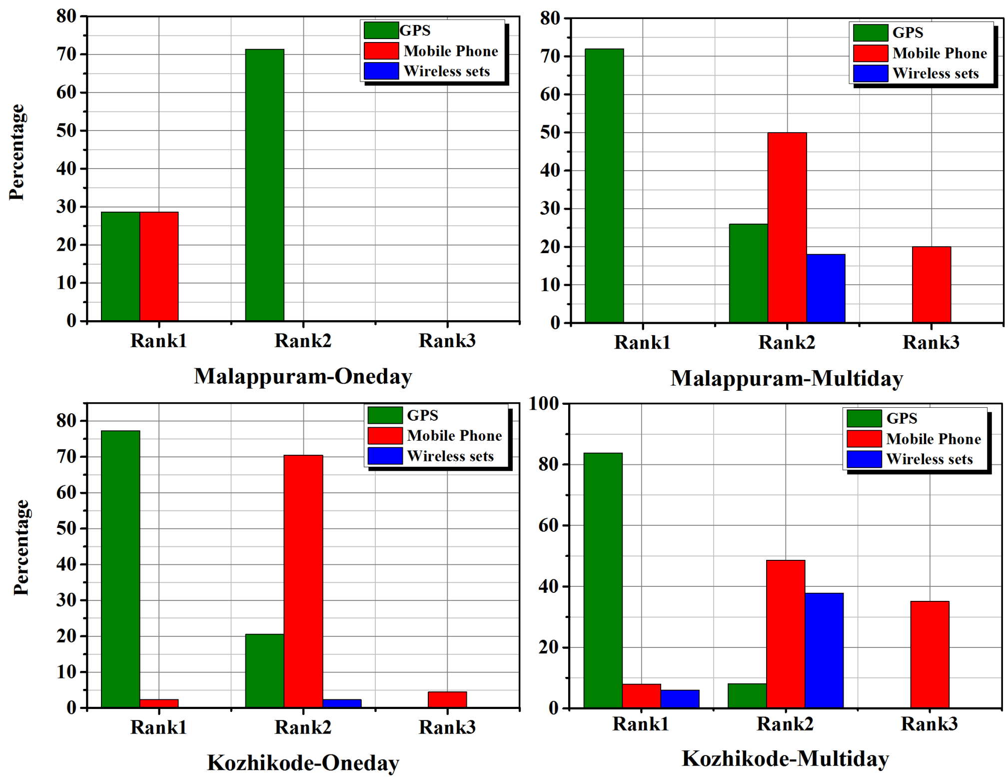


Figure 5.3: Ranking of ICT tools based on benefits in Northern Kerala coast

5.3.2 Central Kerala Coastal regions: Ernakulam and Alappuzha

Ernakulam is a fast developing economy of the state. Alappuzha is more of a traditional small-scale fishing concentrated region which had also adopted ICT tools for fishing and related activities. Fishermen of Ernakulam achieved technology capability much earlier than the Alappuzha fishermen, due to reasons such as demographic, geographical, infrastructural, different types of fishing gears and methods of fishing etc.

Table 5.5 shows a degree of adoption of ICT tools in Central coastal districts of Kerala. Table 5.5 shows that SD & MD fishermen of central regions adopted mobile phone during

2005-2008 and it was adopted by maximum users in the year 2009. Adoption rate of GPS is high in Ernakulam coastal district and it began earlier than the to Alappuzha coastal district. Large size of mechanised and inboard motorised boats operated in Ernakulam much earlier than the other coastal districts of Kerala. The study shows that the degree of GPS adoption was high in Alappuzha during 2010. During 2010, fishermen of SD fishing began to travel more distance and a large number of MD fishing also emerged in the region. Adoption of wireless set in Ernakulam shows an increasing trend after 2007, due to the increased number of multi-day OBM boats 2007. Whereas, a few of SD fishermen from Alappuzha use wireless sets which were adopted in 2015. The number of MD fishing crafts in Alappuzha is less and also they stay only two days in the sea. MD fishermen of Ernakulam also started to use echo-sounder for finding out the fish shoals in the sea from 1995 and but the number did not increase after 2005. Since it had reached its optimum level during 2005.

Figure 5.4 shows the trend of adoption level of ICT tools in Alappuzha and Ernakulam coastal districts. The trend shows that adoption of ICT tools in Ernakulam reached a maximum during 2000-2008, due to an increase in the number of multi-day outboard motorised boats in the region. The maximum rate of adoption of ICT tools in Alappuzha was during 2005-2011 due to the large improvement rate of mobile production and active participation of different mobile network companies. Number of adoption of mobile phone in Alappuzha was the maximum during the period from 2005 to 2011. Adoption of wireless set in Ernakulam showed an upward trend when it was relatively constant in Alappuzha coastal district. Adoption of echo-sounder was high during the period 1998-2005 in Ernakulam. Adoption of mobile phone has been decreasing after the year 2008 in both the Central districts.

As per CMFRI Fisheries Census Report 2010, number of fishermen who use mobile phone in Alappuzha district is high (10,454) when compared to other coastal districts in the state during 2005-2010 (Sabu and Shaijumon, 2016). An interesting trend in the adoption of mobile phone reveals that the use of mobile phone decrease whereas that of wireless set increase in the future time periods.

Table 5.5
Degree of adoption of ICT tools in the study areas of Central Kerala

	Ernakulam (in %)($n = 30$)					Alappuzha (in %)($n = 85$)		
Year	M. Phone	GPS	Wireless set	Echo-sounder	Beacon	M. Phone	GPS	Wireless set
1995	0	6.3	0	6.3		0	0	0
1999	0	15.6	0	2.3		0	0	0
2000	0	34.4	0	71.9		0	0	0
2005	43.8	43.8	9.4	21.9		19.4	1	0
2007	40.6		12.5			5.8	2.9	0
2008	15.6		18.8			21.4	2.9	0
2009			12.5			41.7	1.9	0
2010			46.9			1	39.8	0
2011						1	4.9	1
2012							19.4	1
2013					1		1.9	
2014							1	
2015							1	

Source: Primary Survey, 2015-16

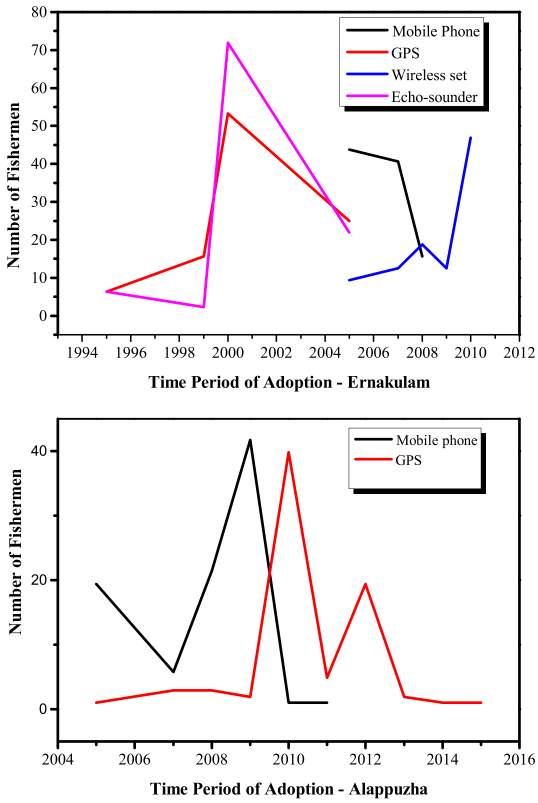
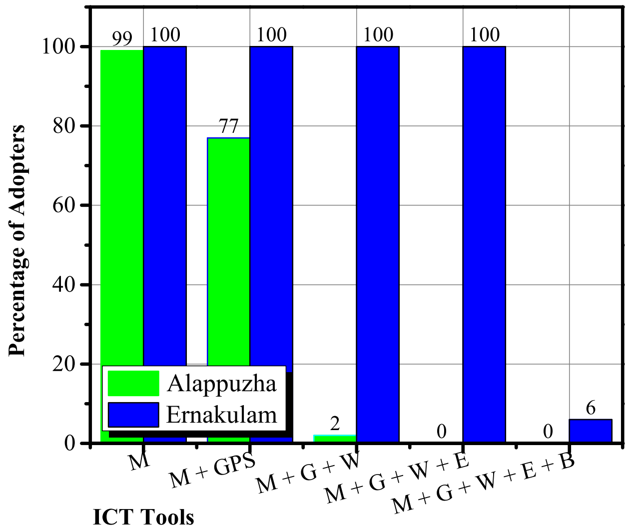


Figure 5.4: Trend curves of the adoption of ICT tools in Central Kerala



Note: M = mobile phone, M+GPS = mobile phone and GPS, M+G+W = mobile phone, GPS and wireless set, M+G+W+E = mobile phone, GPS, wireless set and echo-sunder, M+G+W+E+B = mobile phone, GPS, wireless set, echo-sounder and beacon

Figure 5.5: ICT tools usage level in both the coastal districts of Central Kerala

Usage level of ICT tools

The fishermen use different combinations of ICT tools. A few fishermen use all the available ICT tools, depending on the nature of fishing, gears and days of fishing. It is important to access the different combination of ICT tools used for each coastal districts.

Figure 5.5 shows ICT tools usage level of both the coastal districts of northern Kerala. Alappuzha is the least technologically advanced coastal districts in terms of usage of ICT tools in the state. All the motorised small-scale fishing boats in Ernakulam use electronic gadgets such as; mobile phone, GPS, echo sounder and wireless set (M+G+W+E). MD IBM crafts are large in its size and fishermen use IBM crafts for fishing at long distances. In Ernakulam, a very small percentage (6%) of IBM boats is observed in Ernakulam using mobile phone, GPS, echo sounder, wireless set, and beacon (M+G+W+E+B) together.

Ranking of ICT tools

Each ICT tools benefits the fishermen in different ways. Theoretically, less cost technology benefits more and high-cost technology benefits less and vice-versa. It is the only

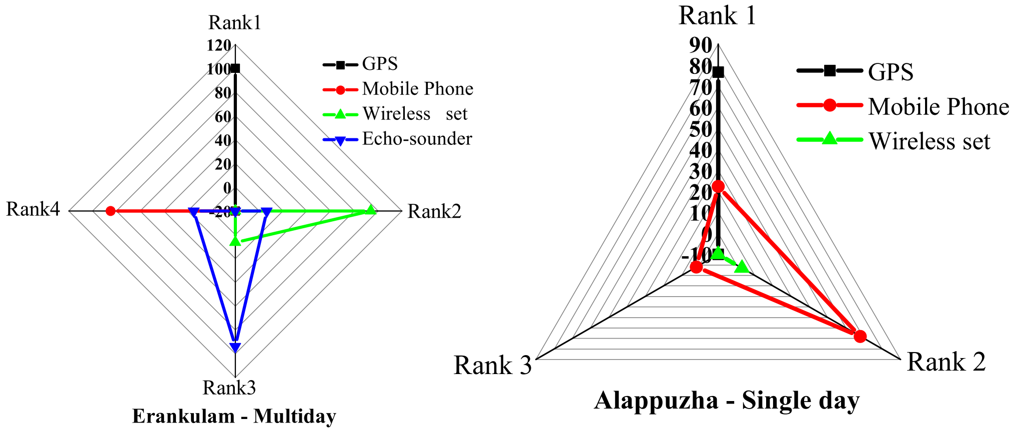


Figure 5.6: Ranking of ICT tools in Central Kerala

rare case that high-cost technology will be adopted irrespective of its cost if the benefits from the technology are more than the cost. Thus, it can be understood that in the marine fishery sector of Kerala, the ICT tools are more beneficial to the fishermen in the Central coastal districts. This can be understood by examining the ranking given for the tools.

Figure 5.6 shows the preferences of ICT tools that were used by both the SD & MD fishermen in the Central coastal regions. GPS tool was most preferred and it was ranked first by both the SD & MD fishermen of Ernakulam and Alappuzha coastal districts. They prefer mobile phone as the second option. In Ernakulam, MD fishermen prefer both mobile phone and wireless set as their second option. Ernakulam MD fishermen gave third preference to echo-sounder, whereas no fishermen gave any preference to beacon since it was the least used and diffused in the sector. Alappuzha SD fishermen gave third preference to wireless set after GPS and mobile phone gadgets. The ranking of each ICT tools was given according to the economic and social benefits of the respective tools.

5.3.3 Southern Kerala Coastal regions: Thiruvananthapuram and Kollam

Most of the traditional fishermen of the state are concentrated in Thiruvananthapuram and Kollam coastal districts. Any new technology useful for the traditional fishermen and their crafts gets adopted at a faster rate in the Southern region. To some extent, such advanced technologies of fishing and related activities helped these fishermen to compete with large size fishing crafts in the sector.

Table 5.6 shows the degree of adoption of ICT tools in the selected Southern coastal districts of Kerala. Mobile phone was adopted by both the SD & MD fishermen in both the coastal districts during 2007-2008 (Table 5.6). This was the time that there was a fall in the price of mobile phones due to the increase in its production and network operations. Adoption of GPS began in 1990 in Thiruvananthapuram coastal regions and it was adopted by SD fishermen rather than MD fishermen. Adoption of GPS started in Kollam only in 1998. Work experience of the fishermen of both the coastal districts helped to adopt GPS and use it effectively since the 1990s. The relative speed of adoption of tools of Thiruvananthapuram was higher than Kollam coastal region. Some technologies were adopted by the fishermen of Kollam as an imitation of the observing its use by the fishermen of Thiruvananthapuram coastal district. Wireless sets were adopted by both the SD and MD fishermen in the year 2005. In 2005, multi-day fishing by Outboard plywood boats began rapidly by 2014. SD fishermen used echo-sounder for catching targeted fish, mainly for cuttlefish. Their work experience in the large size (mechanised or motorised crafts) helped them ineffective usage and adoption of echo-sounder. Adoption of wireless set in Kollam coastal district was 41.7% among MD fishermen in Kollam during the year 2008. Adoption of mobile phone continuous in both the coastal districts of the Southern region and many of the fishing crafts carry more than one mobile phone in their trips. The study found that most of the fishing crafts keep at least two mobile phones during fishing, for purpose of communication. The rate of adoption of GPS (6%) and wireless set (12%) tools was also examined during 2013 in Thiruvananthapuram. This shows the tendency of carrying more than one tool, due to its benefits and safety. However, adoption of wireless set after 2013 did not increase happened in Kollam due to its maximum rate of adoption (every fisherman owns at least one wireless set).

Figure 5.7 shows the trend of use of ICT tools among SD and MD fishermen of the Southern coastal regions. The study found a drastic hike in the adoption of GPS among Kollam SD fishermen during 2008-10. Use of mobile phone during this period increased the confidence of fishermen to adapt to GPS, whereas optimum adoption period of GPS in Thiruvananthapuram was in 1999. The maximum adoption of mobile phone for both the

Table 5.6
Degree of adoption of ICT tool in Southern Kerala (parenthesis gives the rates of single day fishing crafts)

	Thiruvananthapuram (in %)($n = 160$)					Kollam (in %)($n = 30$)		
Year	**M.Phone**	**GPS**	**Wireless sett**	**Echo**	**Beacon**	**M.Phone**	**GPS**	**Wireless set**
1990		(0)1.4						
1998		1.4 (3)					8.3 (0)	
2000		4.1 (31))					25.0 (6.5)	
2003		(0)1.4					(0) 3.2	
2005	19.2 (17)	8.2 (13)	1.4			33.3 (30.6)	8.3(12.9)	8.3
2006	4.1 (1)	1.4 (5)	0					
2007	35.7 (59)	0 (21)	7.1			50.0 (19.4)	8.3 (6.5)	8.3
2008	31.5 (19)	23.3 (19)	0			16.7 (36.1)	8.3 (9.7)	41.7
2009	2.7	6.8 (0)	2.9					
2010	5.5 (1)	37 (4)	41.4			0 (11.1)	33.3 (51.6)	33.3
2012	1.4 (2)	9.6 (1)	35.8 (1)		5	0 (2.6)	0 (9.7)	8.3
2013	0 (1)	1.4	7.1 (1)					
2014		1.4	1.4	0 (1)				
2015		2.7	2.9					

Source: Primary Survey, 2015-16

regions was during the year 2007. Most of the ICT tools were adopted optimally in the period of 2002-2008 in Kollam, whereas, an improvement was examined in Thiruvananthapuram during 2007-2012. Role of mobile phone and its price reduction, multi-day fishing and work experience in the large fishing crafts are the major reasons for this. Adoption trend of the wireless set of both the regions shows an increasing trend during 2008-2012. The trend of GPS showed a declining trend during 2008-2012 in the Southern regions, except among MD fishing crafts of Kollam.

Usage level of ICT tools

Usage of different combination of ICT tools is less in the Thiruvananthapuram and Kollam coastal districts due to the small and medium size of motorised fishing crafts. Combination of mobile phone and GPS is the highest among other combination of ICT tools in the regions.

Figure 5.8 shows the present usage level of each ICT tools among the small-scale motorised fishing boats of Southern coastal regions. All the motorised fishermen in the Southern region use mobile phones for various communication purposes. Use of mobile phone, GPS, wireless set (M+G+W) in both the Southern regions is less compared to

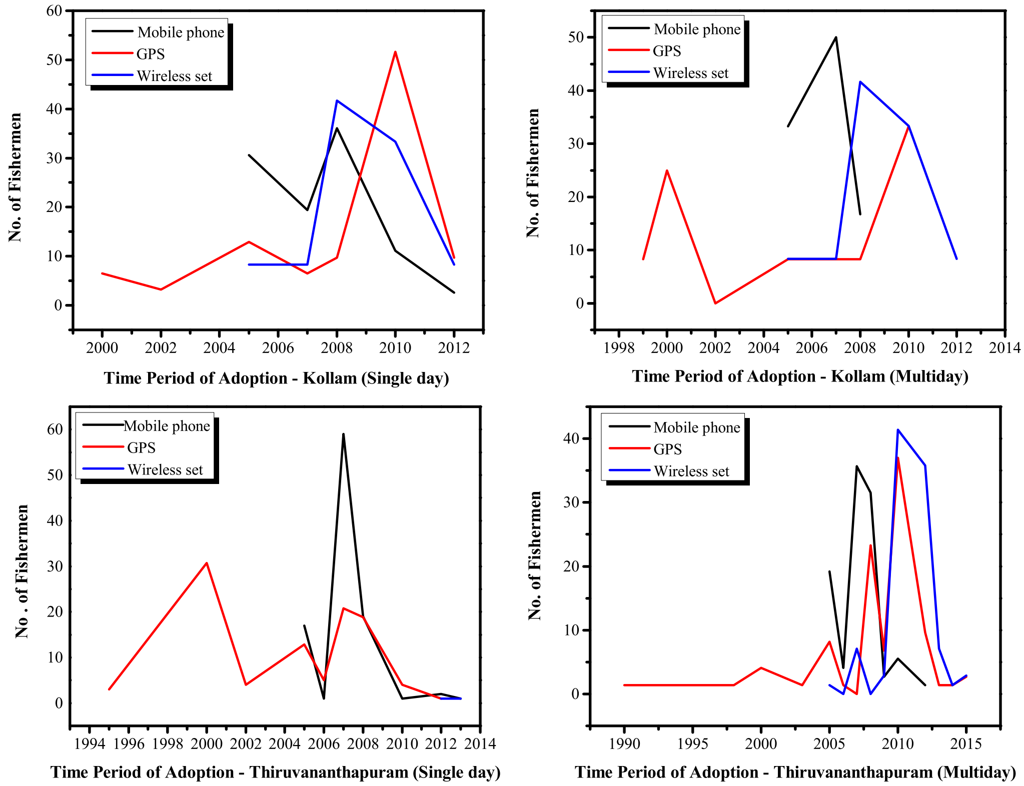
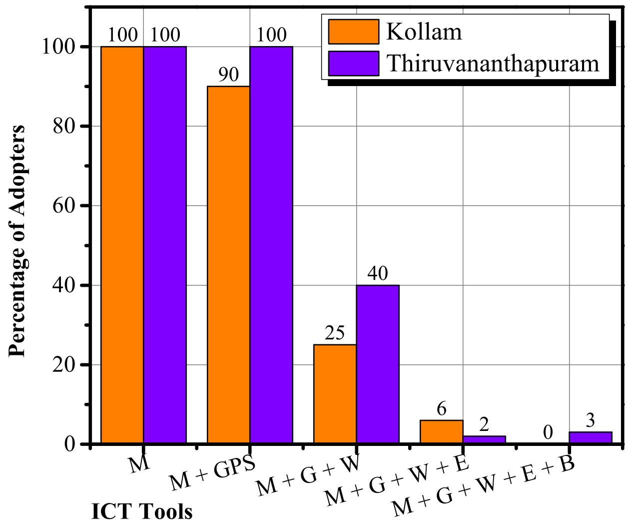


Figure 5.7: Trend curves of the adoption of ICT tools in Southern Kerala coasts



NB: M = mobile phone, M+GPS = mobile phone and GPS, M+G+W = mobile phone, GPS and wireless set, M+G+W+E = mobile phone, GPS, wireless set and echo-sunder, M+G+W+E+B = mobile phone, GPS, wireless set, echo-sounder and beacon

Figure 5.8: Usage level of ICT tools in both the coastal districts of Southern Kerala

other regions (i.e. 45% in Thiruvananthapuram and it is only 25% in Kollam). Only very less fishing crafts use mobile phone, GPS, wireless set, and echo sounder (M+G+W+E) in the southern regions. Less percentage of fishermen use mobile phone, GPS, wireless set, echo sounder and beacon (M+G+W+E+B) together in Thiruvananthapuram. Fishermen from Kollam coastal district do not use the combination of mobile phone, GPS, wireless set, echo sounder and beacon (M+G+W+E+B) in a trip.

Ranking of ICT tools

In the Southern region also, GPS was preferred by the fishermen as the main ICT tool for fishing and other related activities. The fishermen revealed their preference over each ICT tool based on cost-benefit analysis.

Figure 5.9 shows preferences of ICT tools based on its benefits. GPS was preferred mostly by all types of fishermen and a few SD fishermen preferred mobile phone as the most useful tool. MD fishermen of both the coastal districts preferred wireless set as the second best tool than the mobile phones While SD fishermen ranked mobile phone as the second best after, GPS. MD fishermen in two districts ranked mobile phones as the third useful tool and some of the MD fishermen ranked echo-sounder as the third useful tool. The study observed different ranking of ICT tools over different gears and regions in the sector, except ranking of MD fishing crafts of Kollam. MD fishermen of Kollam ranked GPS as the most preferred, wireless set second, and mobile phone third.

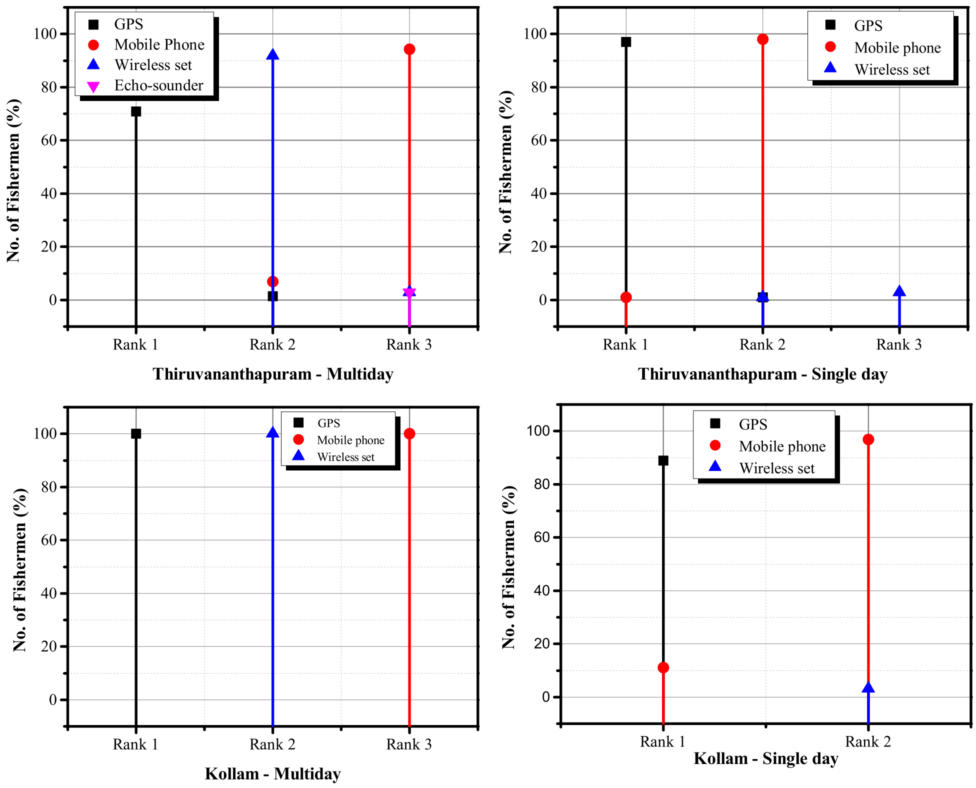


Figure 5.9: Ranking of ICT tools in Southern Kerala coasts

The study shows that the usage level of ICT tool is low in coastal districts of Northern region and the adoption level was high in Ernakulam; a coastal district of the Central region. Small-scale motorised fishermen of Ernakulam use IBM crafts and their adoption of ICT tools was mainly influenced by mechanised trawling boats. The mechanised IBM trawling boats adopted ICT tools much before the motorised boats in Kerala. Operation of SD fishing boats are more in Northern Kerala and that of MD fishing by OBM crafts began in North coastal districts much later than Southern and Central regions of the State. Based on the benefits of ICT tools, fishermen of the three regions ranked GPS as the most useful tool. In all the regions Mobile phones were ranked as second by SD fishermen, whereas, wireless set was ranked as second among MD fishermen. Echo-sounder and beacon were least preferred ICT tools compared to the other. But, an important finding of the study is that small-scale fishermen of Ernakulam preferred mobile phone as a least useful tool because of its less usage in fishing.

Recall data through the questionnaire was used to collect year-wise adoption of each ICT tools among Small-Scale Fishing (SSF) crafts, to figure out the trend of the adoption of ICT tools among small-scale fishermen in Kerala. Based on Rogers (1995) five stages of adoption, the study developed three stages of adoption of ICT tools, viz, early phase, rapid phase of growth, and maturity period to understand the adoption process of ICT tools in Kerala marine sector. All the three regions follow the same trend of adoption of ICT tools, except Ernakulam coastal district. The early phase of ICT tools adoption among small-scale motorised fishing boats was during 1999-2006. The rapid growth phase of adoption was during the period of 2006-2012. The third stage of adoption, i.e., maturity period; started from 2013 onwards. However, this is not the condition of use of beacon. Adoption of beacon is still in the early phase of adoption. Small-scale fishermen started MD fishing during 2005 onwards and mobile phone price and call tariff rate declined from 2007 onwards. Both these reasons caused a rapid adoption of ICT tools during the period of 2007-2012, in the sector. The period of 1995-2005 for GPS & echo sounder was an early phase of adoption in Ernakulam. The periods of 2006-07 for mobile phone & wireless set was a rapid growth phase. The year 2010 was the maturity period of the adoption of ICT tools in Ernakulam. The rapid growth of adoption of ICT tools was achieved in Ernakulam only because of the influence of mechanised trawling boats over the small-scale motorised crafts during these periods.

5.4 Estimation of Diffusion of ICT Tools

Estimating a curve is important to forecast the future trend and that justifies the additional development if needed. Logistics growth model is one of the best models used to test *sigmoidal shape*[7] of diffusion of a technology. The present study also uses Logistics

[7]Dissemination of a new technology is slow in the beginning and increases cumulatively at an increasing rate. This is followed by increasing dissemination at a slower rate before reaching its pinnacle. When we

growth function to confirm the sigmoid shape of the adoption rate of ICT tools in the state. This section is divided into three different sub-sections, where each sub-section deals with the curve estimation of each region of the Kerala marine sector.

5.4.1 Northern Kerala

The study successfully estimated an S shaped hypothetical curve through Logistics growth function. The estimation was based on the data collected from the users of ICT tools in the sector. Figure 5.10 shows the graphical representation of the sigmoid curve of the fitted data of GPS, echo-sounder, mobile phone and wireless sets and Table 5.7 shows the corresponding summarised estimation of the parameters along with the calculated values of the statistical measures.

The high values of chi-square and R^2 of these models show a good fit of the data where a, k, xc are coefficients of the model. The Logistics function of Kozhikode coastal district predicts that the saturation level or point of inflexion (i.e., maximum adoption) of mobile as 90% in the year 2007, GPS as 88% in 2008, wireless sets as 38% in 2010 and echo-sounder as 11% in 1990. Similarly, 72% of mobile phone in 2007, 45% of GPS in 2010, 9% of wireless sets in 2012 have been considered as the potential year of ICT tools adoption in Malappuram coastal district (Figure 5.10). The estimation illustrates that adoption of the wireless set takes more time to reach saturation level compared to other ICT tools. Still, there is a chance to improve the adoption of both GPS and wireless set in both the coastal districts, because of their benefits over fish catch and income. The results of Logistics growth function are better than other growth functions in the case of mobile telephone (Pita Barros et al., 2000; Botelho and Pinto, 2004).

5.4.2 Central Kerala

Logistic function of the Centre Kerala also shows successful fitting of the recalled data of adoption of each ICT tools and the provided sigmoid shape. Steeper curves of GPS and Echo-sounder and flatter curves of mobile phone and fitted curves of wireless set

trace this process of dissemination graphically, we get a sigmoid or an $'S'$ shaped curve.

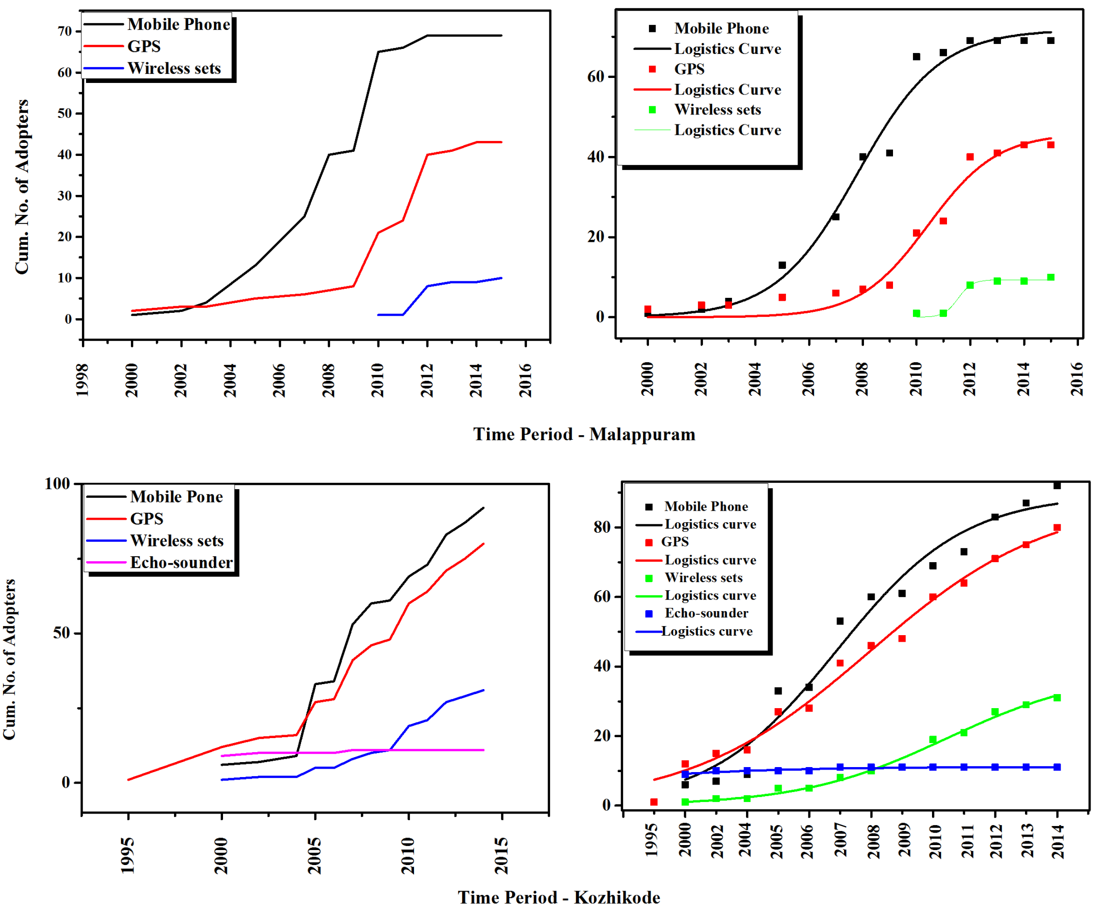


Figure 5.10: Diffusion trend curves of ICT tools' and their fitted Logistic curves in both the study areas of Nothern Kerala

Table 5.7

Estimated results of Logistics growth function in Northern Kerala (n=195)

ICT tools	**a**	**S. E.**	**xc**	**S. E**	**k**	**S. E**	**Chi-Sqr**	**Adj.** R_2
Kozhikode (n=105)								
Mobile Phone	89.5378	5.07866	2007	0.39762	0.4881	0.0751	32.58859	0.96549
GPS	88.39219	5.53596	2008	0.49319	0.34404	0.03489	9.63408	0.98551
Wireless sets	38.79065	3.6659	2010	0.56241	0.42191	0.04652	1.50904	0.98732
Echo-sounder	11.13842	0.19039	1990	1.61548	0.31697	0.1015	0.06798	0.84405
Malappuram (n=90)								
Mobile Phone	71.77423	2.54754	2007	0.23099	0.65413	0.09342	14.86446	0.98192
GPS	45.93605	3.23372	2010	0.32628	0.77551	0.15253	10.37048	0.96482
Wireless sets	9.35693	0.42899	2012	0.13777	3.78576	1.02299	0.53177	0.96955

of Ernakulam coastal district show the adoption speed of each ICT tools. This is not observed in mobile phone and GPS in the Alappuzha coastal region.

Table 5.8 shows the estimation of logistics growth function of adoption of ICT tools in central Kerala. Figure5.11 shows the fitted *S* shape curves of each ICT tool in the respective regions.

The high values of chi-square and adjusted R^2 of these models show a good fit of the data where a, k, xc are coefficients of the model. The Logistics function of Ernakulam coastal district predicts that the saturation level or the point of inflexion (i.e., maximum adoption) of mobile phone is in the year 2007, GPS is in 2008, wireless sets in 2010 and echo-sounder reaches in 1990. The years 2007 and 2010 for mobile phone and GPS have been considered as the potential year of ICT tools adoption in Alappuzha coastal district. The estimation illustrates that adoption of the echo-sounder takes more time to reach saturation level compared to other ICT tools. Logistics function measurement shows the significant rate of 0.93 and 0.97 for mobile phone and GPS respectively. However, the inflexion point of mobile phone adoption in Ernakulam was during the period of 2006-2007 with the speed rate of 0.7. Adoption of GPS and echo-sounder in this region began very earlier than the introduction of mobile phone. Wireless set is the recently adopted technology in Ernakulam (in the year of 2009-2010) and Alappuzha (2012) coastal districts. The estimation result of wireless set in Alappuzha shows its insignificant[8] nature.

Figure 5.11 shows the logistic growth function of adoption of ICT tools. It reveals that all the curves have the characteristics of an S-shaped curve. The estimated results of logistics function support growth function and give a sigmoid shape for mobile phone, GPS, echo-sounder and wireless set in Alappuzha and Ernakulam districts. Figure 5.11 shows that, maximum adoption of GPS and echo-sounder in Ernakulam coastal districts took place earlier than the other ICT tools. However, this is not the case of wireless set and mobile phone tools in the region. The estimated logistic curve for mobile phone and GPS shows that the maximum adoption of mobile phone in Alappuzha coastal district was in the year 2007 and 2010 respectively. The speed of adoption of both the ICT tools in Alappuzha coastal district remains constant.

[8]We got wireless sets data from 2011 and 2012 years which cannot be used to generate estimation

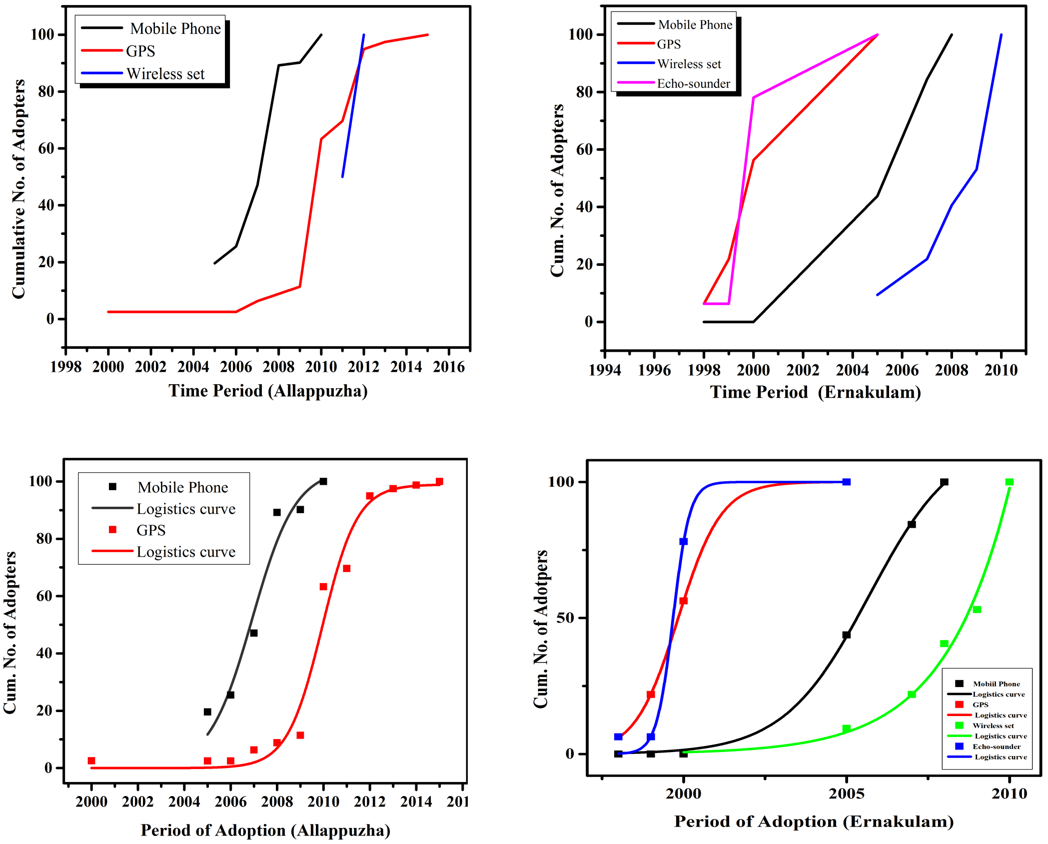


Figure 5.11: Diffusion trend curves of ICT tools' and their fitted Logistic growth curves in both the study areas of Central Kerala

Table 5.8

Estimated results of Logistics growth function in Central Kerala ($n = 115$)

ICT tools	a	SE	xc	SE	k	SE	Adj. R_2
Ernakulam (n=30)							
Mobile Phone	116.74	5.60038	2006.695	0.16193	0.76087	0.07062	0.99935
GPS	100.05	0.45281	1999.835	0.01235	1.50681	0.02716	0.99988
Echo-sounder	100.02	6.1671	1999.677	0.11657	3.92078	1.08614	0.9839
Wireless set	100.02	133.07	2008.802	4.80951	0.61116	0.7132	0.82783
Alappuzha (n=85)							
Mobile Phone	104.38	11.17	2006.92	0.34	1.07	0.32	0.93828
GPS	98.95	3.9	2009.94	0.16	1.32	0.25	0.97742

Table 5.9
Estimated results of Logistics growth function of Southern Kerala ($n = 190$)

ICT tools	a	SE	xc	SE	k	SE	Chi-Sqr	Adj. R_2
Thiruvananthapuram ($n = 160$)								
GPS	118.9101	11.89262	2007.816	0.91278	0.29254	0.04946	50.25778	0.96414
Mobile phone	98.78688	2.65514	2006.568	0.1193	1.74804	0.31277	34.14369	0.97048
Wireless set	100.7007	4.93923	2010.384	0.20996	1.03832	0.18561	42.74549	0.97691
Kollam ($n = 30$)								
GPS	168.1946	83.82073	2010.393	3.33736	0.31652	0.10611	69.74567	0.94037
Mobile Phone	108.9094	17.09428	2006.586	0.54634	0.84401	0.33416	112.2111	0.89013
Wireless set	108.2952	7.12196	2009.869	0.28855	0.80457	0.11462	16.38979	0.99031

5.4.3 Southern Kerala

The estimation of logistics growth function of ICT tools in southern Kerala is shown in Table 5.9. Figure 5.12 shows the characteristics of the S-shaped curve of ICT tools in southern Kerala. The estimated results support and prove sigmoid curve of logistics function for mobile phone, GPS, echo-sounder and wireless set in Kollam and Thiruvananthapuram. Figure 5.12 shows that mobile phone adoption was at a maximum rate than the other tools in Thiruvananthapuram. Wireless set, GPS, echo-sounder and beacon were adopted after the introduction of mobile phone.

The estimated logistic curve of mobile phone in Kollam shows that the maximum adoption of mobile phone was and GPS was in the year of 2007 and 2010 respectively, with a constant speed of both the technology in the sector. Measurement of logistic function also shows the significant rate of 0.89 & 0.99 for mobile phone and GPS respectively. Maximum adoption of wireless set was in the year 2010 with the slope rate of 0.80. But, an inflexion point of mobile phone in Thiruvananthapuram was during the period of 2006-2007 with a speed rate of 1.7. Adoption of GPS and echo-sounder in this region began that of mobile phones. Wireless set is the recently adopted technology in Thiruvananthapuram (in the year of 2009-2010) and Kollam (2012) coastal districts.

5.5 Determinant Factors of Adoption of ICT Tools

The statistic analyses show that the ICT tools diffusion process in marine fisheries sector is largely explained by the epidemic and rank models. However, the models of the study depend on the nature of technology that we study. Thus, information spillovers

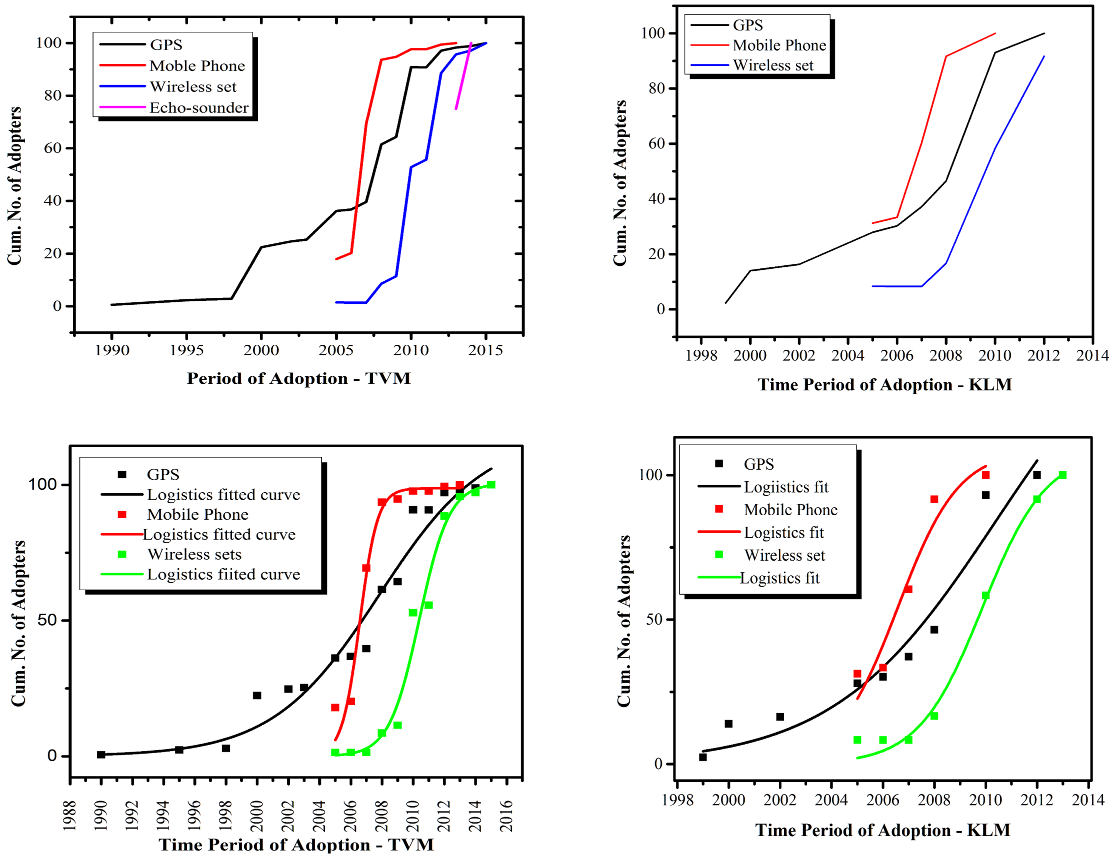


Figure 5.12: Diffusion trend cureves of ICT tools' and their fitted Logistic growth curves in both the study areas of Southern Kerala

(or epidemic models) play an important role in the diffusion of ICT tools. Firm size, age, absorptive capacity, organisation, competitive pressure, environment, cost, imitation, comparative advantage are other important variables related to ICT adoption (Cohen and Levinthal, 1989; Rogers Everett, 1995; Geroski, 2000; Battisti, 2000; Hall and Khan, 2003; Hollenstein, 2004).

There are many factors that influence the adoption of a new or existing technology in the market. The determining factors vary according to sectors, regions and demographic features. Understanding the influencing factors of ICT tools' adoption among the traditional small-scale fishermen is pivotal for the future development of government policies. The major determining factors in the supply side of the marine sector are media, interpersonal communication, cost, comparative advantage of technology, government policies, easiness to use, and imitation.

5.5.1 Descriptive Statistics

Several theories have provided an explanatory explanation to understand ICT adoption behaviour. Prominent among them are Innovation Diffusion Theory (IDT) (Rogers Everett, 1995), Technology Acceptance Model (TAM) (Davis Jr, 1986), Technology Organisation Environment (T-O-E) (Oliveira and Martins, 2011), Decision maker-Technology-Organization-Environment (Thong, 1999), and Theory of Reasoned Action (Yzer, 2013). The study used all such types of theories to find out the influencing factors of the ICT tools adoption and quantified with the help of the PCA.

The study has used Principal Component Analysis (PCA) to reduce the number of variables in the data set into a smaller number of dimensions, followed by an oblique (direct oblimin) rotation model. Nine determining factors with 36 sub features were used in the questionnaire to extract the components of PCA, which are (1) the influence of interpersonal communication, (2) the influence of government, (3) the influence of media, (4) the influence of institutions, (5) the influence of agents, (6) the influence of relative advantage, (7) the cost-effectiveness, (8) accessibility, and (9) demonstration effect. The responses were measured by using a five-point Likert-scale, ranging from 1 = Strongly disagree, 2 = disagree, 3 = moderately agree, 4 = agree, and 5 = strongly agree. The average score and its variance of each component are shown in Table 5.10. Media (newspaper, TV, radio, and advertisement) shows the highest mean value (4.06) among various influencing factors in the model. Inter personal-communication (friends, relatives, co-workers, authorities) stands second with a mean value of 3.57. Mean value of agents (shop-keeper, middlemen, and the shop owner) showed a low value (2.04) compared to the other eight attributes (Table 5.10).

5.5.2 Correlation Matrix of Components

A correlation matrix is used to investigate the dependence between multiple variables at the same time. Once we know that two variables are closely related, we can estimate the value of one variable given the value of another. This is done with the help of regression. The resulting table containing the correlation coefficients between each variable and with

Table 5.10
Descriptive statistics of variables of PCA model ($n = 500$)

Variables	No of items	M	SD	Skewness	Kurtosis
Media	4	4.058	0.98	-1.332	1.647
Intercommunication	4	3.574	0.89	-.275	-.672
Government	3	2.988	0.88	.110	-1.211
Institutions	3	3.838	0.53	-1.884	7.026
Agents	3	2.304	0.57	1.752	1.998
Relative advantage	3	3.740	0.98	-.571	-.668
Cost effective	3	3.628	0.94	-.493	-.391
Ease of accessibility	3	3.532	0.98	-.525	-.049
Demonstration effect	3	3.806	1.02	-1.082	1.182

the other is called Correlation matrix. It lists the variable names (X_1 - X_2) down the first column and across the first row. The diagonal of a correlation matrix (i.e., the numbers that go from the upper left corner to the lower right) always consists of ones. That's because these are the correlations between each variable and itself (and a variable is always perfectly correlated with itself). This statistical program only shows the lower triangle of the correlation matrix. A correlation matrix is always a symmetric matrix. Usually, Principal Component Analysis is performed on a square symmetric matrix.

Table 5.11

Correlation matrix of each components of influencing factors of ICT tools' adoption ($n = 500$)

Variables	**Media**	**Inter-communication**	**Government**	**Institutions**	**Agents**	**Relative advantage**	**Cost effectiveness**	**Ease of accessibility**	**Demonstration effect**
Media	1.000								
Intercommunication	.074	1.000							
Government	.005	.482	1.000						
Institutions	.087	.032	.098	1.000					
Agents	-.021	.011	-.044	-.061	1.000				
Relative advantage	.135	.302	.134	.073	-.024	1.000			
Cost effective	.079	.338	.095	.043	-.060	.303	1.000		
Ease of accessibility	-.061	.300	.218	-.019	.113	.237	.278	1.000	
Demonstration effect	-.031	.234	.176	-.036	.002	.163	-.118	.122	1.000

Here, the PCA Correlation matrix helps us to understand the relationship between the variables that influence the adoption. It also helps us to understand the multicollinearity if it exists. Table 5.11 shows the correlation values of each attribute of the determining factors of ICT tools. Kaiser (1960) recommends the principal component of the correlation matrix of variables with less than one. For this purpose, the factorisability of nine attributes were examined, which was done using a correlation matrix. The study observed that most of the factors are correlated and also shows the lack of multicollinearity. The reliability of primary data was checked through Cronbach alpha method which gave a value of 0.85 [9]. The study used Kaiser-Meyer-Olkin measurement to test the consistency of the data. The study shows that the Kaiser-Meyer-Olkin measure of sampling adequacy of the data was 0.69, above the recommended value of 0.6 (Jollifee, 1972). Bartlett's test of sphericity of the data was also significant ($\chi^2(153) = 461.901, p < .05$). The diagonals of the anti-image correlation matrix were over 0.5, supporting the inclusion of each item in the factor analysis. Finally, the communalities were above 0.3, further confirming that each item shared some common variance with the other items (Table 5.13).

5.5.3 Eigenvalue and Scree Plot of PCA Components

PCA method gives a linear combination of variables, such that the maximum variance is extracted from the study variables. It then removes this variance and finds a second linear combination which explains the maximum proportion of the remaining variance of the variable, and so on. The Analysis of total (common and unique) variance among the study variable in the PCA method is called *eigenvalues*. If a variable has a low eigenvalue, then it is contributing little to the explanation of variances in the variables and may be ignored as redundant with more important factors. This is similar to Pearson's r, the squared factor loading is the percent of variance (eigenvalues) in that variable explained by the factor. The fraction of total variance in the data is represented in a simple line segment plot called *Scree Plot*. It is a plot, in descending order of magnitude, of the eigenvalues of a correlation matrix. These are the main procedures of the PCA analysis of the study.

[9] Cronbach alpha test is one of the important tests for measuring the internal consistency of data. It is given as; $\alpha = \frac{n}{n-1} 1 - \frac{\sum V_i}{V_test}$, where n is the number of questions, Where, V_i = variance of scores on each question, V_test = total variance of overall scores (not %'s) on the entire test (Nunnally (1978)). Normally, the higher the Alpha is, the more reliable the test is. Usually 0.7 and above is acceptable

Table 5.12
Eigenvalues and cumulative percentage of variance of PCA

	Initial Eigenvalues		
Component	**Total**	**% of Variance**	**Cumulative %**
1	2.176	24.175	24.175
2	1.241	13.792	37.966
3	1.127	12.522	50.488
4	0.989	10.993	61.481
5	0.950	10.554	72.035
6	0.853	9.472	81.508
7	0.661	7.349	88.857
8	0.588	6.534	95.390
9	0.415	4.610	100.000

Responses to the five-point scaled questionnaire were measured subjected to a PCA using ones as prior communality estimates. PCA was used to identify and calculate composite scores for the factors underlying adoption of ICT tools. The initial eigenvalues showed interpersonal communication as 25% of the variance, ease of accessibility 14% of the variance, and the role of government 13% of the variance in the system (Table 5.12). These attributes (Ys) comes at second, third, and eighth factors in the PCA technique analysis and showed eigenvalues above one. These eigenvalues are commonly plotted on a scree plot to show the decreasing rate at which variance is explained by additional principal components. Scree plot helps to decide on how many principal components to be retained in the model (Cattell, 1966). Scree plot of the eigenvalues and percentage variance of each PCA variables are shown in Figure 5.13. Figure 5.13 shows the three factors, namely, inter-communication, ease of accessibility, and Government are explained 51% of the variance and have eigenvalues higher than one (Table 5.12). Retaining these three factors in the model is important for the model fit and analysis of the study.

5.5.4 Factor Loadings and Communalities

In order to examine the underlying factors affecting the adoption of ICT tools among motorised fishermen, the study employed principal components extraction followed by oblimin rotation. Main determining attributes and their corresponding factor loadings are presented in Table 5.13. All possible influencing factors of adoptions are included in

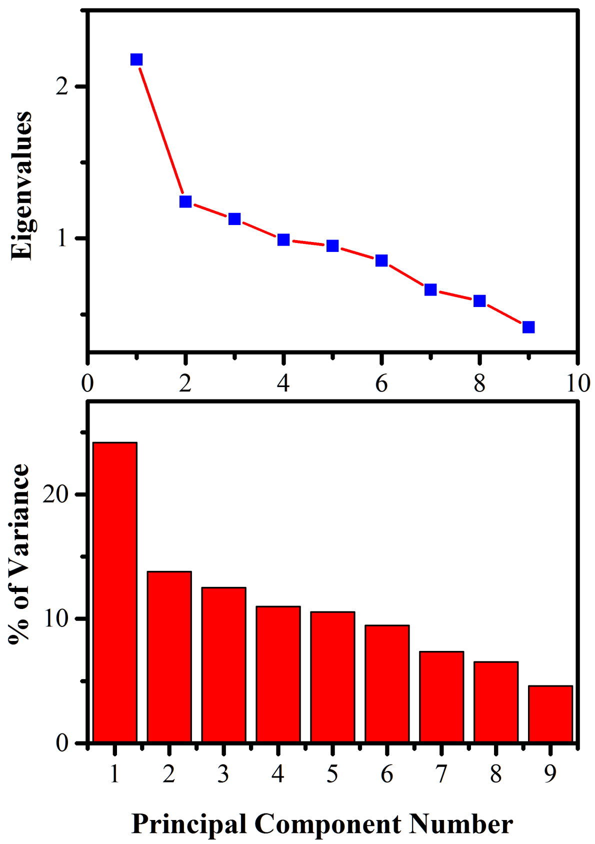


Figure 5.13: Scree plot and bar diagram of Eigenvalues and its variance of ICT tools determining variables

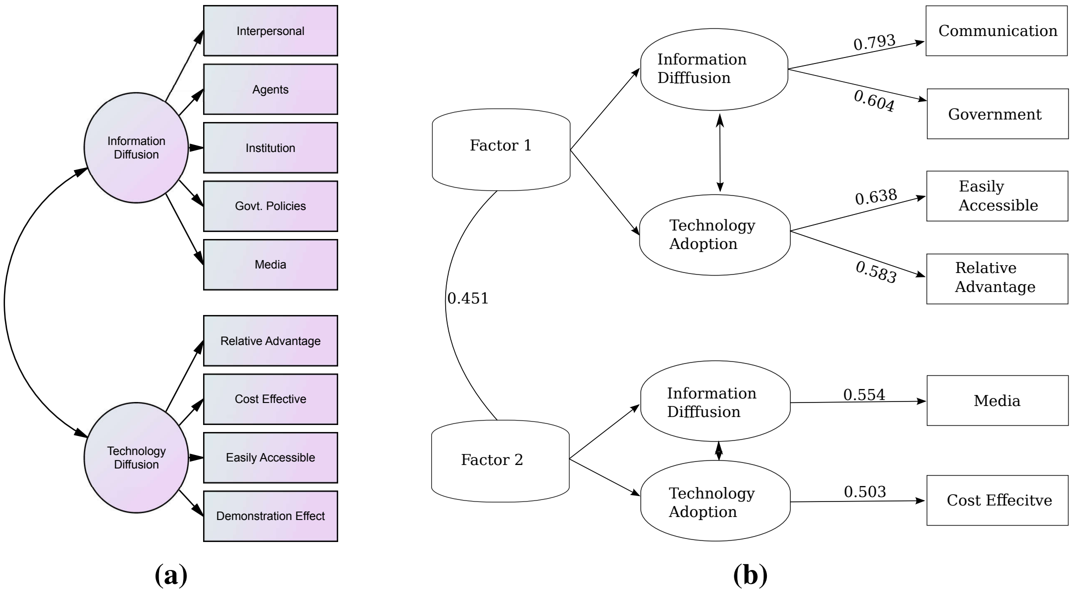


Figure 5.14: Hypothetical model of the present study (Figure (a)) and diagrammatic form of Coefficients of each loadings of selected items of determining factors in adoption (Figure (b))

the factor loading analysis. Factors yielding an eigenvalue greater than one were selected. Factor coefficient scores for individual subjects were estimated using the Anderson-Rubin method (Anderson and Rubin, 1956). Individual factor coefficients for each subject were derived based on the global factor structure. Thus, ensuring orthogonality and normality of the estimated factors. Items with factor coefficients > 0.5 were considered to load on a respective factor.

PCA (oblimin rotation with Kaiser normalisation) was used to find out major influencing factors of ICT tools' adoption and generated each score for all criterion. A relatively high Kaiser- Meyer-Olkin measure of sampling adequacy (KMO = 0.67) confirmed the validity of using a factor analysis for structure detection. The different influencing factors were well characterized using a three-factor solution. From the three-factor solution, the study found that the major influencing factors of adoption of ICT tools are communication networks, Government institutions, and Easily accessible. The top three PCA factors cumulatively accounted for 55 percent of the total variance (Table 5.12). The eigenvalues of these three attributes are 2.54, 1.26, and 1.11 respectively. The top three PCA factors in descending order of eigenvalue were as follows, the first factor named 'Communication networks', contributed 28.3% of the total variance and included all three network

Table 5.13
Factor loading and communalities based on Principal Component Analysis with oblimin rotation for 9 factors influencing adoption of ICT tools (n=500)

	Component		
Variables	**1**	**2**	**3**
Intercommunication	.793		.128
Ease of accessibility	.638	-.131	-.372
Government	.604	-.175	.397
Relative advantage	.583	.277	
Cost effectiveness	.533	.504	-.414
Media		.544	.181
Demonstration effect	.359	-.531	.452
Institutions		.425	.420
Agents		-.336	-.482

variables such friends, relatives, and authorities. Factor two, designated 'Government institutions' contributed 14.0% of the overall variance. Factor three, contributing 12.4 percent of the total variance, was named 'relative advantage' and consisted of benefits, the shape of tools, and mode of operation (Table 5.13). A diagrammatic presentation of factor loading of PCS is shown in Figure 5.14a & 5.14b.

Overall, these analyses indicated that three distinct factors; such as interpersonal communication, ease of accessibility, and the role of Government were mainly responsible for ICT tools adoption in Kerala marine sector. These factors also have better internal consistency among them. The data of this study were well suited for parametric statistical analyses due to the normal distribution of data for the composite scores.

5.6 Influencing Socio-economic Factors of ICT Tools' Adoption

Crosstabs is a statistical technique that used to display a breakdown of the data by two variables. In this section, the study used Crosstabs and a Non-parametric test (Pearson's chi-square test) for interpreting the relationship between the nominal or categorical variables with the adoption score. Categorical variables of the study are age, education, boat size, crew size, fishing distance, fishing experience, days per trip, revenue per trip, the role of cooperative society, and initial investment. Table 5.14 shows that the frequencies of different socio-economic attributes' breakdown by ICT tools, i.e., 1,2,3,4, & 5. *Pearson's chi-square test*, a non parametric test is used to study the relationship between socio-economic features (age, education, income, revenue, boat size, crew size, distance of fishing, days spent for fishing) and ICT tools (1,2,3,4, & 5) of the fishermen.

Pearson's chi-square test is assumed as one of the important non-parametric tests in social science. The Pearson's chi-square is used to determine whether nominal variables are associated with each other in any manner. It tells us whether the results of crosstabs are statistically significant or not. Here, we use chi-square (X^2) test for understanding the association between the adoption of ICT tools and socio-economic features of fishermen and their crafts in the state. We assume that there is no relationship between socio-economic features (categorical variables) and the adoption of ICT tools (dependent variables) (Null hypothesis, H_0). Our alternative hypothesis is that there is a relationship between socio-economic, crafts features, and use of ICT tools (H_1). Table 5.14 shows region wise (north, south and centre) total frequency of each categorical variable and their row percentages are shown in brackets. Table 5.15 shows the frequency of each socio-economic factors and crafts and their percentages of total frequency (500) of the study.

Table 5.14

Crosstabs values of socio-economic factors and craft features with number of adopted ICT tools in three regions (n=500)

Variables	Categories	No. of ICT tools: North Kerala			No. of ICT tools: Central Kerala					No. of ICT tools: Southern Kerala				
		1	2	3	1	2	3	4	5	1	2	3	4	5
Age	18-35	12(22.6)	27 (50.9)	14(26.4)	0	32(50)	29(45.3)	3(4.7)	0	3(9.7)	14(45.2)	1(3.2)	13(41.9)	0
	36-55	25(27.8)	53(58.9)	12(13.3)	5(3.7)	83(61)	43(31.6)	3(2.2)	2(15)	20(23.3)	45(52.3)	5(5.8)	15(17.4)	1(1.2)
	Above 55	0	3(42.9)	4(57.1)	1(6.3)	13(81.3)	2(12.5)	0	0	3(17.6)	11(64.7)	0	2(11.8)	1(5.9)
Education	Illiterate	7(19.4)	17(47.2)	12(33.3)	2(5.6)	24(66.7)	9(25)	1(2.8)	0	3(27.3)	2(18.2)	0	6(54.5)	0
	Educated	30(26.3)	66(57.9)	18(15.8)	4(2.2)	104(57.8)	65(36.1)	5(2.8)	2(1.1)	23(18.7)	68(55.3)	6(4.9)	24(19.5)	2(1.6)
Boat Size	Below 32	34(28.6)	72(60.5)	13(10.9)	6(4.3)	119(85)	15(10.7)	0	0	26(26.3)	67(67.7)	5(5.1)	1(1)	0
	Above 32	3(9.7)	11(35.5)	17(54.8)	0	9(11.8)	59(77.6)	6(7.9)	2(2.6)	0	3(8.6)	1(2.9)	29(82.9)	2(5.7)
Crew Size	01/05/16	37(29.8)	70(56.5)	17(13.7)	3(2.5)	93(77.5)	23(19.2)	0	1(0.8)	2(20)	7(70)	1	0	0
	Above 5	0	13(50)	13(50)	3(3.1)	35(36.5)	51(53.1)	6(6.3)	1(1)	24(19.4)	63(50.8)	5(4)	30(24.2)	2(1.6)
Fishing Distance	5.0-35	17(37.8)	22(48.9)	6(13.3)	6(4.4)	123(89.8)	8(5.8)	0	0	25(25.5)	67(68.4)	5(5.1)	1(1)	0
	36-200	20(19)	61(58.1)	24(22.9)	0	5(6.3)	66(83.5)	6(7.6)	2(2.5)	1(2.8)	3(8.3)	1(2.8)	29(80.6)	2(5.6)
Fishing Experience	Below 10	5(19.2)	14(53.8)	7(26.9)	0	10(40)	13(52)	2(8)	0	3(23.1)	6(46.2)	0	4(30.8)	0
	Above 10	32(25.8)	69(55.6)	23(18.5)	6(3.1)	118(61.3)	61(31.9)	4(2.1)	2(1)	23(19)	64(52.9)	6(5)	26(21.5)	2(1.7)
Days per trip	SD	19(31.7)	40(66.7)	1(1.7)	6(4.4)	124()90.5	7(5.1)	0	0	26(25.5)	70(68.6)	5(4.9)	1(1)	0
	MD	18(20.0)	43(47.8)	29(32.2)	0	4(5.1)	67(84.8)	6(7.6)	2(2.5)	0	0	1()3.1	29(90.6)	2(6.3)
Revenue per trip	1000-10000	20(40)	27(54)	3(6)	4(3.8)	95(91.3)	5(4.8)	0	0	6(27.1)	16(72.7)	0	0	0
	10001-20000	14(33.3)	22(52.4)	6(14.3)	2(7.1)	19(67.9)	7(25)	0	0	11(36.7)	17(56.7)	2(6.7)	0	0
	Above 20000	3(5.2)	34(56.6)	21(36.2)	0	14(16.7)	62(73.8)	6(7.1)	2(2.4)	9(11)	37(45.1)	4(4.9)	30(36.6)	2(2.4)
Co-operative society	Yes	36(25.9)	73(52.5)	30(21.6)	6(2.8)	128(59.5)	74(34.4)	5(2.3)	2()0.9	26(19.8)	67(51.1)	6(4.6)	30(22.9)	2(1.5)
	No	1(9.1)	10(90.9)	0	0	0	0	1	0	0	3(100)	0	0	0
Initial Investment	1.0-10	36(29.3)	76(61.8)	11(8.9)	6(4)	121(80.1)	21(13.9)	3(2)	0	19(25.7)	51(68.9)	3(4.1)	1(1.4)	0
	11-20.0	1(3.7)	7(25.9)	19(70.4)	0	7(13)	44(81.5)	2(3.7)	1(1.9)	6(22.2)	19(70.4)	2(7.4)	0	0
	Above 20	0	0	0	0	0	9(81.8)	1(9.1)	1(9.1)	1(3)	0	1()3	29(87.9)	2(6.1)

5.6.1 Socio-economic Factors

Table 5.16 shows the Pearson chi-square values of socio-economic factors and crafts features with the reference category of ICT tools in Kerala. A number of demographic variables including age and education have also been studied and shown (in some contexts) to influence technology use (Chwelos et al., 2001). The present study showed a significant association between age and amount of ICT tools used by fishermen ($\chi^2 = 17.880, df = 2, P =< 0.05$) in Kerala. A large section of the fishermen (n = 312, 63%) belonging to the age group of 36-55 range use all the available ICT tools. The study showed that the middle age (age group of 35-55) fishermen have the skill to use a number of tools for fishing and communication. In addition, a significant difference between age and adoption of ICT tools were examined in Southern and Central regions of Kerala. The study did not observe any significant relationship between education of fishermen and the use of amount of ICT tools ($\chi^2 = 1.872, df = 4, P =< 0.759$), except in the Southern region ($\chi^2 = 9.294, df = 2, P =< 0.05$). Initial investment or cost of motorised craft and its revenue per trip also showed a significant association with the adoption of the tools in the state. Majority of the fishing craft who spends ₹1 million and below as an initial investment of motorised crafts use only two ICT tools than a craft which spends ₹2 million (which use three or four ICT tools). Any craft which spends initial investment more than ₹2 million use four to five ICT tools.

5.6.2 Features of Motorised Crafts

Size, cost and types of the craft, distance of fishing, method of fishing etc are also important factors in adoption of ICT tools. Table 5.16 shows the results of Pearson's chi-square and feature of motorised crafts in the sector. Study showed a significant relationship between craft size and the use of ICT tools in the state ($\chi^2 = 263.65, df = 2, P =< 0.000$). Most of the motorised fishermen in the state use 32 metre L_{OA} and less feet size craft for fishing (72%). Craft size of 9.7 metre L_{OA} and less size use mainly two ICT tools, viz mobile phone and GPS. Above 9.7 metre L_{OA} size crafts use more than two and a maximum five ICT tools (i.e., 77%). Crew size of a craft also showed a significant positive relation with the adoption of ICT tools ($\chi^2 = 59.663, df = 2, P =< 0.000$). The average

Table 5.15

Crosstab classification of socio-economic features and ICT tools in Kerala (n=500)

Variable	Categories	ICT tools					
		1	2	3	4	5	Total
Age	18-35	15(10.1)	73(49.3)	44(29.7)	16(10.8)	0	148(100)
	36-55	50(16)	18(58)1	60(19.2)	18(5.8)	3(1)	312(100)
	>55	4(10)	27(67.5)	6(15)	2(5)	1(2.5)	40(100)
Education	Illiteracy	12(14.5)	43(51.8)	21(25.3)	7(8.4)	0	83(100)
	Educated	57(13.7)	238(57.3)	89(23.1)	29(7)	4(1)	417(100)
Boat Size	<32	66(18.4)	258(72.1)	33(9.2)	1(3)	0	358(100)
	>32	3(2.1)	23(16.2)	77(54.2)	35(24.6)	4(2.8)	142(100)
Crew Size	03/05/16	42(16.5)	170(66.9)	41(16.1)	0	1(4)	254(100)
	>5	27(11)	111(45.1)	69(28)	36(14.6)	3(1.2)	246(100)
Fishing Distance	5.0-35	48(17.1)	212(45.1)	19(6.8)	1(0.4)	0	280(100)
	36-200	21(9.5)	69(31.4)	91(41.4)	35(15.9)	4(1.8)	220(100)
Fishing experience	<10	8(12.5)	30(46.9)	20(31.3)	6(9.4)	0	64(100)
	>10	61(14)	251(57.6)	90(20.6)	30(6.9)	4(0.9)	436(100)
Days per trip	Single Day	51(17.1)	234(78.3)	13(4.3)	1(0.3)	0	299(100)
	Multiday	18(9)	47(23.4)	97(48.3)	35(17.4)	4(2)	201(100)
Revenue per trip	1000-10000	30(17)	138(78.4)	8(4.5)	0	0	176(100)
	10001-20000	27(27)	58(58)	15(15)	0	0	100(100)
	>20000	12(5.4)	85(37.9)	87(38.9)	36(16.1)	4(1.8)	224(100)
Co-operative Society	Yes	68(13.9)	271(55.5)	110(22.5)	35(7.2)	4(0.8)	488(100)
	No	1(8.3)	10(83.3)	0	1(8.3)	0	12(100)
Initial investment	1 -10	56(17.5)	229(71.6)	31(9.7)	4(1.3)	0	320(100)
	11-20	11(9.6)	48(41.7)	53(46.1)	2(1.7)	1()0.9	115(100)
	Above 20	2(3.1)	4(6.2)	26(40)	30(46.2)	3(4.6)	65(100)

Table 5.16

Pearson chi-square values of socio-economic, crafts features with the reference category of ICT tools in Kerala (n=500)

Variables	Categories	Pearson χ^2			
		North	South	Centre	All Kerala
X1	Age	10.67	12.56	14.02	17.88⋆
X2	Education	5.30	3.081	9.29⋆	1.87
X3	Boat size	30.05	126.87⋆	109.79⋆	263.65⋆
X4	Crew size	22.07⋆	40.71⋆	3.97	59.66⋆
X5	Experience	1.14	8.19	1.53	5.149
X6	Distance of fishing	6.39⋆	164.53⋆	105.33⋆	161.70⋆
X7	Days per trip	21.11	171.97⋆	124.10⋆	230.11⋆
X8	Fisheries society membership	6.26	135.16	NA	4.70⋆
X9	Initial Investment	52.783⋆	112.305⋆	119.765⋆	290.601⋆
X10	Rev per trip	28.379⋆	126.771⋆	32.615⋆	159.082⋆

Note: ★Significant at $p =< 0.05$

Source: *Primary Data, 2015-16*

number of crew size is 3-5 (49%) and >5 (51%). However, the study showed an insignificant relationship between crew size and use of tools in central Kerala regions. Experience in the field is important for the adoption of new technology. But, it also shows that fishing experience or work experience in fishing was not having any significant relation with the adoption of ICT tools in the state ($\chi^2 = 5.149, df = 4, P =< 0.272$). Distance of fishing (more nautical mile) showed a significant association with the adoption of ICT tools in Kerala ($\chi^2 = 161.704, df = 4, P =< 0.000$). All the regions such as, Northern ($\chi^2 = 6.931, df = 2, P =< 0.02$), Southern ($\chi^2 = 164.530, df = 4, P =< 0.000$), and Central regions ($\chi^2 = 105.33, df = 4, P =< 0.000$) also showed a statistically significant relationship between fishing distance and the use of ICT tools. Single day and multiday fishing also showed a significant relationship with adoption of tools (Chi-square (χ^2) $= 230.116, df = 4, P =< 0.000$). Northern (Chi-square (χ^2) $= 21.113, df = 2, P =< 0.000$), Southern (Chi-square $\chi^2 = 171.97, df = 4, P =< 0.000$), and Central (($\chi^2$) $= 124.01, df = 4, P =< 0.000$) regions of Kerala coast also showed a significant relationship between fishing distance and the use of tools. The membership in the fisheries Co-operative Society have a positive significant association with use of ICT tools in the state ($\chi^2 = 4.704, df = 4, P =< 0.319$). Almost all the fishermen (n = 488, 98%) in the state registered their crafts in any of the societies. But, north ($\chi^2 = 6.257, df = 4, P =< 0.04$) and south ($\chi^2 = 135.163, df = 4, P =< 0.000$) coastal districts showed a insignificant relationship between the membership of the Society and adoption of the tools.

5.6.3 Binomial Logistic Regression Model

The present study used a Logistic regression function to measure the influence of socio-economic features (categorical independent variables) with the adoption of advanced ICT tools (dependent categorical variable). Here, the study assumed that the motorised crafts which use mobile phone[10] alone, as non users of advanced ICT tools (denoted as '0') and users of echo-sounder, wireless set and beacon as users of advanced ICT tools (denoted

[10]The main limitation of the present study is that we do not have controlled variables. Since the user of the mobile phone in the Kerala coast is almost 100 percent and other users of other ICT tools are less. Thus, we assume users of mobile phone alone and GPS as non users of advanced ICT tools and users other remaining ICT tools as users of advanced ICT tools in the sector

as '1'). The binomial logistic regression model is well suited for this kind of analysis[11]. Here, the nominal dependent variable (Y) of the study is the use of advanced ICT tools and the independent variable of the study is socio-economic variable like age, education, cost etc. The study measures the effect of the independent (X) (socio-economic features) variables based on the probability of obtaining a particular value of the dependent variable in the advanced use of ICT tools. Socio-economic factors such as, age, education, total initial cost, and total revenue per trip (independent variables) were measured based on the probability $(P(Y) = E(Y)/X)$ that a motorised fishing craft will have advanced ICT tools or not.

Overall Evaluation of the Model

The evaluation of logistic regression model is studied based on the analysis of overall model evaluation parameters. Tables 5.17 and 5.18 show the overall evaluation of the binomial regression and Logistic regression analysis of socio-economic factors (n = 500) of users and non-users of advanced ICT tools. It was measured by various statistical tests and measurements. The statistical measurements are estimated with the help of likelihood ratio, Wald ratio, Hosmer-Lemeshow (HL), Negelkerke, and Cox and Snell R^2 ratios in the model. Cox and Snell's R^2 attempts to imitate multiple R^2 based on 'likelihood', but its maximum can be (and usually is) less than one. In this study, Cox and Snell's R^2 shows 50.8 which shows 51% of the variation in the dependent variable was explained by the logistic model. The Nagelkerke modification ranges from 0 to 1, that shows a reliable measurement of the relationship of both the categorical variables. Nagelkerke's R^2 will normally be higher than the Cox and Snell measure. Nagelkerke's R^2 shows 0.71 (71%), indicating a significant relationship between the predictors and the prediction.

The study accepts the null hypothesis if the H-L goodness-of-fit test is greater than 0.05 for well-fitting models. It does mean that there is no difference between observed and model-predicted values of adoption of advanced ICT tools. The model's estimates fit the data at an acceptable level if H-L rate is greater than 0.05. That is, well-fitting

[11]Binomial logistic regression is well suited describing and testing hypotheses about relationships between a categorical outcome variable and one or more categorical or continuous predictor variables (Sreejesh et al., 2014)

Table 5.17
Overall model evaluation of binomial logistic regression function

Test	X^2
Likelihood ratio test	236.90
Wald test	90.21
Hosmer & Lemeshow	0.05
Goodness of fit	R^2
Nagelkerke	0.710
Cox & Snell	0.516

models show non-significance on the H-L goodness-of-fit test. This desirable outcome of non-significance indicates that the model prediction does not significantly differ from the observed. The study showed H-L statistic a significance rate of 0.583 and therefore, the present model is quite a good fit for this function. The statistical tests of individual predictors which were tested by Wald X^2 value with respect to its coefficients. The simplest way to assess Wald is to take the significance values and if the values are less than 0.05 reject the null hypothesis (H_0 = model is not good) as the variable does make a significant contribution.

Odds ratio (OR) is one of the important measurements of logistic regression function which helps to understand the probability of occurrence or non-occurrence of an event. Univariate odds ratio (OR) and 95% confidence intervals (CI) of users and non-user of advanced ICT tools by socio-economic factors are shown in the Table 5.10. Table 5.10 shows that variables such as age ($p = 0.009$), education ($p = 0.039$), total cost($p = 0.000$), and total revenue per trip ($p = 0.000$) added significantly to the model/prediction. Regression coefficient was estimated with an increase in the odds ratio (OR)[12] when a logistic regression is calculated. The odds ratio (e) column in the table 5.10 presents the extent to which raising the corresponding measure by one unit influences the odds ratio. The study interprets the odds ratio in terms of the change in odds. If the value exceeds 1 then the odds of an outcome occurring will increase; if the figure is less than 1, any increase in the predictor leads to a drop in the odds of the outcome occurring. Table 5.10

[12]Odds ratios (OR) are used to compare the relative odds of the occurrence of the outcome of interest (e.g. have or have not), given exposure to the variable of interest (e.g. age, education, income (Scotia, 2010). That is; $OR = \frac{exposedcases(n) \times unexposedcases(n)}{exposednoncases(n) \times unexposednoncases(n)}$. OR = 1 (exposure does not affect odds ratio, OR >1 (exposure associated with higher odds of the ratio), OR < 1 (exposure affects outcome negatively)

Table 5.18
Logistic regression analysis of socio-economic factors ($n = 500$) of users and non-users of advanced ICT tools

Variables	N	Row %	Odds ratio 95% CI
Age			
18-35(ref.)	113	23	1
36-55	313	66	5.22 (2.2 - 12.5)*
>55	74	15	1.97 (1.0 - 3.7)*
Education			
Illiteracy (ref.)	98	19	1
Primary	193	39	4.11 (1.5 - 11.6)*
Secondary	179	36	2.88 (1.1 - 7.4)*
SSLC and above	34	7	4.78 (1.9 - 12.0)*
Boat size			
28 feet (ref.)	358	72	1
35 feet	102	20	1.08 (0.03 - 30.6)
55 feet	40	10	15.1 (0.5-445)*
Fishing distance			
10-50nm (ref.)	280	56	1
>50nm	220	44	11.78 (6.2 - 22.3)*
Fishing experience			
1-10 (in ys)(ref.)			1
10 - 20			0.360 (.14-.89)*
20 - 30			0.382 (.22-.69)*
Help from Co-operative Society			
Yes (ref.)	397	79	1
No	103	21	0.545 (0.30 - 1.0)*
Revenue pet trip (in ₹)	500	100	1.13 (1.04 - 1.22)*
Initial investment (in ₹)	500	100	1.00 (1.00 - 1.00)*
Total	**500**	**100**	$R^2 = 0.41$

Note: ✱Significant at $p =< 0.05$

shows that the odds of having use of advanced ICT tools ("yes" category) is 3.7 times greater for the age group of 18-35 as opposed to its absence in the age group of 55 and above. It is 3.4 times greater for illiterate fishermen as opposed to educated fishermen to use advanced ICT tools. The odds ratio for using advanced ICT tools shows that the adoption of advanced technologies have increased when the initial investment of revenue per trip increased. A chance of use of advanced tools is more (1.33) when the distance of fishing was more.

5.7 Economic Performance of Small-Scale Motorised Crafts

Many researchers have acknowledged that it is quite challenging and difficult to measure the impact of ICT on socio-economic development (Pohjola, 2001; Lamberton, 2001; Adam and Wood, 1999). The most common economic measurement for any technology's value is the calculation of benefits to costs (Pilat and Lee, 2001). Estimation of the techno-economic efficiency of fishing operations is a necessary condition for improved utilization and optimum substitution of inputs to enhance production (Najmudeen and Sathiadhas, 2007). For that, capital productivity, labour productivity, net operational ration, average income per crew and craft are to be evaluated (See the appendix A.2). In this section, the study measures capital productivity, labour productivity and operational cost [13] and revenue of each region. The study also compares those estimates with their calculated adoption index of ICT tools. Finally, the study also analyses the performance of electronics technology by calculating the adoption rate and comparing it with income, (*ceteris paribus*).

The use of ICT tools in the three regions helped the motorised fishermen to improve their revenue. The ICT tools helped them to stay more days in the sea through which they could save more money. This also helped the multi-day fishing fishermen to earn more money than single day fishermen. However, Adoption index is negatively related with capital productivity, except in Ernakulam whereas, revenue of the fishermen has increased due to the catch of high valuable fishes. Monthly income of the fishermen and operation ratio of each trip is also significantly related with adoption index in all the three regions.

5.7.1 Northern Kerala : Kozhikode and Malappuram

The use of ICT tools benefited the fishermen of Kozhikode and Malappuram coastal districts to increase income. The average income of the Kozhikode fishermen in more compared to Malappuram fishermen, due to differences in size of crafts and uses of ICT tools.

[13]The operational cost includes wages to crew, bata (Boarding Allowance Travel Allowance) for crew, cost of kerosene and petrol, auction charge, repair and maintenance charge, mobile charge cost, cost of food and other costs.

Normally, income shows a positive relationship with the uses of ICT tools.

Table 5.19 shows the economic performance of motorised crafts in Northern Kerala. The study shows that the average income of fishermen is directly proportional to the technology adoption indices. In the case of SD fishing crafts in Kozhikode, when adoption index increased from 25.71 to 35, income also increased from ₹ 167 to ₹ 12,052. MD fishing crafts, the income increased from ₹ 14,904 to ₹ 18,729, when the adoption index improved from 38.7 to 48.6. The adoption indices an relatively low among the SD and MD motorised fishing crafts in Malappuram and therefore, here small-scale fishing crafts earn less than in Kozhikode.

The concept of Gross margin/net operating ratio is very useful to explain the profitability of fishing crafts. The net operating ratio is also helpful for the fishermen to choose effective fishing crafts and fishing methods, subject to the existing resource constraint. Single day fishermen are generally less productive and earn less monthly income compared to MD fishermen in both the coastal areas of the Northern region. The average fishing days are almost the same for both the SD and MD motorised crafts. However, in Malappuram, the labour productivity of SD fishing boats was better than MD fishing boats. This is mainly due to the different size of crew size in the crafts. Better labour productivity in Malappuram leads to less dependency on MD fishing method.

5.7.2 Central Kerala : Ernakulam and Alappuzha

In the Central region, especially Ernakulam coastal district, ICT tools benefited more due to the adoption of more number of ICT tools. Marginal revenue in Ernakulam coastal district is more than Alappuzha and Ernakulam holds the highest adoption index of ICT tools in the State.

Table 5.20 shows the economic performance of motorised crafts in Ernakulam and Alappuzha coastal districts. The calculated results in Table 5.20 shows that, when adoption index of ICT tools increased, the income of the fishermen also increased. The adoption of the ICT tools depends on craft and crew size, gears and fishing days. The average monthly income of IBM fishermen of Ernakulam (₹15000 - ₹25000) was high compared to average income of OBM single day fishermen of Alappuzha (₹3000 - ₹5000). Per

Table 5.19
Economic performance indicators of the motorised boats in Northern Kerala ($n = 195$)

Items	**Kozhikode** ($n = 105$)		**Malappuram**($n = 90$)	
	Single Day	**Multiday**	**Single Day**	**Multiday**
Average Monthly Income/fisherman	7964.29	8554.05	4976.19	6104.35
Average monthly expenditure	5452.38	7689.19	4976.19	5995.65
Initial investment(₹)	556000	102700	62300	942000
No. of fishing days in a Year	240	256.2	252.05	247.68
Capital productivity (per trip)	0.38	0.51	0.52	0.45
Labour productivity (per trip)	26.94	37.21	32.25	38.17
Net Operating ratio	12051.91	18729.39	3166.67	14904.08
Adoption index	35.00	48.64	25.71	38.77

capita income of fishermen of the state at current price is ₹61,538 (Dept. of Fisheries, 2014), where single day fishermen earn less compared to other fishing crafts. The capital productivity of Alappuzha was high compared to Ernakulam IBM fishing crafts due to its less initial investment and lesser crew size. However, labour productivity of Ernakulam IBM fishing crafts was high compared to Alappuzha SD fishing crafts due to large catch of high-value fish.

Table 5.20
Economic performance indicators of motorised crafts in Central Kerala ($n = 115$)

Variables	**Ernakulam (MD)** ($n = 30$)		**Alappuzha(SD)** ($n = 85$)	
	Mean	**Std.D**	**Mean**	**Std.D**
Average monthly Income	25593.75	7975.2	5269.61	1805.75
Average monthly expenditure	16093.75	4160.95	5176.47	1661.51
No. of fishing days/year	240	5.26	264	8.2
Initial investment(₹ in million)	2.0	-	0.4	-
Capital productivity/trip	0.318	0.13356	0.434	0.175
Labour productivity/trip	73950.96	107047.2	2382.16	1613.53
Net operating ratio/trip	841562	1218197	14960	10133
Adoption index	80.0	-	35.5	-

Table 5.21
Economic performance indicators of motorised crafts in Southern Kerala ($n = 190$)

	Kollam ($n = 30$)		**Thiruvananthapuram** ($n = 160$)	
Items	**SD**	**MD**	**SD**	**MD**
Average monthly Income	6361.11	14090.91	6693.07	14493.06
Average monthly expenditure	4511.1	14090.9	6346.53	13173.61
Initial Investment (₹ in million)	0.781	2.241	0.542	1.593
No. of fishing days in a year	245	230	252	242
Capital productivity/trip	0.54	0.39	0.44	0.39
Labour productivity/trip	98.80	8363.63	88.20	4629.65
Net operating ratio/trip	4136.11	95363.65	4816.14	49190.9
Adoption Index	37.22	65	40.19	59.72

5.7.3 Southern Kerala : Thiruvananthapuram and Kollam

Table 5.21 shows the economic performance measurement of motorised crafts in Thiruvananthapuram and Kollam coastal districts. The Table shows that the adoption of ICT tools has influenced income, in Southern Kerala. When the adoption indices increased from single day fishing crafts to multi-day fishing crafts, the operating profit also increased. SD fishing crafts use less number of ICT tools than MD fishing crafts. Single day fishing crafts have more capital productivity than multi-day fishing crafts, due to lesser crew size and more concentration on pelagic fish. The average income of as SD fisherman is ₹6000 and the average income of an MD fisherman is ₹14000 in South Kerala. The initial investment of an SD craft, gear, and engines cost is four to six lakh (0.4 - 0.6 million rupees). Whereas, investment of MD fishing craft, gears, and engine cost around 14-15 lakhs (1.4 -1.5 million rupees). SD and MD fishing crafts of Kollam attained more labour productivity than Thiruvananthapuram fishing crafts. When adoption index of SD fishermen in Kollam increased from 37 to the adoption index of SD fishermen in Thiruvananthapuram became 40. It provides a difference of ₹ 7000 in the revenue. The difference in the revenue also exists among MD fishermen of both the coastal districts. When an adoption index in Kollam increased from 59 to 65 (adoption index of MD fishermen in Thiruvananthapuram), profit also increased from ₹ 49000 to ₹ 95000. This clearly states that when the adoption index increases, there is a chance to increase the profit in the southern Kerala coastal regions.

The study shows that, when there is an increment in the adoption index or adoption level, average revenue per trip also increases, *ceteris paribus*. When adoption index of SD fishermen in the northern region increased from 25.71 to 35, income also increased from ₹3,167 to ₹12,052. In SD fishing, Alappuzha is the better coastal district of the state than the other. In MD fishing Ernakulam is the better one than the others. In terms of profit, least earning income is Malappuram coastal districts. In the case of MD fishing boat, income increased from ₹14,904 to ₹18,729, when the adoption index improved from 38.7 to 48.6. The calculated results of central coastal regions also showed that, when adoption index increased from 35 to 80, the revenue per trip was also increased. The large difference in adoption value is due to the comparison between the SD fishing boat and MD fishing boats in Central Kerala. Southern coastal regions also supported the positive relationship of the adoption index and revenue per trip. When adoption index increased from SD fishing crafts from 37.22 to 40.19, revenue per trip was also increased from ₹4,136 to ₹4,816. When the adoption index of MD fishing crafts in Kollam increased from 59 to 65, revenue per trip also increased from ₹49000 to ₹95000.

Along with the relationship between adoption index and revenue, other economic performance indicators; such as capital productivity, labour productivity, operating ratio, monthly income etc. were also calculated to understand the economic performances of ICT tools. Capital Productivity of SD and MD fishing boats in the North is (0.59 and 0.48) higher than the other two regions (0.32, 0.49, 0.48 and 0.43, 0.39 Central and Southern respectively). Labour productivity of SD small-scale fishing boats is high in (93.5) Southern regions than the Central and Northern regions. The labour productivity of MD boats (73950) is high in the Central region.

5.8 Summary

Information and Communication Technology tools play an important role in fishing and communication purposes in the marine sector. The small-scale motorised fishermen are getting maximum fish catch (productivity) with the help of presently available ICT tools in Kerala. The adoption of ICT tools in the sector is based on the epidemic effect, i.e., information from a fisherman who uses tools passes it to non-users. It is proved that the adoption of ICT tools (trend curve) follows all the characteristics of the ‘sigmoid shape’ as theoretically stated. Communication between friends, relative, and colleagues, the role of government organisations, and accessibility are the major determining factors for effective use of ICT tools in the sector. The study also reveals that there exists a significant positive relationship between the number of tools adopted for fishing and revenue of motorised crafts. Enriching the small-scale fishermen with a new application of Fish Potential Zones is a necessary condition for the growth of the sector, but it is not sufficient. Proper and effective use of new ICT tools in fishing and related activities brings about the growth of income of fishermen along with sustainability of sea resources.

Chapter 6

FINDINGS AND DISCUSSION

A detailed discussion of findings of the study and its validation are presented, in different sections namely, socio-economic factors, trend of ICT tools and influencing factors in adoption and economic benefits of the ICT tools, in this chapter.

6.1 Major Findings and Discussion

The present study mainly focuses on small-scale fishermen and their usage level of new ICT tools in the marine sector of Kerala. The study also understands the determining factors in the adoption of such ICT tools. Measuring the economic performance of small-scale motorised crafts is also done through this study. The study assumed a large number of fishermen usage level of ICT tools in the sector and assumed that communication between fishermen and observation during fishing paved way for adoption of ICT tools in small-scale motorised crafts. The study objectives and hypothesis were systematically accessed and discussed in different sections. Section 6.1 is a continuous to the analysis part of the last Chapter 5. The major findings and reasons for those findings are discussed in this chapter. The following sections explain objective wise findings and their discussion.

6.1.1 Nature and Functions of SSF Motorised Crafts in Kerala

A radical change in the small-scale fisheries (SSF) sector occurred, when the motorisation of crafts with Outboard and Inboard engines were introduced in the 1980s. The introduction of motorisation of crafts resulted in an increase in the size of crafts, increase in duration of fishing, changes in methods of fishing, use of different gears, increase in crew size, adoption of new electronic gadgets etc. Also, the usage of new Information and Communication Technologies in the marine sector helped the fishermen to make optimum use of motorisation of small and medium-size crafts.

Nature of Crafts and Gears

Fisheries sector of Kerala has achieved an increase in the quantity of fish catch, skilled labour capacity, and use of new techniques and technologies over a period of time. These features are different in different regions. Across the state, small-scale fishing depends on different gears, methods, and nature of crafts. The intensity of usage of ICT tools also varies according to the nature of crafts, the method of gears, species of fish, and region's particular geography.

This study focused mainly on medium and small size gillnets hook and line motorised crafts of Kerala coast, on which 90% of the traditional fishermen depend. Medium size motorised crafts are used in the Northern and Central region of Kerala, whereas small size boats are more prominent in the Southern region (especially in Thiruvananthapuram) due to its steep ocean floor and rough sea surf wave pattern. In this region, motorised boats are largely used in Pallithottam, Muthakkare, Vadi, and Neendakara. During the monsoon, most of the beach landing centres of south disappear due to rough sea. A very few seashores are available for shoreline fishing (Kambavala or karamadi); a traditional fishing craft and its gear, also known as *rampon fishing*) exists in the Southern region, especially in Pozhiyoor, Poovar, and Pulluvilla, the coastal villages of Thiruvananthapuram district. The gear karamadi is used a traditional planked canoe called vallom (a fishing craft which is constructed with wood and tread) and now OBM plywood boats have started using the same. This change improved the efficiency of karamadi fishing in terms of saving time, reduction in physical labour etc. The majority of the fishermen who work in karamadi are old people because of the less physical activity needed for this gear of fishing. The study could not observe any fishing gears of karamadi in the Centre and Northern coastal regions. This is because of unavailability of the elder fishermen and less catch and income from this fishing gear. But, the new version of karamadi in the Southern regions is seasonal boat seine, locally called *Thattumadi* (a smaller version of ring seine).

The usage of *thattumadi* gear has drastically increased in Southern regions, especially in Vizhinjam, Poovar and Pozhiyoor coastal villages during the last five years, due to the availability of large quantity of different types of squid in these regions. Neerodi (TN), Pozhiyoor, Poovar, Pulluvila, and Poonthura fishermen depend on Vizhinjam coastal village, where a mini harbour has been built for fishing, landing and selling fish. Traditionally, the boat seine (*thattumadi*) was operated by two large sized cattamarams. Now, the fishermen have shifted from cattamaram to motorised plywood boat and the average size of this craft is 28-32 feet. The traditional method (using cattamaram) was purely labour intensive, where 3-4 crew members work in each cattamarams. However, now the number of crew in the boat seine increased from four to six and also reduced the workload on crew members. The method of catching squid is also unique in nature. Fishermen fit either electric or gas lights around the OBM plywood boats. Because of more lights and its dazzle, the cuttlefishes would come from bottom to top of the sea, where they get caught with boat seine. Fishermen prefer only night time for using boat seine operation so as to attract squid and other kinds of fishes. The other fishes which get caught in this gear are ribbonfish, whitebaits and rainbow sardine. However, the night fishing caused many regional riots among the day fishing and night fishing fishermen. Again, region wise clash occurs between local coastal village fishermen with the other coastal village fishermen who use boat seine at night. This kind of technological development for catching a specified fish with SD OBM is not found in other Centre and Northern coastal districts due to their lack of skill in catching cuttlefish.

No mechanised trawling boat was found in Thiruvananthapuram coastal district. Small-scale motorised fishermen are slowly moving to ring seine crafts. Ring seiners with the large size of IBM boat were observed in southern coastal districts. However, the number of IBM ring seines is less due to the continuous opposition of small-scale motorised fishermen against its fishing gear and a huge investment of the crafts. The majority of the OBM medium size plywood crafts of north and centre regions are owned and operated by fishermen of the Southern regions. Yet, a large number of ring seine crafts with Inboard engines were found in Central (Eranakulam and Alappuzha) and Northern coastal districts (Kozhikode and Malappuram). In Alappuzha, the ring seiners are operated in the traditional planked canoe (vallam) with outboard fitted 9.9hp Yamaha or Suzuki engines. The number of crew and size of the boat is comparatively less in Alappuzha coastal district than other coastal regions. This is due to the smaller size of planked canoe compared to OBM and IBM ring seiners of other regions than the other. The study found more number of IBM ring seiners in Kozhikode and Malappuram coastal regions. This type of crafts cost a huge initial investment, because of its large size and more labour intensive gear. This initial investment of ring seiners are raised by a group of fishermen and ownership is collective in nature. Because of the large size of ring seine crafts, small-scale fishermen of SD get less quantity of fish in Northern regions. Mainly, small-scale fishing (pelagic fish) is carried out by motorised ring seine units (60 ft) in the Northern region. The operation of a large number of IBM ring seines will destroy the operation of small-scale motorised crafts and sustainability of fish resources.

The study found a difference in types of crafts, gears and fishing methods in three different regions of the small-scale motorised fishing sector. This combination of crafts, gears, and fishing method entirely depends on geographic features of each coastal villages, different oceanographic conditions of the sea, socio-economic factors of the communities, religious and political factors of the state, distance of fishing, and volume of varieties of fish they catch. The prominent small-scale motorised boats prevalent in the sector are a single day outboard motorised (SD OBM), multi-day Outboard Motorised (MD OBM), and Multi-day Inboard Motorised (MD IBM) crafts. IBM boats spend more than one week for fishing in the sea. Medium size boats spend less than one week and small size boats spend less than 24 hours for fishing. This segregation of fishing of crafts was adopted for improving the fuel efficiency of boats and to catch more fish from inshore and offshore water of the sea. More small sized fibre/plywood boats (28 ft) are located in the Southern region, which spends less than 24 hours (single day) for fishing in the sea. Small and medium types of motorised boats operate in Malappuram, Kozhikode, Alappuzha and Ernakulam coastal districts.

Diffusion of motorised boats

Diffusion of motorised fibre/plywood boats took place from Southern to Northern regions from the 1980s onwards. Now, fishermen from Malappuram coastal villages buy used OBM plywood/fibre boats from Kollam and Thiruvananthapuram of the Southern regions, even though private boatyards are situated around their coasts. Good quality fibre/plywood boats are available from in the Southern coastal districts (especially from SIFFS boatyards). Fishermen from Northern coastal districts also demand second-hand small-medium size OBM crafts from southern coastal districts, due to craft quality of the Southern products. They get the good quality crafts from the Southern coastal districts with less price of the crafts and gears. Thus, Malappuram OBM gill net fishermen use second-hand outboard motorised crafts and spend less money on the craft and gears. Kollam and Thiruvananthapuram OBM boat fishermen buy crafts either from SIFFS or from private boatyard of Vallavila, Neerodi, and Marthandamthurai (Tamil Nadu).

The adoption of the fibre (now most of the fishermen use fibre boat than plywood) and plywood motorised crafts took place in the state due to its fuel efficiency. It is competent enough for use in the rough sea surf conditions. Fishermen use one or a multiple numbers of engines depending upon the distance they travel for fishing. SD OBM fishing crafts of Tannur and Puthiyappa (Kozhikode) carry only one outboard engine of 9.9 hp Yamaha or Suzuki, whereas SD OBM of Vizhinjam, Kollam, Beypore (Kozhikode) carry two number of outboard engines of 9.9 Yamaha or Suzuki. SD OBM runs 12 NM per hour, whereas, MD OBM runs 6 NM per hour on an average with one outboard engine. This differences in the efficiency of the fuel are due to the size of the crafts and weight of the gears. MD OBM caries more quantity of gill nets, long line, food and other amenities than SD OBM. If they operate both the engines at the same time, the average nautical mile of running is only 15 and 9 for SD and MD OBM respectively.

Crew members and their relationship

Crew members are the backbone of any motorised crafts in the state. Size of fishermen depends on the size of the crafts. Large size crafts like ring seine, carry a more number of fishermen and small size crafts like SD OBM carry fewer crew members. Fishermen who work efficiently get more in demand in the sector and get an extra share of income.

Crew size of the SD and MD OBM boats is three to four and five to six members respectively. It is almost eight to ten fishermen work in IBM gill net boats. The study found that most of the crew member of the crafts are either relatives or own family members. SD and MD OBM are usually owned by a single fisherman, who runs his crafts with his relatives or children. MD IBM gillnet crafts have a more number of crews, because of its labour intensive work and more quantity of gears. The study also observed that spatial migration took place from North Indian to coastal places like Beypore (Kozhikode) and they worked along with Kerala fishermen in MD IBM and OBM crafts. Rapid industrial growth in coastal districts like Ernakulam and Kozhikode has attracted cheap and unskilled labour from other states. IBM and OBM motorised crafts occupy two or three shareholders for initial investment and the major portion of the initial investment is done by a middleman (a local non-fisherman), who holds the power of management. IBM from Northern and Central coastal districts operates with mutual understanding, because of the huge investment of IBM crafts. Normally, MD IBM boats owned and operated by Southern coastal fishermen and middleman for this crafts would be from local coastal villages, where they land.

Gear technology of crafts and its operation

The type of gear being used for fishing is important for improving the efficiency of the crafts and sustainability of fish. The selection of gear depends on the crafts and fish seasons. There are various gears used by small-scale motorised crafts in the sector which are legally allowed.

Knowledge about the efficiency of gill nets is important for the reconstruction of the population of fish stock (Machiels et al., 1994). Gill nets are very cost effective means of fishing in Kerala, for catching targeted fish species. Different mesh sized gill nets are being used by the small-scale motorised crafts. This also varies according to region and availability of fish species. The study observed that SD OBM uses 4th numbered gill nets, MD OBM boats use 6, and 8 numbered gill nets (number increases when the mesh size of the net increase) in Kollam and Thiruvananthapuram. Whereas, IBM use 6,8, and 10 numbered gill nets for fishing deep-sea fishes. Different mesh sized gill nets are used for catching different fish species and small fish will not get trapped in those gills. According to the season, the size of gill nets varies. The MD OBM fishermen stretch the gill nets for one to two nautical miles and they are typically 8-10 ft high and this can be set at different depths according to the season and ocean current. Fishermen leave this nets for one day or a couple of days depending on the type of boat they use. The net will set between 5 to 6 pm and hauled in the next day between 4 and 5 am. The fish caught in the net are arranged in the deck and pulled back into the boat. Daytime is spent for using longline gear which contains of 200-300 hooks and for repairing the gill nets if any damage happens during the last suspension of the net. SD OBM fishing crafts, who use only 4^{th} numbered mesh sized nets stretch their net only for few hours. The small-scale motorised craft of all the three regions uses either green or red drift gill net or mid-water gill nets. It is suspended in the top or mid-depths of the water which is used to catch species that lives in the top or mid-depths of the ocean, such as tuna, sharks, mackerel, swordfish, sheer fish and salmon.

The study found that SD fishing crafts of the state are using either gill net or hook and line at a time. This varies according to the regions of the state. Northern SD fishing craft uses hook and line for catching a variety of fishes including sheer fish, different types of tuna, flat needlefish, and groupers. But, in the other two regions, SD fishermen use gill nets to catch tuna, sheer fish, Indian mackerel, Pomfret, anchovies and oil-sardines. Normally, hook liners start their voyage early in the morning around 4-5 am and lands in the evening around 4-6 pm, whereas gillnetters start their voyage at 2-3 pm and lands 5-6 am of the next day. Use of different gears for fishing by motorised crafts depends on seasons and distance of fishing. In Beypore, use of hook and line gear is during the months of June, July and August. The study found that a large number of fishermen from Thiruvananthapuram and Southern districts of Tamilnadu migrate to Beypore harbour during this period. In other regions, SD fishing is operated by the local fishermen themselves. Vizhinjam SD fishermen use the size of 4^{th} numbered gill net for fishing whereas SD fishermen of Kozhikode and Malappuram use nylon flag-style gill nets or multifilament nylon gill nets for fishing. This is the most effective net available for catches pelagic fish as oil sardines, mackerel and carangids. MD gill net and hook and line caught the same kind of fish of as SD hook and liners along sharks.

Crafts revenue and method of sharing

The revenue per trip and its method of sharing vary according to the nature of fishing crafts, gears and the social structure of each region. The revenue per trip (Total sales amount - Total cost[1]) is divided between the boat owner and the labourers in a 50:50 ratio

[1]Total cost includes fixed and operating cost. Fixed cost includes interest, insurance, maintenance and depreciation(Bhat and Bhatta, 2006)

in Kollam and Thiruvananthapuram. The per trip revenue in Kozhikode and Malappuram have divided into 40:60 ratio between owner and labours. However, SD OBM in Southern coastal villages divides the profit into three shares, where two shares go to the owner and one share is divided equally to the crew. In South, sales commission (auction charge) around two to five percent i.e., charged by an auctioneer, which goes as a levy to the respective Christian church of that coastal areas. The total cost of the small-scale motorised boat includes the cost of fuel, loan repayment, cost of food, commission charge, ice, and other costs. The costs of operation, productivity, use of ICT tools in the state vary between fishing methods and region. Majority of respondents availed loan from the financial institutions, house construction, the marriage of their children, and new crafts construction. Moreover, they also depend on nearby private banks and or their friends and relatives for various expenditure, like daily expenses, education, festivals etc.

Subsidy policies of the Government

Kerosene is the major fuel use for OBM crafts. The study results also shed some lights on the existing kerosene subsidy policy of the Government. The state Government subsidizes kerosene costs incurred by small-scale motorised crafts. A major portion of the cost lies on the fuel expenses which accounts around 50%-60% of their operating cost. Exploitation of middlemen (kerosene wholesale dealers) is more in these regions. The average expenditure of fuel of SD OBM per trip is 30-50 litres of kerosene and it is 200-250 litres (in season time they carry 500-700 litres) of kerosene for MD OBM. The average expense of fuel in SD OBM per month is 700 litres and it is 4000 litres for MD OBM. On the other hand, fishermen get 125 litres of kerosene per month at a subsidised price of ₹23 from Matsyafed (Kerala State Co-operative Federation for fisheries development Ltd) and remaining fuel is consumed from either open market or black market with a cost of ₹50/litre. Black market price of the kerosene varies according to the region and the coastal villages. In Munambam one litre of kerosene costs ₹75 whereas, it is ₹55 in Neendakara. The kerosene subsidy policy of the State, therefore, is economically inefficient for the fishermen. MD IBM crafts use 2000-3000 litres of diesel where they get no enough subsidies from the Government. Most of the fishermen need to borrow money from friends or banks to maintain their daily trip, because of the high operating cost per trip.

Role of religious institutions

A large number of churches, mosques and temple are located near coastal areas and is receives a small portion of income from the fish sale. This portion of income is used for several purpose, such as, religious daily expenditure, religious festival, welfare programmes of the community, interfering legal issues of the fishing community, educating poor children etc. For the last several decades' Christian religion and its priests have played a significant role in the making of fisheries policies and fisheries management issues of the state. Interdependency between the fishing population and Christian church is clearly visible in the coastal villages of Thiruvananthapuram and Kollam through their strict local rules and regulations. In Vizhinjam, night fishing with electrical lights (boat seine) is not allowed to other coastal village fishermen and anyone can participate in the auction process and buy fish. This local regulation helps the local fishermen to increase their income and reduce the exploitation by collusion in the auction by agents or company representatives. However, no such facility is available in Beypore and Munambam of Kozhikode or in Ernakulam. Fishermen co-operative societies of each coastal village also play a significant role in small savings of the fishermen, by collecting certain commission at each point of selling. In Thiruvananthapuram, the commission is five percent of the total value. Three percent of this gets credited to the Fisheries Co-operative Society, and the rest two percent fisherman's small saving account of the Society. However, fishermen from Thiruvananthapuram who work at Chavakad in Thrissur coastal districts are charged seven percent as a commission for the Society and again, an extra four percent for head loaders for unloading fish on the land. The share of the profit per trip also varies according to region, crafts and gears. In Neendakara commission of each 100 rupees is five and in Munambam it is ten rupees. This variation of commission charge is due to the local social system, which again depends on the regulations of the religious institutions, head load workers, Fishermen Co-operative Societies etc.

Unlike other fishermen, Christian and Muslim fishermen usually engage in fishing for six days a week opting out Sundays, Fridays by Christians and Muslims respectively for attending their religious ceremonies. There are many multi-day fishermen who were found to strictly follow the weekend for religious rituals, even though, they do not get any fish during those days. The social system in the Southern region is that the Christian fishermen do not go for fishing on Sundays and the Muslim fishermen on Fridays. Even the Southern SD fishermen who work in the Northern region could go for fishing on Fridays due to the inefficiency of the market. Christian Fishermen of Beypore, Chavakad, Munambam, Kollam, and Thiruvananthapuram have been playing an active role in the administrative and financial management process in their respective local Christian churches since several years.

Internal and external migration of the fishermen

The Southern Kerala coast has a predominantly Christian population, while the Northern region is largely Muslim populated, and the Central region is dominated by both Christian and Hindus population. Migration of the fishermen and their family members to gulf countries play an important role in adopting new technologies for households and fishing activities. The study found a large number of migrant fishermen of Southern and Tamil Nadu moving to Northern and Central coastal regions of Kerala for fishing, called as *inter state migration*. In Beypore (Kozhikode), almost 100-200 SD OBM crafts of Tamil Nadu and Southern coastal village were operating very effectively, since they do fishing only during a particular season, called as *intrastate migration*. This type of migration of SD fishermen from the South to Beypore takes place in June, July and August months. They migrate either by road or by sea to the landing centres for fishing purposes during these months. Majority of MD IBM in Kerala are also operated by migrant fishermen of Tamil Nadu. The migrant fishermen of the Southern region of the state are mainly from Pozhiyoor, Poovar, Pulluvila of Thiruvananthapuram districts, and Kulachel, Thuthoor, Chinnathuraia, Eraimanthurai, Valavilai, Marthamthuria, Puthuria, Neroodi from Kanyakumari district of Tamil nadu. This migration from Southern Kerala and from Southern

Tamil Nadu is due to various factors like geographical[2], socio-economical[3], demographic and ethnographic features[4], difference of skills in fishing[5], demand and supply condition[6], and political and religious conditions[7]. This traditional MD IBM fishermen use hook-and-line gear for hunting sharks and highly valuable fish resources and use 8,10,12" mesh size gill nets along with hook and line. They stay at deep sea for 25-30 days per trip. They also carry large mesh size gill nets along with the large quantity of hook and line. In some cases they travel up to 1500-2000 nautical mile for fishing, it may be either to a foreign country (Qatar, Saudi Arabia) territories or some union territories (Lakshadweep) of India. Sometimes, they begin their voyage from one landing centre of Kerala, and lands at other landing centres of the other states of India, such as; Goa, Maharastra (Mumbai), Gujarat or Karnataka (Malapa). This is because of the presence of infrastructural facilities are available at these landing centres and a better market price for their fish.

Investment of MD IBM crafts ranges from ₹30-₹40 lakh because of its size and technologies used. Average cost per trip ranges from ₹1-₹2 lakh because of more number of days spent for fishing. MD IBM fishermen use their boat for taking bath (once in two to three days), toilet purpose, watching movies on TV and for playing cards at the free time. One person from the group is assigned for cooking daily food for all the crew of the boat. The quantity of food they eat during the fishing days is more than their normal food. They carry food and beverages items, gas/kerosene and 2000-3000 litres of drinking water to last for almost a month. There is no migration of Northern fishermen of Kerala to the Southern or Central regions within the state. This is due to the rough sea surf, the presence of a large number of active fishermen and lack of enough infrastructure facilities in the landing centres of the Southern coastal districts. The North and South regions also differ in terms of active fishermen, craft size, weather, coastline, oceanography, bathymetry,

[2]The coastal villages of Tamil Nadu are situated at the Southern border of Kerala and Tamilnadu, the specific coastal villages lack the specified crafts and gear operation due to unavailability of fishes of MD and IBM crafts.

[3]Lacks infrastructure facilities such as harbours, and gain low income from their coastal fishing village

[4]Participation of youngsters are more, they are hard-working fishermen, they are very determined and are risk lovers. All these factors are also the reasons for the deep sea fishing in Kerala.

[5]They are very expert in shark hunting which needs specific set of skills and experience and they have traditional knowledge of sea and its resources

[6]Kerala is a consumer state and the demand for fish is more, which motivates fishermen to catch more fish at any cost, due to these reasons, fishermen from other state come to Kerala for fishing

[7]They are conventional in their religious belief and make sure that they follow them in the migrated areas also.

fish species, market customs and infrastructure facilities. Also, motorised fishermen of Northern Kerala are unskilled to catch certain deep-sea fishes and also they are satisfied with their own coastal villages. SD and MD fishermen of Kozhikode and Malappuram are fully dependent on their own coastal villages and landing centres for fishing and related activities. Due to this, the adoption process of ICT tools takes more time in Northern regions than the Southern region.

The use of imported electronic gadgets helped for the better understanding of new innovated technologies in both the households and fishing activity centre. For example, the GPS was introduced by the Gulf migrated fishermen. Kerala has a high rate of migration to the middle east since 1970s (Zachariah et al., 2001), especially the Muslim community of Northern Kerala. Remittance from the gulf migrants and from returnees of the Gulf Countries has played an important role in the financial investment of fisheries sector in Northern regions, especially, adoption of large size purseine-net motorised (IBM) crafts and new electronic gadgets, recently. The working experience and work condition in the Gulf Countries also help to adopt and use new ICT tools effectively for fishing. These emigrants to the Middle East also played a significant role in family expenses.

A new technology on shore

The study found a new version of tractor and its operation in the Southern coastal districts. Tractor, a new technology, was introduced by small-scale motorised crafts in the Thiruvananthapuram coastal districts to push into and to pull back the OBM SD and MD boats to sea and seashore when they set and land their boats. For this operation, they gave ₹200 per boat both during the selling and landing. This helped the fishermen to save the time and energy which they spend now for fishing.

6.1.2 Importance of Information, Communication and Role of ICT Tools

Dissemination of information regarding fishing and its related activities plays an important role in increase productivity and effective management of commercialisation of fish in the sector. ICT tools, such as mobile phone, GPS, wireless set, echo sounder and beacon play a significant role in information dissemination. Kerala Marine Fisheries Census 2010 shows that of the 1,45,396 active fishermen, 36,965 (or 25%) use mobile phones. Among 11,175 motorised crafts, 3288 crafts (29% to the total) use GPS for fishing and communication. The Fisheries Census report of 2010 shows only the data of users of GPS and mobile phone. The report does not provide estimated data of other ICT tools in the sector.

Mobile phone: An effective communication tool

The mobile phone plays an important role in communication which gives advanced information about the fish prices at various landing centre. The mobile phone plays a more important role in social aspects than in the economic aspects. Determination of market price of fish (demand and supply) not only depend on the role of the mobile phone in the sector but also depend on the other economic reasons. Steyn and Das (2015) found that population growth, increase in industrialisation, and Gulf migration has also influenced the increase the fish price in the market. Normally, the mobile connectivity is within the range of 10-15 NM and it varies according to the service provider. The mobile phone also helps the fishermen to understand climate condition and availability of fish in the sea. Every fishing crafts, especially MD boats call their own agent to know the demand and price of the fish at the local landing as well as neighbouring landing centres. The middlemen/agents help in the partial investment of crafts and gears and the fishermen are indebted to the middlemen/agents until the debt is recovered. The middlemen/agents have the power to suggest where to land and when to land at the centres. Because they are better aware of market price fluctuations of fish than the fishermen in the sea. SD boats get more benefits than the MD fishermen from the information of market price fluctuations because they are operating in the inshore waters and are able to come back as early as possible if they get good catch and a good price in the market. The mobile phone is used for enquiring about fish availability, and to determine a better market price at local landing centres. MD fishermen use a mobile phone to chat with their relatives and family members when they come to landing centres. The market price of fish also depends on local demands resulting from differentiated prices in various markets (Steyn and Das, 2015). By using mobile phones they can find out the best market prices, sell their fish there, and increase their economic welfare and also reduce fish wastage (Jensen, 2007; Abraham, 2007). However, the present study does not support all the findings of Jensen (2007) when it comes to the case of small-scale fishermen of Kerala marine sector. They use the mobile phone only to know the market price of a particular day and to communicate when to land and not where to land. Here, the middlemen would tell their concerned boat when to land rather than where to land. The fishermen forced to land at a particular landing centre because of the influence of the middlemen. This is done, not to prevent the fish being sold in another market, where they can get more money, but to know the price trend for each type of fish. Local political and religious regulations are also the reasons for the *'not where to land'* in the landing centres/harbours. Where to land option comes in very rare occasion among small-scale sector. Again there will not be any much price variations around a radius of 5 - 10 km from their specified landing centre. Many of the landing centres prevent landings of crafts from other landing centres. An information on when to land saves more money compared to where to land. This also is based on the trust of the fishermen towards the local people of their landing centres. The study also found a large number of SD fishermen do not land at landing centres other than their own as they do not know the people at the other sites, and hence could not trust them. They prefer their home market where they have trusted people networks. MD fishermen trust their agent(*tharakan*) and land only in their permanent landing centres. The movement of freedom is restricted for MD fishing boats in the state, but not for SD fishing boats. The study found that, mobile is also used for safety purpose, such as risk avoidance, emergencies, functioning of the market, and chatting with relatives and family members. The present study supports both the studies of Jensen (2007); Steyn and Das (2015) for the case of SD fishermen in the state. MD OBM and IBM fishermen depend on mobile phone to retrieve information on when to land to get a better price from the market. If the market charges a lower price on a particular day, they postpone their landing to the next day to strike a better deal. Thus, the study concludes that, *law of one price* as Jensen (2007) stated in his study, is not applicable for MD fishermen. This is the case found in Fort Kochi, Munambam (EKM) and Beypore (KZD) of Central and Northern regions.

Jensen 2007 assumed that mobile phone helps in increasing the welfare or well being of the fishermen, welfare being declined in general aspects. Amartya Sen says that welfare has got many sub-components also. The general statement of welfare is not correct in the marine sector where a complex social system always persists. The present study found that fishermen do not really use mobile phones for economic welfare, but they use it more for emotional and social welfare, that is, to keep in touch with their family and friends, apart from safety/reasons. Thus, the study does not support the argument of Jensen that mobile phone usage by fishermen increase economic welfare, but support the findings of Steyn and Das (2015); Srinivasan and Burrell (2013a). The evidence of the study shows that emotional and social welfare is very strong in the MD fishermen than the SD fishermen in the sector in terms of mobile phone usage. This is because of lack of communication between MD fishermen and their family members when they are in the deep sea.

The role and benefits of mobile phone for MD OBM is different from SD fishermen in the state. Mobile phone is not used for navigational purpose in the sector. SD fishermen of Chaliyam, Puthiyappa, and Parappanangadi of Northern coastal villages use mobile more for enquiring market price of each fish and rarely land nearby other markets for a better price. in Southern regions, such as Vizhinjam and Poovar SD fishermen land in their own landing centres whatever the price of fish exist in other local markets. This is due to the high demand for fish in these coastal regions and better support and involvement/regulations of locals in the auction and other related activities. Mobile GPS is not being used by MD fishermen for searching location or navigational purpose, because of the unavailability of the mobile network and internet access. On the other hand for SD fishermen, time and not network is the issue.

MD OBM shifts landing centres, because of their familiarity and assistance of particular landing centre. SSF boats also shift their selling place very rarely from their local landing centre to other landing centres for high fish price. There exist fewer phone contacts between the fishermen (producers) and buyers (consumers), but there is contact between auctioneer/middleman and buyers (they may be representatives of various fish exporting companies). The buyers also include small-scale vendor (women/men), restaurant owners, and local people.

SD fishing boats predominately use Reliance or MTS GSM mobile phone connections which costs around less than ₹1,500 per set. Such connections are preferred for their connectivity even at a distance of 10 NM, when compared to other companies such as; BSNL, Vodafone, Airtel, Idea etc., which provide minimal or less network coverage. Infrastructure facilities of Reliance and MTS in the fishing sector are better than the other network providers. Most of the SD fishermen use a mobile phone for communication purpose whereas, MD OBM and IBM fishermen depend on wireless set (marine VHF radio) for communication purpose when they are at sea. This helps them to get all the details of the previous and present market fish price even when they are at deep sea. They use mobile phone to confirm the informed market price with the agent when they are in the mobile network coverage area. MD fishermen use the costlier mobile phone than SD fishermen, because of its various entertainment uses such as; playing the game, watching movies, music etc.

GPS: A more preferred ICT tool

Global Positioning System (GPS); works with the help of satellite, plays an important role among SSF boats in safety and fuel efficiency aspects. There are two types of GPS existing in the industry; handy and fixed GPS. Handy *72H GPS* of *Garmin* company was used by the small-scale fishermen of FRP/plywood boat of SD and MD. Fixed *GPS 128* (black and white and colour) was used by MD IBM and was rarely used by MD OBM boats. GPS was used to understand the position of boat, location of fish shoal and landing centre/sea shore of the coastal village. A separate wooden box is constructed near the deck for keeping the fixed GPS and wireless set in every OBM multi-day boats. It is fit under the ceiling, just above the steering in the IBM multi-day boats. This helps easy accessibility of the tool by for driver (or shrank) who controls the engine of the boat. Both the handy and the fixed GPS are different in price, size, and functions. Majority of the fishing boats carries a minimum of two handy GPS tools and two mobile phones minimum due to its benefits in fishing. They carry two handy GPS tools because of the fear that they can use the other in case of damage. GPS can be also be used to get data of Potential Fish Zone (PFZ)[8] from the fisheries department which helps the fishermen to save energy, money and human effort. The study found that there are authentic PFZ advisories for information dissemination in coastal districts, but no infrastructure facility is maintained in the coastal villages or landing centres to diffuse such vital information to small-scale fishermen.

The study found no infrastructure facilities in any of the landing centres for disseminating any kind of fish related information, such as; Fish Potential Zone data (PFZ), climate conditions, wind conditions, sea temperature etc. Pillai and Nair (2010) found that oceanic satellite information was very useful when it is used by traditional fishermen for catching marine resources. It was successfully tested empirically by Pillai and Nair (2010); Nammalwar et al. (2013); Choudhury et al. (2007) in various Indian coastal regions and found that the distribution of PFZ data is an added benefit to its users. Awareness classes or training programmes of PFZ and its operation are conducted very rarely in the coastal regions. A technologically well equipped fish landing centres were not found in any of the fish landing centres or harbours. The infrastructure facilities to display Indian National Coastal Information Service (INCOIS) electronic information were also not maintained properly in all fish landing centres. Matsyafed can take up the task of maintenance. These facilities of PFZ would help to diffuse the ICT tools to its optimum level and get fish resource data and other related information. Government authorities are also not ensuring the availability of ICT tools in crafts when they register in the department. Any review or follow up actions are not being done by the authorities regarding use of ICT tools when renewal of kerosene permits take place. These actions will help the fishermen to understand about the importance of ICT tools.

Wireless set or VHF radio: An useful deep sea communicative tool

Wireless sets are used to communicate with other mechanised or motorised fishermen about the fish shoals, boat and net position, emergencies news or just for a friendly talk

[8] PFZ is reliable and short time forecast on fish aggregation zone in the open sea. PFZ advisory are brought out by Indian National Centre for Ocean Information Services (INCOIS) under the Ministry of Earth Science (ESS), Hyderabad, during the cloud-free days on thrice a week basis earlier and daily recently and are disseminated through FAX/telephone to different fish landing centres and boat owners along the Indian coast.

when they are in deep sea. Wireless set or marine VHF radio is a communicating tool for the fishermen, when they do fishing in deep sea, and is one of the most benefiting tools used in MD fishing crafts in the Kerala marine sector. The popularity of the use of VHF radio is because of the fact that they can be used at any distance within the sea, whereas a mobile phone which has a limited coverage. There are two types of wireless sets being used by the small-scale motorised fishermen [9]. Majority of the small-scale motorised fishermen use handy VHF, because of its ease of accessibility and low cost. Fixed VHF radio needs to be fixed on the deck of the boat. There are no proper infrastructure facilities in the OBM boat to install the fixed VHF radio. There are some OBM boats which use fixed VHF radio, fixed on a corner of the crafts under a wooden box along with the GPS. This fixed wireless set is more expensive than a handy wireless set because these have more channels and varied usage when compared to the handy ones. These are mainly used by IBM small-scale motorised fishing crafts in which it would be fixed on top of the steering. There are different companies producing various types of wireless sets, available at different prices. The fishermen mostly adopt wireless sets of model ICM-304 of ICOM company due to affordability of price and its utility. Most of the wireless sets are supplied by the *ICOM* company, model of *IC-M304* is popular in the markets in of Kerala.

The study found that wireless set benefits IBM motorised boats mostly more in terms of effective communication because they spend more days fishing in the deep sea. If any serious health issues, death cases, or other emergency situation occurs to any of the fishermen, of IBM boat at deep sea, other fishermen come to know within hours, since it provides for faster information dissemination. While on fishing trips to deep sea, emergency messages from families caused worry to the person. But, he can not come to the landing centres when he receives the information at deep sea. Sailing back is never a viable option because of the huge loss it causes to the owner and the other crew. Therefore, they depend on wireless sets to call and communicate with other fishing boats nearby which is set to go to the sea-shore/landing centre. Such emergency calls are well attended by the other boats because of the interdependency between fishermen. Sometimes, the communicated boat may run for 20-30 NM to reach the near by boat. This nearby boat helps the fishermen to reach their specified landing centre, as early as possible. Fisher-

[9] The main two types of VHF radio or wireless et are handy marine VHF and fixed marine VHF

men of OBM boats also face same situation and follows communication with help with the help of wireless set as in IBM boats. The two-way communication process helps the fishermen when they get seriously injured while fishing or when he gets sick. Earlier such communication passages were fewer, thus, causing mental and agony to the fishermen. Fishermen are mostly worries about unhelpful situation during serious accidents cases of their close relatives.

Echo sounder: A competent fish finder tool

Echo-sounder is a specific purposive technology, used for understanding the fish shoal and various natural and artificial reefs at sea. The study found that the majority of fishermen are using Garmin company's 350C fishfinder. Garmin echo sounders are user-friendly and affordable for the fishermen. There are two types of echo-sounders used by IBM small-scale motorised boats. One is black and white and the other is coloured echo-sounder. Black and white echo sounder is less priced than coloured echo-sounder. New type of colour echo sounders also do the functions of GPS that cost more than the normal black and white echo sounder.

No MD OBM crafts use echo-sounder for fishing purpose. This is due to the nature of the craft and its gear that they use. They use more quantity of different mesh sized gill-nets and very less quantity of hook and line which do not depend on echo sounder. Moreover, OBM crafts are not designed to suits echo sounders. On the other hand, the study found that, in Southern coastal areas, single day OBM boat has gradually begun to use echo-sounder for finding natural and artificial reefs for squid catch. There are no scientific technologies to fix the echo-sounder in the boat. They fix a PVC pipe at the back of the deck to insert the camera of the echo-sounder for finding out both the natural and artificial reefs of the sea. Mainly, single day OBM boat use echo-sounder to find out the artificial reefs. These artificial reefs are made by the fishermen by using *klanjil*[10] and placed in a particular position. The position of artificial reefs is saved in GPS at different name or number. But, they do not communicate this information to other fishermen and keep this a secret. This is to get more fish whenever they reach this location. After two-

[10]It is constructed from twigs from coconut tree

three weeks they go back to area and catch different types of squid and cuttlefish with the help of long-line. This process is continued for two to three months and the artificial reef would deteriorate within this period due to the high surf and the current of the sea. They then wait till the next squid season to develop artificial reefs for fishing. But, use of echo-sounder by single day OBM boats for either finding out artificial or natural reef of sea is not found in Centre and Northern study regions. The northern and central region, SD fishermen are not skilled in using such artificial reefs. Also presence of a number of different crafts operating in the Northern and Central region limits the quantity of squid and related fishes in these areas. This is the reason why the echo sounders are not being used by Central and Northern SD fishermen.

Beacon: A life safety tool

Becon, ISRO developed technology that used for saving fishermen life by detecting distress signals immediately alerted the Indian Coast Guard for search and rescue operations. Beacon or Distress Alert Transmitter (DAT) is used to give emergency information when a fisherman or fishing boats face any dangerous situation. It is an electronic device which has a switch, to be pulled at and turn on into the water during an emergency situation. This will emit a signal that is received by ISRO, Banglore space centre via satellite communication. This space centre intimate about the accidents to the local coast guard of that particular location. This coast guard travels to the accident zone and rescues the fishermen.

Government of Kerala claims that almost 3000 beacons have been distributed all over Kerala coastal villages at a subsidized rate in 2012 under the *Sea Safety Project*[11] through the Kerala State Coastal Area Development Corporation Ltd (KSCADC). KSCADC is the nodal agency for implementing the Integrated Sea Safety Project that envisages vessel tracking, detection and identification of vessels and establishment of communication systems and monitoring facilities. The study found that only very less number (almost 5%) of fishermen use beacon that too not effectively. The study could not trace over a single

[11]The project was implemented by Kerala government at an estimate of ₹9.10 crore to cover initially 3,000 traditional fishermen of Kerala coast. Beacon an attractive electronic tool of the project developed by ISRO and distributed by Keltron. The total cost of a kit that served to a fisherman is 1.25 lakh was distributed at ₹94,000.

case of fishermen's life being saved by the use of beacon from the sea. This is mainly due to several reasons, like non-availability of Beacons are not available in the local market, the tool is very costly and also not easily accessible, and fishermen are afraid of being fined by the Government in-case of its miss use. Moreover, they feel confident with the other ICT tools, mainly wireless set or mobile phone which can be used for emergency periods. But, the fishermen want a tool which is easily accessible like; GPS, mobile phone those which have multiple and a tool which has several uses at a single time. It is important to note that for implementing an effective use of safety tools at any sector is possible only through various awareness programmes and strict enforcement of rules. A few have Disaster Transmitter tool (Beacon), but no one is reportedly using it effectively. It reveals that costly and troublesome technology will not be effective in the marine fisheries sector.

Regarding supply and demand of beacon, ISRO can take necessary action for helping the poor fishermen at the time of unprecedented natural calamities with the affordable and effective tool of the beacon (DAT). ISRO can start the procedure of the online registration of craft for genuinely in the vernacular language. If the technology can also dictate some other parameters such as depth of the sea, the number of fishermen, type of craft, ISRO can produce cost less (It can go maximum to ₹10, 000) and can supply it through ISRO kiosk can cause a tremendous impact on the fishing community and their life. Fishermen can trust the product and working process of the tool. This kind of policy change would help reduce the impact of death and missing of fishermen during the various cyclone in the region.

Presently, use of all the available ICT tools is necessary in Kerala coastal regions. Using these tools are not sufficient condition for the safety concern of the fishermen lives. Still, many of their crafts and gears are being attacked and destroyed by various foreign ships and trawling boats during night time. Many of their gill nets are damaged and missing due to the crossing of ships or trawling boats, where gill nets are meshed by a propeller of crossing boats or ships. This also causes huge financial loss to the fishermen. A very large number of different types of crafts are operating in the Kerala coast along with various merchant and foreign vessel in the sea. MD OBM and IBM try to avoid this kind of incidents, by communicating with other crafts through VHF radio to inform the location of their boat and crafts. Sometimes, language makes a major the problem for proper communication with foreign vessels in the sea. The Arabian Sea is the main channel linking West Asian countries with China and South East Asia. Earlier, ships used to navigate through a channel off the Lakshadweep shore, but now they sail close to the Kerala coast since it keeps them away from the piracy-prone areas. This causes more accidents in the sea at night time. This can be avoided by using or initialisation of vessel monitoring system and effective use of beacon on every SD and MD OBM and MD IBM crafts in the sector.

6.1.3 Adoption Categories and Diffusion Process of ICT Tools

Beal and Bohlen (1957) and Rogers Everett (1995) developed five main categories of adoption of a technology, and Manueli et al. (2007) has developed four categories for the adoption of ICT tools. The five stages of the adoption categories of the ICT tools are innovators, early adopters, early majority, late majority, and laggards. This study has constructed three main categorises of adoption of ICT tools, based on all the mentioned studies in the marine sector. The three categories of adoption of technology in the present study are *early phase*, *phase of rapid growth*, and *phase of maturity*. The present study has also confirmed three main stages of ICT tools adoption categories in all the coastal regions of the marine sector. Innovators are the fishermen who are the active information seekers of new technology and risk lovers, and they hold a wide range of interpersonal network within and outside their local system. All other categories are developed on the basis of the time and rate of their adoption. This depends on many factors that are discussed in the Section 6.1.5.

The study found that innovators of ICT tools in the study areas were the mechanised trawling boats of the state. The adoption of ICT tools among motorised fishing crafts of both outboard and inboard come under the early adopters and early majority and late majority categories or early phase, phase of rapid growth, and phase of maturity, because of later adoption of these crafts than the trawling boats. In region-wise analysis of the study, Beypore SD and MD fishermen of Kozhikode adopted each ICT tools earlier than SD and MD fishermen of Tannur in Malappuram. The other remaining coastal areas of Northern regions also come under late majority adopters' stage when to compared to

Beypore. This was due to the difference in nature of fishermen, fishing crafts, gears, infrastructure facilities for landing and method of fishing availed in this region. There are more laggards of new ICT tools (wireless sets) seen in Malappuram districts than Kozhikode. This is due to lack of knowledge or awareness about the technology, lesser distance of fishing area and using of gears for pelagic fishes in Malappuram.

Number of SD OBM crafts and MD OBM & IBM crafts is increasing year by year and various changes in marine policies have also speeded up the adoption of these technologies. Motorised crafts were introduced 30 years after the development of mechanisation. Mechanised fishermen adopted the ICT tools much before the small-scale motorised fishermen. Motorised fishermen observed the technological facilities of the mechanised crafts and adopted it at a later stage of its adoption process. This was called *early majority adopters* by Rogers Everett (1995). The study establishes the role of observability or demonstration effect (in economics) of motorised fishermen ICT tools, especially for GPS and wireless sets in the sector. These are the external factors of technology adoption.

The present study found a positive trend of ICT diffusion and its rate. All the ICT tools except wireless sets and beacon have reached maximum growth and some are showing a tendency to fall. Wireless sets are showing an increasing trend (adoption rate is increasing) because demand for wireless set is more compared to the other tools in the sector. Beacon is not showing any adoption trend in the study areas, even though it has been distributed among a certain number of Malappuram fishermen. Therefore, measures should be taken to distribute it effectively and subsidy should be given to such small- scale motorised fishermen in the state.

6.1.4 ICT Tools Adoption Process and Its Influencing Factors

The adoption of new Information Communication Technologies (ICT tools) such as mobile phone, GPS, wireless set, echo-sounder, and beacon among small-scale motorised fishermen are presently the developed technologies in the Kerala marine sector. The study found many factors affecting the rate of adoption, including innovation's characteristics, internal, external, and technological factors as classified by Butler and Sellbom (2002) (see Chapter2). Study also compared the adoption factors with Rogers Everett (1995) feature of adoption; ease of use (user-friendly), the relative advantage (comparing with other technologies), compatibility (suitable for the present environment), trialability, and low cost, in the sector for better understanding of the influencing factors of adoption of ICT tools. The study constructed the terms such as; internal, external, and technological factors based on diffusion level of innovative research studies of Butler and Sellbom (2002); Rogers Everett (1995); Venkatesh and Davis (2000).

Internal factors of adoption of ICT tools

Various factors that affect the society/organisation is considered as internal factors (Huang et al., 2016). The concept varies according to the nature of the study (Wu et al., 2008; Perez et al., 2017). The study establishes that the *internal factors* are one of the main determinants of the adoption of ICT tools in the marine sector. The study identified the internal factors that influence the adoption of ICT tool as interpersonal communication (communication among fishermen), educational status, and social structure of the marine sector of Kerala. The study of Manueli et al. (2007) confirmed these criteria in his study. The communication between fishermen *who use* an ICT tool and *who do not use* is the interpersonal communication. If it is crafts wise, communication of SD fishermen with MD fishermen and communication of OBM MD fishermen with MD IBM or trawling boat is the interpersonal communication. Fishermen of trawling boat act as the opinion leaders in the adoption of ICT tools (Opinion leaders are members of the social system who exert their influence) for IBM and OBM MD and SD fishermen. Region wise also, the Northern fishermen communicate with Southern fishermen and thereby Northern fishermen adopt the ICT tools eventually. This process is known as *epidemic effect* and supports the theoretical view of Stoneman (2002); Hall and Khan (2003). This means spreading/-communicating information about new technology occurs from users to non-users in the fishing sector. The study also supports the findings of Mazuki et al. (2013) which reported that the communication between fishermen or social interaction is the prime factor for the adoption of technology in the sector. Communication media such as TV, radio, advertisement, and internet played a very important role in penetrating information about new technology among the fishermen. GPS was the first ICT tools in the sector which was adopted by the fishermen through the process of interpersonal communication between fishermen. However, mobile phone penetrated at a faster rate because of its low price, multiple benefits and user-friendliness. The mobile phone using experience helped the fishermen to use advanced technologies of the sector.

The adoption of a technology also includes time span as an essential factor (Rogers Everett, 1995). The time starts with the innovation and ends with successful adoption of end users. This adoption process passes through three-time factors. They are the innovation-decision process, relative time, and rate of adoption (Manueli et al., 2007). The innovation-decision process of IBM boats was influenced by the mechanised trawlers, which were the innovators (initial adopters) of the ICT tools. This is because of the interpersonal communication and observation of IBM MD fishermen when they hault at harbours, where number of mechanised boats are high. Therefore, MD OBM fishermen took more time and a slower rate to adopt the tools such as wireless set, echo-sounder, and beacon for fishing, compared by MD IBM. The Northern coastal regions of the State took more time than the Southern fishermen for the adoption of VHF ratio, echo-sounder and beacon, because, MD OBM and IBM fishing began in Southern regions and then penetrated to other regions of the state. The migration of fishermen from Southern to Northern region helped, the information about ICT tools to be disseminated among the fishermen of the Northern regions. However, IBM boats took very less time to adapt to all these ICT tools, because of the influence of the trawling boats in these regions. The social system of these regions also influenced the time of the adoption of ICT tools.

The social system includes social structure, norms, agents, types of innovation, and consequences of innovation (Manueli et al., 2007; Oliveira and Martins, 2011). The study found social structures that exist in the coastal villages as communal and caste-based. Northern coastal villages are concentrated by Muslim culture and caste-based system. In the South, most of the fishermen carried out the fishing activities in adherence to values (culture) of the Christian community. In Alappuzha coastal village, both the Christian and Hindu fishermen work strictly adhering to their values and culture of their religion. This different social structure of the society in each region also affect the catch of the fishermen. This is also the case with the Muslim fishermen of the Southern regions. But, the study could not trace any differences of cultural values (regional and religious), norms, and obligations as obstacles to the adoption of ICT tools. The study found infrastructure as one of the main obstacles of the adoption in the ICT tools. Once the fishermen are provided with enough infrastructure facilities, high-tech harbours and landing centres, the migration of nearby and far away fishermen comes to the harbours/landing centres landing to more communication about new technology and information dissemination among fishermen. Majority of the motorised boats are hauled in Beypore in Kozhikode and Munambam in Ernakulam harbour due to its infrastructure facilities for landing and marketing. When they do fishing in the Northern sea and they have to travel lesser distance to reach either Fort Kochi (Munambam) or Beypore when compared to the Southern landing centres. Also, both the landing centres are near to cities where industrial areas are flourishing. Large quantity of valuable fish are exported from these landing centres to various districts and states of the country. There are almost 60 registered motorised (OBM) boats in Beypore harbour alone. Beypore (Kozhikode) fishermen took less time to adopt ICT tools compared to other coastal villages under study in the Northern region due to migration of Southern regions. The second major factor that influences adoption is the communication between agents/middlemen (*tharakan*) and fishermen. Normally, the agent/middlemen are well educated and they are capable of communicating about new technologies for fishing and able to pass fishing related information to their concerned fishermen at less time from their landing centres. The middleman (*tharakan*) shares the information about fish harvesting areas with the fishermen. Sometimes, fishermen life depend on their middlemen. The agent/middlemen sort out the problems ranging from his crafts to their family. They also help the fishermen in buying crafts and gears by investing capital share and they charge certain commission (6-8%) at each selling instead of the interest rate. The study found the presence of agents/middlemen in all coastal district and they were selected either from the same village or from another village. But, it is more in the case of MD OBM and MD IBM crafts, due to its large amount of initial investment.

External factors in adoption of ICT tools

External influencing factors of adoption are the factor that lies outside a society or institution(Premkumar and Roberts, 1999). The study found several *external factors*, such as Government, research, and NGOs institutions for the technology adoption in the sector. The external factors played a very effective role in disseminating information about the new technology to small-scale OBM and IBM fishermen in Kerala. Kerala State Co-operative Federation for Fisheries Development (known as Matsyafed) played a very important role of passing information about new technology, which stands to one of the best example of the participatory role of government institutions in the diffusion of information. It also provides loans to fishermen, subsidies to the new technologies and kerosene to all the members of the society, which helped to speed up the use of OBM motorised crafts in the sector. Matsyafed also equipped the fishermen in using some new technologies by conducting training, with the help of NGOs.

Technological factors in adoption of ICT tools

Main characteristics features of technologies are considered as technological factors that influence the spread of new technologies (Rogers Everett, 1995). This study confirmed the role and influence of *technical factors*, such as; relative advantage, accessibility, ease of use and cost of technology for the adoption of ICT tools in the sector. These technological factors are derived from the studies of Rogers Everett (1995); Stoneman (2002). The study found that adoption of wireless sets (VHF radio) in the sector by MD fishermen was based on its *relative advantage* over the mobile phone, since it helps to communicate each other even, when the fishing boats are operating from the deep sea. They can not use mobile phone at deep sea due to its network problem. The present ICT tools are suitable for the environmental condition of the sea and none of them is harmful to the ocean resources. This feature of ICT tools helped the fishermen to ensure its wide acceptance and usability in the sector. The fishermen were not familiar with the use of GPS and wireless sets at an earlier stage of its adoption. However, by continuous use of these ICT tools, they achieved the confidence to recognised the benefits of GPS and wireless sets in fishing and communication purpose. The motorised fishermen were not victims of trialability, because of earlier adoption of ICT tools by mechanised boats in the state. Mechanised crafts adopted all the present ICT tools much earlier than motorised crafts, which helped the motorised fishermen to adopt the gadgets within less time. Fishermen from motorised crafts observed the use of ICT tools of mechanised boats and communicated with mechanised fishermen about cost benefit analysis of a new technology. This is called *Rank effect* of a new technology (Stoneman, 2002). It means that the adoption of ICT tools depends on the difference of mechanised- motorised crafts, adoption time, intensity, and emphasises of differences among firms in terms of profit. An effective communication between mechanised and motorised fishermen in the fields was found by the study in several harbours of Northern and Central regions. Due to inter-firm communication between mechanised and motorised fishermen, MD OBM boats use *Garmin* handy GPS (single day and 4-6 multi-day OBM) which is cost effective and a good quality gadget available in the market. All the fishermen of Kerala are aware of ICT tools and its role in fishing and communication.

The study found that the ease of accessibility and affordable cost are the main reasons for the adoption of the of ICT tools in the fisheries sector of Kerala. Many fishermen are able to use ICT tools effectively, for communication and for fishing purposes because of its ease of accessibility in the market or in the shops that are situated nearby the landing centres. Many of the ICT tools in the sector are affordable. Mobile phone is very cheap compared to other ICT tools. Again, the study found that financial constraint was not a problem for the adoption of ICT tools in the sector. The average cost of a mobile phone, GPS (OBM) and the wireless set used by SD or MD OBM, is ₹2, 000, ₹10,000 INR, and ₹15,000 respectively. The cost of ICT tools of MD IBM is more than MD OBM. They use costlier ICT tools than SD or MD OBM due to long distance and several days of fishing. Less price of mobile price and its services during the study period helped the fishermen to use mobile phones effectively for fishing. This caused more adoption of mobile phone in the sector after the year, 2007.

6.1.5 Socio-Economic Indicators and Adoption Progress

The study also found that fishermen's socioeconomic status is highly related to their degree of adoption. Some observations of the study claimed that different levels of socioeconomic indicators cause unequal rate of adoption among motorised fishermen. Therefore, socioeconomic factors did influence access or adoption of ICT tools in the sector.

Majority of fishermen in the study area are already using ICT tools. All of the current and expected adopters were well-educated fishermen. The relationship between socioeconomic features and adoption of ICT tools is partly due to the relatively affordable cost (generally low cost for the mobile phone). A few ICT tools are appropriate for fishing and some others for communication. Well educated fishermen, moreover well knowledgeable fishermen were able to use advanced ICT tools for fishing and related activities. Perhaps this situation may change as fishermen use these on a daily basis or as fisheries extension services launch more awareness programs about ICT tools use so that less elite fishermen can also learn about ICT tools use.

Age is another social factor influencing the adoption of ICT tools. Fishermen who belong to the age group of 20-30 adopt ICT tools faster than the other age group. They also become masters of its operation in the crafts, compared to elder fishermen. High risk at work and high remuneration (on an average) attract the younger fishermen to MD OBM IBM crafts' operation. In most of the small-scale motorised crafts, ICT tools were operated by the younger fishermen, which caused earlier adoption of new ICT tools, especially in IBM crafts.

Many researchers found a positive relationship between farm size and adoption of ICT tools in various sector. The present study found a positive relation of adoption of ICT tools with crafts size. This connection of socio-economic status with the adoption to non-adopters of tools may be due to the high initial investment cost (₹10,0000 for MD PBM and 30-40 lakh for MD OBM), and larger-sized operations spending more days of no-adopters. Attitude is another reason for the non-adoption of new ICT tools because a fisherman may know about a new tool of the sector but do not think it as relevant to his fishing operation, as potentially useful. Attitudes toward innovation, therefore, frequently intervenes between the knowledge and decision making.

6.1.6 Economics of Motorised Crafts

Fishermen income is one of the most significant factors in measuring their socio-economic development. Income of a fisherman depends on seasons; availability of fish. The average income of the SD OBM fishermen (₹6,531) is very less compared to MD OBM fishermen

(₹11,523). Same time income of SD OBM fishermen and MD OBM is less than MD IBM crafts in Kerala (₹25,593). The average yearly income of the motorised fishermen may vary, due to fishing days. Fishing days of SD and MD OBM crafts are more compared to MD IBM crafts. This is due to trawling ban of fifty to sixty days for MD IBM crafts by the government. and this will not affect SD and MD OBM fishermen. Income earnings of the fishermen depend on many factors such as size of crafts, gears of crafts, size of crew, the distance of fishing area, and ICT tools they use. Due to these factors, the income of motorised fishermen varies accordingly. The study found that the motorised crafts with more number of those factors will obtain more income.

6.2 Summary

Fishing sector and its market condition of each region in the state are not homogeneous in nature and it is very difficult to draw a unique conclusion. In general, the study confirmed that the theoretical approaches of *epidemic effect* and *rank effect* reasons for the adoption of ICT tools in the sector. The study also found some socio-economic aspects in ICT tools adoption. The study found a positive correlation between the size, initial investment of the craft and adoption of ICT tools in the sector. Along with these factors, fishermen's age and fishing experience also influence adoption of ICT tools. Through the division of adoption categories according to its adoption process, the study found that small-scale motorised crafts, the initial adoption category comes under early adopters rather than innovators of the sector. This is purely dependent on the size, investment, education, influence of the agent (opinion leaders) and basic infrastructure facilities in the coastal areas.

Chapter 7

CONCLUSIONS AND POLICY RECOMMENDATIONS

In this chapter, a brief summary of general features of small-scale motorised fishermen and their crafts, the trend of ICT tools and trend and influencing factors of adoption of all the selected coastal districts are discussed. Various suggestions and recommendations for effective use of new technologies are also briefly discussed. Finally, the future work possible in this field is also explained.

7.1 Conclusions of the Study

The use of ICTs has resulted in a tremendous impact on the progress of Kerala fisheries' community and the economy. Understanding the present usage of ICT tools and its benefits is necessary during this era of technological revolution particularly in the marine sector of the State. The advanced Information and Communication Technology tools have helped the small-scale fishermen to enhance their fish catch, income and safety and also they began to adopt new gadgets from the beginning of the 21^{st} century. The study focused on when and how the new advanced ICT tools were used by motorised outboard (OBM) and inboard (IBM) boats for improving their catch and safety. The main thrust of the study was to analyse how adoption took place and what were the factors that influenced the adoption process to improve the products and productivity of fishing.

Fishing operation of Kerala marine fisheries sector is heterogeneous in nature. This heterogeneous type of fishing crafts and gears caused an optimum level of fish caught but caused deterioration of sea resources. Adoption of the ICT tools in the sector helped the traditional fishermen in life and society. In this background, the present study focuses on examining the application of ICT tools in the overall development of the marine sector of Kerala, collecting information from Northern (Kozhikode and Malappuram), Southern (Alappuzha, Ernakulam), Central (Kollam and Thiruvananthapuram) coastal districts of Kerala. The study found that adoption of ICT tools increased the fish catch in the deep sea. The study claims also that, ICT tools do not contribute to any direct role in overexploitation of fish resources, rather it helps to go offshore, helps to stay more days at sea, improves communication among fishermen and enhances safety measures during fishing. The study observed that use of ICT tool for fishing by small-scale motorised fishermen helps the fishermen in various ways and the effective use of tools can be considered as the initial stage of blue revolution in the state.

GPS, echo sounder, wireless set (marine VHF), mobile phone and beacon have a huge potential for providing information on fishing and it's related activities to the fishermen, which justifies the results of a few previous studies. The present study focused on both the role of ICT Tools and the capability of fishermen for using these new gadgets and it contradicts with some past studies which have studied only the role of mobile phone in the fisheries sector. Overall, the role of ICT tools was found important in the marine sector, particularly in the case of increasing income and reducing the information asymmetry. Use of mobile phone helped to reduce information asymmetry and price dispersion in the sector. GPS & wireless set helped the fishermen to improve income and efficiency of crafts. However, ineffective use of GPS for collecting PFZ data by the motorised fishermen creates less utilisation of the tools in the sector due to its lack of awareness and lack of proper infrastructure facilities in the landing centres.A two-way process of communication for sharing ideas and knowledge using a range of communication tools and approaches that empowered fishermen and their communities to take immediate actions to improve their fish catch and lives. Kerala marine sector has adopted an approach that integrates the best elements from several models, while also ensuring that maximum participation of traditional fishers, types of crafts, and government management.

The observed *sigmoidal* shapes of diffusion of ICT tools from the data of the marine fisheries sector supports its theory. It shows an evidence that, unorganised sector like marine fisheries sector also follows the features of the sigmoidal shape curve. The confirmation of perfect fit of *logistics growth function* also reveals and supports the different stages of the adoption process of ICT tools by traditional fishermen in Kerala. It implies that, whatever be the category of adopters, the adoption process follows the theoretically sigmoidal shape in any manner. Study segregated the stages of adoption of ICT tools of the sector into three; early phase adopters, maturity phase adopters, and rapid phase adopters according to the degree of adoption of small-scale fishing crafts. The period 2007-2012 is considered as the *rapid growth phase* in the sector. Ernakulam coastal district of the Central zone was observed to have the fastest penetration rate of the ICT tools, due to the substantial influence of mechanised trawling boats and fast developing infrastructure facilities in the district. The slowest penetration of ICT tools was observed in Alappuzha coastal districts due to the different nature of fishing methods, gears and geographical features. Based on different perspectives and diffusion models, *epidemic rank effect* was confirmed as major adoption perspectives of adoption of ICT tools in the sector. Communication among fishermen, various government policies, and accessibility of tools are the major determining factors of adoption in the sector.

Communication among fishermen, various government policies, and accessibility of tools are the major internal and external determining factors of adoption in the Kerala marine fisheries sector. Meanwhile, size of crafts and crew, distance of fishing, age of fishermen, education, and revenue per trip are the main socio-economic factors that affect the adoption of ICT tools. It revealed that **internal, external and organisational factors** are equally responsible for the adoption of ICT tools in the fisheries sector.

The use of ICT tools helps the traditional fishermen of small-sized outboard crafts to sustain in the society and to compete with other types of fishing crafts in the community. The socio-economic status of small-scale motorised fishermen community is low compared to the state as a whole. The study found the conditions of social factors such as education, type of house, access to drinking water and electronic gadgets poor, compared to the state average. The average earnings of the motorised single day (SD) and multi-day (MD) OBM fishermen is also low and MD IBM motorised fishermen earn a better income than the former, due to their traditional skills of fishing, more distance of fishing and large size of fishing craft. The fishermen's income depends upon the seasons, even get worse in off-season months. Use of new gadgets helps the fishermen to reduce such worse condition to a certain level.

The study also showed a positive relationship between the revenue per trip of small-scale motorised crafts and adoption level of ICT tools in the sector. It means that when there is an increase in the use of ICT tools, revenue per trip also increases. This finding was achieved by comparing adoption of ICT tools and average revenue per trip of the boats. It is possible to segregate the impact of ICT tools alone with help of advanced econometrics models and methods in further research.

Finally, in many countries, the concerns over digital divide or ICT-divide is more in the poor and uneducated section of the society than wealthy or educated people. There are many avenues opening up in the fisheries sector of Kerala like free information dissemination of new techniques of production, combining traditional knowledge with innovative ICT tools and use of innovative best practices among poor and uneducated fishers. The fisheries sector focused one the effective communications and information access between advanced crafts and traditional crafts and showed a clear evidence for eradicating 'digital divide' with the aim of accelerating the positive impact of ICT tools among fishers. A huge amount of risk in using such innovated ICT tools is reduced now. Adopting policies for the effective use of ICT tools by all types of crafts can be beneficial for all stakeholders in the industry. Fisheries cooperative such as MATSYAFED and NGOs such as SIFFS contributed significantly to the development of credit facilities to reduce financial barrier for adoption. Along with this, Fishermen-Scientist-Political leaders (FSP) participatory approach for future policies and collective follow-up action of fisheries is very much important. Timely diffusion of serious information on fishing-related activities and safety of fishers are important in the marine sector. In this regard, NGOs and various Departments are an indispensable part of the effective use of new technologies and necessary for policy management decisions of 'Sustainable Fishing'. Proper usage of new advanced technologies along with restrictive policies on the physical capital inputs of fishing enhance the welfare and productivity of fish in the sector. The greater ICT-driven inclusive growth, highlighting specific policies and programs to enhance the income effects of ICTs on such marginalized populations is necessary for economic growth and development.

7.2 Policy Implications for Enrichment of Small-Scale Motorised Fishermen

Traditional small-scale fishermen are the most vulnerable section of the state. They face many problems in the society as well as in the sector. Development of new technologies in the sector has helped the fishermen to cover some social and economic problems of the society. But, to use the new technologies efficiently in a sustainable manner, certain policies are to be followed in the sector.

Increasing technological dynamism has created sustainability issues in the sector. New policies of this will help the traditional small-scale fishermen to overcome these sustainability issues. Systematic and effective use of ICT tools and use of allowed gears of fishing will reduce this issue to an extent. For this purpose, new management policies to be taken up. Recommendation of policies and its effective implementation are two important and necessary steps for the future sustainability of the fisheries sector and its allied sectors. The present study suggests some policy corrections in five categories; fishing management, increasing productivity or production, adoption of new ICT tools, and recommendations for the safety of fishermen. These issues need to be incorporated in the local development plans and policies.

Fishing management

1. Create Smart Training Centres in all the fishing villages', Smart Fishermen Cooperative Societies to train traditional fishermen in the usage of Information and Communication Technology tools.

2. Conduct workshops, seminars, and symposiums each year, under the guidance of various NGOs or fisheries research institutions for imparting the technical know-how and various skills to use technology to all the fishermen for proper handling and operating of Information and Communication Technology tools.

3. Each fishing harbour or village should be maintained with sufficient infrastructure facilities for the easy dissemination of information about fish resources, seasons,

and emergency messages instantly.

4. Present kerosene subsidies are not sufficient since it lasts only for a single trip (40 litres). The volume of kerosene should be increased to reduce the burden of income loss in fishing per trip.

5. Restrict the registration and entry of foreign vessels into the Indian maritime territories.

6. Small-scale fishermen are capable of going deep into the sea. Therefore, we can make use of experienced traditional fishermen and their traditional knowledge of the sea for an effective fish catch in the deep sea.

7. Avoid unscientific construction of the landing centres in the beach shore. It is observed that construction of unscientific landing centres is used for other purposes than fishing related activities.

8. In order to increase employment opportunities, programmes for its generation in the non-fishery sectors must be designed with the help of various religious or autonomous NGOs.

Increasing production/productivity

9. Each fishing villages or harbours should have sufficient infrastructure facilities to disseminate the Fish Potential Zone (FPZ) data to small-scale fishermen and it should be presented in an electronic display board in a local language.

10. Prediction for pelagic fish resources is to be encouraged. This can be done with the help of innovative satellite technologies and more R&D work.

11. Trawling ban system should be introduced twice a year and direct the mechanised fishermen to use traditional fishing methods during these periods.

12. Introduce fine for catching juvenile fishes by any crafts.

13. Spread awareness among the fishermen about the maximum fish size available in the Arabian and Indian sea.

Adoption of new tools

14. New communication and information tool called *Mesh-routers* can be installed in all the crafts for live communication and get accessibility of internet, even at deep-sea area.

15. Solar system for engine and lights in the crafts should be encouraged to reduce the cost to save income

16. Digitalise the fishing selling auctions and supplying procedure for reducing middlemen exploitation and getting a reasonable market price.

Safety measures

17. With the help of GPS, Vessel monitoring system should be introduced in all crafts, which helps in sustainable development of marine resources, and for monitoring the crafts in the sea.

18. Introduce unique painting for each type of crafts and introduce glazing colour which illumines at night. This will help to reduce accidents in the sea.

19. Introduce *blue ID cards* to all the active fishermen and *red ID cards* to middlemen/agents for systematic calculation of the fisher population and allied activities in the sector.

7.3 Future Scope of Work

The present theoretical and empirical study raises some important questions for further research. What remains unaddressed by the present study is to evaluate mathematically the impact of ICT tools alone with other influencing parameters of fish catch or productivity in the sector. This can be done with advanced econometrics models which will provide us with a perfect picture of the impact of ICTs in the marine fish catch.

Appendix A

APPENDIX

A.1 Selection of Sample Size

The present study used the following formulas for selecting sample size of population.

$$n_0 = (Z^2pq/e^2) \tag{A.1}$$

$$Sample\ Size(n) = \frac{n_0}{1 + \frac{(no-1)}{N}} \tag{A.2}$$

where, n_0 = sample size, N = population size, Z^2= abscissa of the normal curve that cuts of an are α at the tails (1- α equals the desired confidence level e.g., 95%) or it is z score, p = estimated portion of an attribute that is present in population and $q = 1 - p$, e = desired level of precision or error.

The study substituted the A.2 to study data as, $n_0 = \frac{1.96^2(0.5)(0.5)}{0.05^2} = 385$, where the total sample size is $(n) = \frac{n_0}{1+\frac{n_0-1}{N}} = \frac{385}{1+\frac{384}{8862}} = 370$. Thus, the minimum number of sample size to be collected is 370. N is the total number of small-scale motorised boats in Kerala.

A.2 Economic Parameters

The study used the following basic calculations for measuring the economic performance of each motorised fishing crafts.

$$GM_i = TR_i + TVC_i \tag{A.3}$$

$$TR_i = \sum_{i=1}^{n} PY \tag{A.4}$$

$$TVC_i = \sum_{i=1}^{n} PX \tag{A.5}$$

$$GMC_i = \sum_{i=1}^{n} PY - \sum_{i-j}^{n} PX \tag{A.6}$$

GM_i = gross margin of i^{th} fishing boat

TR_i = Total revenue of i^{th} fishing boat

TVC_i = Total variable cost of i^{th} fishing boat

X = quantity of inputs

P = price of inputs

Y = yield of i^{th} fishing boat

A.3 Questionnaire of the Study

The study used the following questionnaire for collecting the primary data from the fishermen of selected study areas. The questionnaire contains 89 open ended and closed ended questions, mainly segregated into six parts. Each part of the questionnaire focused on each objective of the study. Maximum two fishermen (out of six or ten) from a small-scale motorised boats were made to fill a questionnaire at a time. This is done in order to avoid bias in the results of the primary data.

Questionnaire

ICT Tools' Diffusion, Determinants, and its Economic Performance on Small-Scale Motorised Fishing Boats in Kerala: A Case Study

(The information are used only for research purpose and will be kept as secret)

1 General Information

1. Name ____________________
2. District & Village ____________________
3. Household Details

Member	Sex	Age	Religion	Marital status	Education	Occupation
1						
2						
3						
4						
5						
Codes	Female1 Male 2		Christian-1 Hindu-2 Muslims-3 Others 4	Unmarried- 1 Married- 2 Divorced- 3	Illiterate 0 Primary 1 Secondary 2 SSLC 3 Graduation 4	Fishing 1 Gulf 2 Unskilled 3 Skilled 4

4. Type of House ☐ Pucca ☐ Katcha ☐ Semi
5. Electricity ☐ Yes ☐ No
6. Do you hear radio? ☐ Yes ☐ No
7. Purpose of Radio
   ☐ News ☐ Entertainment ☐ Fishing related news ☐ Weather Information ☐ Others
8. Do you use TV ☐ Yes ☐ No
9. Purpose of TV
   ☐ News ☐ Entertainment ☐ Fishing related news ☐ Weather Information ☐ Others
10. Do you use Computer? ☐ Yes ☐ No
11. Purpose of Computer
    ☐ Watching movies ☐ Watching new fishing technology use ☐ Watching training programme ☐ Others
12. Do you use Computer with internet facilities? ☐ Yes ☐ No
13. if yes, Purpose?
    ☐ Updating fish price ☐ Updating fishing seasons ☐ Updating new technology ☐ Entertainment
14. Pls fill in the given coloumn

Types of gear	Types of craft	Owned/ Leased	Year of purchase	Size (in ft)	Total labours	Cost of c,g &e	HP of engine	Life expectancy
Motorised(IBM)	Trawler							
	Gillnetter & Liners							
	Others if any							
Motorised (OBM)	Plywood boat							
	Fibre glass boat							
	Others							

15. Is your crafts old? ☐ Yes ☐ No
16. If old, how many years old? ☐ 1-3 ☐ 4-6 ☐ 7-9 ☐ 10-12 ☐ >12

2 Profile of ICT tools

17. Pls fill in the given coloumn

Tools	Year of purchase	Purchased Cost	Company	Times of usage (in hrs/day)	Usage rank	Distance of usage(nml)	No. of tools	Reason if not using
Mobile Phone								
GPS								
Echo-sounder								
Wireless set								
Radar								
Beacon								
Others (sp.)								

3 Details of Crafts and ICT tools

18. From where did you buy the vessel?
☐ From SIFFS boat yards ☐ Pvt. Boat yards ☐ Matsysafed boat yards

19. Do your village have Fishermen Co-operative Societies? ☐ Yes ☐ No

20. Does the Fishermen Co-operative Society help you in fishing? ☐ Yes ☐ No

21. If yes, in what ways?
☐ Give loan ☐ Give training of new technology ☐ Give awareness of fishing ☐ Helps for proper selling of fish

22. Does the Fishermen Co-operative Society help you in buying GPS, Echo, wireless & mobile?
☐ Yes ☐ No

23. If yes, in what ways?
☐ Give loan for buying ☐ Give training to use these tools ☐ Give awareness of new tools ☐ Send PFZ data

24. Do you get any help from the Matsyafed/Fishermen Co-operative Society to buy the vessel?
☐ Yes ☐ No

25. If yes, what ways?
☐ Subsidies for new boat ☐ Incentives for new technology ☐ Loan ☐ others

26. Does your or village get any help from Panchayat/municipality/corporation in fishing activities?
☐ Yes ☐ No

27. If yes, in what ways?
☐ Fishing landing centers ☐ Maintain harbours ☐ Financial help ☐Others

28. Did you work in trawling or mechanised boats ☐ Yes ☐ No

29. If yes, how many years?
☐ < 1 ☐ 1-5 ☐ 6-10 ☐ 11-15 ☐ > 15

30. From where do you get the information about ICT tools(pls tick appropetly)?

Reasons	GPS	Echo-sounder	Wireless set	Beacon	Mobile phone	Total
Advertisement						
SIFFS/CMFRI/CIFT etc.						
NGOs						
Govt						
Friends/relatives						

31. Reason for using these ICT tools (pls tick appropetly)

Reasons	GPS	Echo-sounder	Wireless set	Beacon	Mobile phone	Total
More advatange						
Saves money						
Easy to use						
Less cost						
Less repair						

32. From where do you purchase the equipments?
☐ Govt. Dept ☐ NGO ☐ Pvt.Shop ☐ Rent

33. Have you work in trawling boat after 1990s? ☐ Yes ☐ No

34. If yes, how many years?
☐ $<$ 1 ☐ 1-2 ☐ 3-4 ☐ 5-6 ☐ 7-8 ☐ $>$ 8

35. Do trawling boats influence you to adopt any ICT tools in fishing? ☐ Yes ☐ No

36. If yes, which ICT tools
☐ GPS ☐ Echo-sounder ☐ Wireless sets ☐ Mobile phone ☐ Beacon

37. How?
☐ Saw the ICT tools in TB ☐ Friend from TB told ☐ Worked in TB ☐Others

38. Do you think that there is enough infrastructure facilities for giving proper information regarding fishing?
☐ Yes ☐ No

39. How do you come to know of the emergency messages during fishing?
☐ Through mobile through GPS ☐ Through wireless ☐ Through direct contact ☐ Other(specify)

40. From whom do you come to know of the emergency messages during fishing?
☐ Through Friends ☐ Through coastal navy ☐ Through fisheries officers ☐ Other(specify)

41. Did you get any seminar/training/workshop regarding usage of ICT tools? ☐ Yes ☐ No

42. If yes, how
☐ Weekly ☐ Monthly ☐ Yearly

43. Do you think that the present new ICT tools are more advantageous than radio, news paper & TV?
☐ Yes ☐ No

44. If yes, why
☐ Ease to access ☐ Spot information ☐ Saves life ☐ Saves money ☐ Others (specify)

45. Satisfaction with present ICT tools?
☐ Satisfied ☐ More satisfied ☐ Less satisfaction

46. Do your social culture harms to adopt ICT tools? ☐ Yes ☐ No

47. Do you feel difficulty to use ICT tools? ☐ Yes ☐ No

48. If yes, which one?
☐ GPS ☐ Echo-sounders ☐ Mobile phone ☐ Beacon ☐ Wireless set

4 Productivity profile

49. You are working as
☐ Technical operator ☐ Manual labour ☐ Food preparing ☐ Others

50. How many years of fishing experience you have?
☐ $<$ 1 ☐ 1-5 ☐ 6-10 ☐11-15 ☐ 16-20 ☐21-25 ☐$>$ 25

51. How much nautical mile distance you use to fishing?
☐ 50-100 ☐ 100-150 ☐ 150-200 ☐ 200-250 ☐ 250-300 ☐ $>$ 300

52. How many days you spend for fishing per trip?
☐ 1-5 ☐ 5-10 ☐ 10-15 ☐15-20 ☐20-25 $>$ 25

53. Type of fish you got on your last trip

Fish type	Price/kg	Total kg
Sharks		
Oilsardine		
Other sardine		
Anchovies		
Perches		
Ribbon fish		
Croakers		
Mackerel		
Sheer fish		
Tunnies		
Paneaid prawns		
Others		
Total		

54. How much diesel is used in a trip (in litre)?
☐ 500-1000 ☐ 1000-1500 ☐ 1500-2000 ☐ 2500-3000 ☐ > 3000

55. How much Petrol is used in a trip (in litre)?
☐ <50 ☐ 511-100 ☐ 101-150 ☐151-200 ☐201-250 ☐> 250

56. From where do you buy diesel?
☐ Coastal bunk ☐ Pvt.bunk ☐ Other

57. How much kerosene is used in a trip (in litre)?
☐ 50-150 ☐ 150-200 ☐ 250-300

58. From where do you buy kerosene?
☐ Pvt. agents ☐ Ration shop ☐ Relatives/friends ☐ Operative societies

59. Where did you go for fishing last year?
☐ Own coastal village ☐ Other state ☐ Other country

60. What are the seasonal months?
☐ Quarter I ☐ Quarter II ☐ Quarter III ☐ Quarter IV

61. How do you sell your fish?
☐ Local market ☐ Agent Market ☐ E-Auction ☐ Other

62. Which instrument is most useful for selling your fish?
☐ Mobile phone ☐ GPS ☐ Echo-sounder ☐ Wireless set

63. Give details (per trip) of fish catch ____________

Fishing cost	Rs/-
Bata	
Fuel cost	
Ice cost	
Fish meat cost	
Mobile charge cost	
Maintenance cost	
Auction charge	
Food cost	
Others	
Total Revenue	

64. Do you have any other sources of income during the time of trawl ban? ☐ Yes ☐ No

65. If yes, specify?
☐ Penson ☐ PDS subsidies ☐ Traditional fishing ☐ Non-fishing work (specify)

66. Does your children help you with fish business? ☐ Yes ☐ No

67. If yes, specify?
☐ Fishing ☐ Pass the information regarding fishing ☐ Helping to sell in right place ☐ Other

68. Do you face any problem during fishing? ☐ Yes ☐ No

69. If yes, specify?
☐ Attack of foreign vessel ☐ ICT tool repairs ☐ Net loss ☐ Technical error ☐ All

70. Have you ever asked for any help from the authority at emergencies during fishing?
☐ Yes ☐ No

71. If yes, from where?
☐ Indian coast guard ☐ State Fisheries Dept. ☐ Fishermen Co-operative Societies

72. Did you get any life saving help from the authority? ☐ Yes ☐ No

73. If yes, what help you get?
☐ Direct help ☐ Communication help ☐ Third party help ☐ Others

74. Do you have any idea of the daily international market price of fish? ☐ Yes ☐ No

75. If yes, how?
☐ Friends ☐ News through media ☐ Agents ☐ Fish vendors ☐ Others

76. Are you satisfied with the present market price of fish? ☐ Yes ☐ No

77. If no, why?
☐ Middle men exploitation ☐ Collusion ☐ Obligations

78. By using GPS how much money do you save in a trip?
☐ 500-1000 ☐ 1000-1500 ☐ 1500-2000 ☐2000-2500 ☐ 2500-3000 ☐>3000

5 Economic Status

79. Pls fill in the column given below

Sl.No.	Items	In Rs/-
1	Avg income/month	
2	Avg saving/month	
3	Avg spending/month Domestic purpose Entertainment Fishing Purposes Other	

80. Where do you deposit?
☐ Pvt chit ☐ Govt. chit ☐ Commercial bank ☐ Co-operative bank ☐ Post Office

81. Do you have any debt? ☐ Yes ☐ No

82. If yes, sources of debt
☐ Commercial bank ☐ Money lender ☐ Friends / Relatives ☐ Co-operative Bank ☐ Fisheries co-operative societies ☐ Private chit

83. What is the reason of debt??
☐ Marriage ☐ Interest payment ☐ Loan payment ☐ Get employment ☐ Purchased boats/nets
☐ Other

84. How long you have been a debtor (in Year)?
☐ < 1 ☐ 1-5 ☐ 6-10 ☐11-15 ☐16-20 ☐> 20

85. Do you own land ☐ Yes ☐ No

86. If yes, how much?
☐ 1-5 ☐ 6-10 ☐ 11-15 ☐16-20 ☐>20

87. How did you acquire the land?
☐ Earned money ☐ Bank loan ☐ Debt from others ☐ Inherited ☐ Others

6 Determinants of Adoption of ICT tools

88. Pls fill in the following coloumn

Features	SD	D	PA	A	SA
Communication	☐	☐	☐	☐	☐
Friends	☐	☐	☐	☐	☐
Relatives	☐	☐	☐	☐	☐
Co-workers	☐	☐	☐	☐	☐
Auctioneers	☐	☐	☐	☐	☐
Government	☐	☐	☐	☐	☐
Fisheries cooperative society	☐	☐	☐	☐	☐
Panchayat	☐	☐	☐	☐	☐
Central govt. programme	☐	☐	☐	☐	☐
Media	☐	☐	☐	☐	☐
Radio	☐	☐	☐	☐	☐
TV	☐	☐	☐	☐	☐
Newspaper	☐	☐	☐	☐	☐
Internet	☐	☐	☐	☐	☐
Institution	☐	☐	☐	☐	☐
Research institutions	☐	☐	☐	☐	☐
Infrastructure facilities	☐	☐	☐	☐	☐
NGOs	☐	☐	☐	☐	☐
Agents	☐	☐	☐	☐	☐
Shop Keeper	☐	☐	☐	☐	☐
Shop Owner	☐	☐	☐	☐	☐
Middle men	☐	☐	☐	☐	☐
Relative advantage	☐	☐	☐	☐	☐
More benefits	☐	☐	☐	☐	☐
Easy structure	☐	☐	☐	☐	☐
Cost effective	☐	☐	☐	☐	☐
Less cost	☐	☐	☐	☐	☐
High performance	☐	☐	☐	☐	☐
Increase efficiency	☐	☐	☐	☐	☐

Features	SD	D	PA	A	SA
Easily accessible	☐	☐	☐	☐	☐
User friendly	☐	☐	☐	☐	☐
Less repair	☐	☐	☐	☐	☐
Demonstration effect	☐	☐	☐	☐	☐
Observing	☐	☐	☐	☐	☐
Use after trial	☐	☐	☐	☐	☐
Less repair	☐	☐	☐	☐	☐
Because others use	☐	☐	☐	☐	☐

89. Further relevant information regarding above topic, if any

____

____

____

____

____

Thank You

Date........................
Mob.No...................

Checklist for FGD

1. General information about the locality
2. The enquirer may take note of the general profile of the fishermen on the socio-economic and cultural status
3. Details of crafts
4. Technology development before ICTs
5. Use of ICT tools (mobile phone, GPS, echo-sounder, wireless sets etc) for fishing
6. Detailed information about the year of adoption of such tools in the sector
7. The agencies/persons/ institutions through which the fishermen were made aware of the tools
8. Internal factors (ease of use, relative advantage, less price etc.) that influenced the adoption.
9. Cost of trip
10. The process of selling fish and share of revenue
11. Seasons of fishing
12. Landing details
13. Migration of fishermen
14. Benefits of each ICT tools
15. The difficulty of using ICT tools
16. Difficulty in fishing and problems in the sea
17. Level of satisfaction
18. Debt and reasons
19. Awareness about the Law of the Sea
20. Any suggestions to improve fishing related activities

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List of Publications

Published Papers

1. **Sabu, M.** & Shaijumon, C. S.(2014). Socio-economic Impact of Information and Communication Technology: A Case Study of Kerala Marine Fisheries Sector. **International Journal of Information Dissemination and Technology**, 4(2), 124-129.

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