USER CENTERED DESIGN, DEVELOPMENT, AND END-USER ASSESSMENT OF AN M-TOOL FOR VEGETABLE CULTIVATION IN POLYHOUSE

by

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(2017 - 21 - 001)

DEPARTMENT OF AGRICULTURAL EXTENSION

COLLEGE OF AGRICULTURE

VELLANIKKARA, THRISSUR - 680 656

KERALA, INDIA

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THESIS

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DECLARATION

I, hereby declare that this thesis entitled **"USER CENTERED DESIGN, DEVELOPMENT, AND END-USER ASSESSMENT OF AN M-TOOL FOR VEGETABLE CULTIVATION IN POLYHOUSE"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Vellanikkara
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CERTIFICATE

Certified that this thesis entitled **"USER CENTERED DESIGN, DEVELOPMENT, AND END-USER ASSESSMENT OF AN M-TOOL FOR VEGETABLE CULTIVATION IN POLYHOUSE"** is a bonafide record of research work done independently by Ms. Poornima C P under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PHOTOPLATES

LIST OF APPENDICES

Introduction

CHAPTER 1

INTRODUCTION

With its associated industries, agriculture is indisputably India's primary source of income for around 58 per cent of the population, particularly in the country's vast rural areas (Jain and Srivasthava, 2021). It also contributes significantly to the Gross Domestic Product (GDP) (Govt. of India, 2021). Though India is the second-largest producer of vegetables globally, the sector confronts new problems in meeting rising food demand, remaining internationally competitive, and producing high-quality agricultural goods. Agriculture requires a constant and sustainable rise in productivity and efficiency at all production levels and the cautious and efficient use of water, energy, fertilisers, *etc*., to meet these problems (Naresh *et al*., 2020).

Unlike other sectors, farming depends highly on climatic factors, and hence the profit and yield are largely unpredictable. In India, vegetable cultivation practices are restricted chiefly to local and seasonal requirements. The technology and techniques are primarily traditional, resulting in low yields and varying quality. The factors such as erratic climatic conditions, glut in yield in the favourable season, small and scattered land holdings, and increased demand for quality vegetables in the offseason force many farmers to adopt protected cultivation in polyhouses (Ghanghas, 2019).

With technological innovations like hi-tech farming, a proper information transfer mechanism must be developed to make the farmers aware and well informed of the advances in crop production. The rapid diffusion of information from the Agricultural Research System to the farmers and reporting of farmers' responses to the research system have to be crucial fuels for agricultural technology improvisation and its effective delivery (Shanthy, 2011). The role and importance of ICT (Information and Communication Technologies) becomes evidently crucial in these situations. Extension agencies can provide agriculture data required to farmers using modern ICT devices such as mobile phones and conventional methods such as print media, radio, and television (Bolarinwa and Oyeyinka, 2011).

Information and communication technology tools such as mobile phones, computers, social media *etc.*, are hailed as digital platforms which can revolutionise the farming sector (Santosham and Lindsey, 2015; World Bank, 2018).

ICT in Agriculture

Information and communication technology (ICT), frequently used as a synonym for information technology (IT), is defined as a varied set of technological tools and resources used to generate, disseminate, store, and manage information (World Bank, 2011). The term ICT was first coined by Lord Stevenson in the year 1997 (O'Mahony, 2003). It is a phrase now used to describe a wide range of services, applications, and technologies that employ various types of equipment and software and are frequently delivered over a telecommunications network (Raghuprasad *et al.*, 2013). It covers a vast range of technologies, from radio to television, and telephone to mobile phones. Today, multimedia, the internet, and satellite-based communication systems are taking over ICTs.

In agriculture, ICTs are not only restricted to research and development; but also, for extension activities. They have had a considerable impact on the economic development of countries such as India. One of the most significant benefits of adopting ICT tools for farm communication is its increased efficiency in recent years (Tomar *et al.*, 2016).

India has not trailed behind in the use of ICT to give farmers the information they require. In 1971, the Jute Corporation of India (Quasi sector) designed a Financial Accounting Information System that covered seven states, including Andhra Pradesh, Assam, Bihar, Meghalaya, Odisha, Tripura, and West Bengal. Later, several programmes such as the Information Village Centre, the Gyandoot Project, e-Choupal, e-grama, and others came up (Das and Sangma, 2019). The application of ICT in agriculture surpassed many phases and reached a position where decision making is possible through IoT (Internet of Things), AI (Artificial Intelligence), *etc*.

Kerala Agricultural University has made notable contributions in developing ICTs for supporting farming communities. The KAU-Agri-infotech portal developed by the Centre for e-Learning, Kerala Agricultural University, provides information and advisory services on agriculture, animal husbandry, fisheries, and allied aspects. FEM@Mobile - a mobile app developed by Kerala Agricultural University, is one of the most popular and informative ICT tools among the farmers in Kerala, covering detailed information on 100 crops cultivated in Kerala. Apart from these, the University provides services through many e-learning platforms such as e-Krishi Padashala, KAU MOOCs, e-Karshaka Jaalakam, KAU moodle *etc.*, to name a few.

ICTs have created significant prospects for the development of rural people, particularly in social and economic activities, throughout the previous few decades, with some technologies excelling over others. Mobile telephony is a popular technology that has experienced rapid expansion in recent years (Pliakoura *et al.*, 2018). Mobile phones have drastically lowered the cost of communication and information for rural residents. This technology opened up new avenues for rural farmers to gain knowledge and skills. (Chhachhar and Hassan, 2013). Similarly, ICTs in agricultural extension services, particularly mobile phone services, provided information on the market, weather, transportation, and farming techniques, and the ability to communicate with concerned agencies and departments. (Aker, 2011).

Mobile phones and mobile apps in agriculture

In developing nations, the rise of mobile communication technology offers a slew of new prospects for social empowerment at the grassroot level. The introduction of mobile phones has led the way to develop new services and applications in the farming sector for the benefit of farmers and other stakeholders. Services initiated with occasional short messages have advanced to the multimodal and multimedia transfer of information and later to m-agriculture applications for smartphones. Mobile applications are software/sets of programmes that run on a mobile device and help users with certain activities.

In the past few decades, the availability of smartphones at affordable prices, wireless and cheaper data connections, and consumer preferences led to considerable penetration of mobile phones among the rural community (World Bank, 2012). These factors exposed the vast potential of mobile phones to revolutionise information communication among farmers, enhancing their decision-making ability. Studies reveal that mobile phones positively impact sustainable farming, poverty reduction (Bhavnani *et al.*, 2008). The introduction of mobile phone-based technologies could reduce human intervention in the farming sector and enhance the efficiency and accuracy of the service provided (Aker, 2011).

The other significant advantages of mobile apps include the ease of accessing the information at their fingertips by storing a large amount of information related to farm activities such as pest and diseases data, the package of practices, post-harvest practices, *etc*. Two-way communications were made possible through different mobile apps, making the agricultural information exchange a dynamic process. The information generated, stored, and spread was accurate, timely and need-based. With the advent of mobile apps, the farmers could keep up their knowledge with trends, and real-time information exchange is also possible. These applications assist in delivering market information, facilitating market linkages, providing access to extension services and farm-related information (MANAGE, 2017).

The Indian government has created various free web-based and mobile-based applications to disseminate information on agriculture-related activities to benefit farmers and other stakeholders. There are apps developed by agricultural institutions, the private sector, and Non-Governmental Organisations. These applications broadcast information to farmers and other stakeholders and facilitate exchanging information among stakeholders from agricultural research and extension processes. Kisan Suvidha, Pusa Krishi, Soil Health Card Mobile App, Crop Insurance, Bhuvan hailstorm app, e-NAM Mobile App *etc.*, are such apps developed by the Ministry of Agriculture and Farmers Welfare, Govt. of India. IFFCO Kisan agriculture by Indian Farmers' Fertilizer Cooperative Ltd., Farm Extension Manager (FEM) by Kerala Agricultural University, Krishi Vigyan by Krishi Vigyan Kendra, Amadalavasala, AP, Havaamana Krishi by University of Agricultural Sciences, Dharwad, *etc*. are some of the popular mobile applications among farmers in India.

Though mobile apps have their positive side, there are some limitations as well. With the diversity in languages in India, it is nearly impossible to provide information through a single language. Lack of communication in the vernacular can considerably reduce the acceptability and popularity, even though the quality of the information provided is of the required standard (Cantor, 2009). Due to network issues and the speed of the data transfer, getting updated and complete information is a constraint in many areas of the country (Kirk *et al.*, 2011). Knowledge and skill barriers hamper mobile-based tools, especially illiterate farmers (Baumuller, 2012). At least section of the farmers in a developing nation like India find it difficult to afford mobile phones and the internet and hesitate to adopt the technology due to socio-cultural and infrastructural barriers (World Bank, 2011).

While designing a tool, especially for knowledge upscaling, should address various pedagogical problems concerning the end-users. Once suitably developed, it would serve as an efficient technology transfer mechanism.

Vegetable cultivation in polyhouse

Seasonality is one of the essential quirks of agricultural production. Although agrarian goods are produced only for a limited period, the demand is constant throughout the year. The price dynamics of agricultural production show that farmers face significant price risk for their output over the season. Superior and feasible crop production technologies should be prioritised to mitigate this risk. Protected cultivation under polyhouse is a strategy that helps farmers by providing crops during the off-season (Jain, 2021). Apart from these problems, the technology should also be capable of addressing constraints such as shrinking of cultivable land and urbanisation. This issue also can be solved by switching to polyhouse farming.

Polyhouse farming is an alternate new crop production system that reduces its dependency on natural factors such as rainfall, temperature, humidity, and other geographical conditions. It also uses resources like water, fertilisers, and other inputs necessary for farming most economically (Bhandralia *et al.*, 2016). The hi-tech farming method has proved to improve the productivity of crops qualitatively and quantitatively by several manifolds (Hena, 2017).

Kerala State Horticulture Mission had given sanction for 1,115 polyhouses in the state under the National Horticulture Mission programme, a Central Government-sponsored scheme from 2005-2006 with subsidies covering up to 75 per cent of the initial cost of the unit (Kerala State Planning Board, 2016). The project aims to deal with problems such as climatic change, production decline, scattered land holdings, *etc*. Polyhouse vegetable cultivation in Kerala is highly focused on two vegetables, initially - salad cucumber and yard-long beans. Vegetables from poly-house farmers were procured jointly and sold through the State Horticulture Mission, Kerala. Later, farmers adopted the cultivation of different crops, which included exotic and high valued vegetables also (Kumar, 2018).

Besides other benefits polyhouses utilise vertical and horizontal spaces for cultivation, increase harvest frequency, promote early yield, provide disease-free and high-quality seedlings, and facilitate multiple cropping. Like any other practice, polyhouse cultivation has certain limitations too. High initial cost, rapid spread of pests and diseases if not adequately controlled, difficulty in hand pollination for certain crops, difficulty in maintaining and repairing the structure are some of the problems (Reddy, 2016; Ghanghas, 2018; Hena, 2017).

Studies showed that polyhouse cultivation could revolutionise the farming system in India, thereby enhancing farm income and sequentially ensuring the livelihood security of farmers. However, it is also evident that the adoption of this practice is limited due to some barriers (Maheshwari *et al.*, 2008; Prabhakar *et al.*, 2017; Kumar *et al.*, 2017).

Earlier, many researchers attempted to study the profile characteristics, information needs, training needs, ICT, and mobile usage, and they have extensively explored these concerning conventional farming methods. But relatively few studies are based on hi-tech farming, especially polyhouse farming, which is considered a progressive crop cultivation method in Kerala.

Disseminating information to farming communities are made easier with the introduction of mobile-based technologies in the agriculture sector. Today, various organisations design and release mobile apps to upgrade knowledge and fill the information gap between researchers and farmers. But mobile apps designed specifically for polyhouse cultivation is not available in India. Mobile phone based ICT tools are a necessity during present-day to give support and easy accessibility to farmers.

In this study an attempt has been made to analyse the ICT utilisation and m-readiness of the polyhouse farmers along with their information needs and training needs. Based on the vegetable crop-wise information needs of the polyhouse farmers, a user centred mobile app for polyhouse vegetable cultivation was also made.

Objectives of the study

- To analyse the ICT utilisation of polyhouse farmers in Kerala
- To analyse the m-readiness of polyhouse farmers
- To analyse factors affecting the m- readiness of polyhouse farmers
- To assess the vegetable-wise information needs of polyhouse farmers
- To assess the training needs of polyhouse farmers
- To develop an m-tool for vegetable cultivation under polyhouse
- To conduct an end-user assessment of the developed m-tool
- To analyse the constraints faced by the farmers regarding cultivation of vegetables in polyhouse

Scope of the study

As we are moving through an advanced technological era, it is necessary to upkeep the societies to a high-tech one. To trace their footsteps and to promote their way towards modern technologies of high-tech agriculture, there is a need to find the gap. The assessment of training needs will be helpful to bridge this gap by conducting training programmes as per the needs of the farmers. Assessment of information needs, constraints, and analysis of other variables would help to identify the problems and prospects of polyhouse cultivation thereby helping the authorities and policymakers to design suitable strategies for promoting polyhouse cultivation. As there has been no study regarding the assessment of m-readiness of farmers in Kerala, the present study will be of great use to the stakeholders. New mobile-centred ICT tools are a necessity of the present day in order to provide support and easy accessibility to farmers. Thus, the study has immense practical utility. The outcome of the study implies a significant role in promoting protected cultivation in Kerala by upgrading the knowledge and skill of farmers.

Limitations of the study

The study faced with the following limitations

- Difficulties in conducting exhaustive interviews due to the COVID-19 pandemic situation.
- Only four commonly cultivated vegetable crops could be included in the developed m-app due to time and resource constraints.
- The results are based on the expressed responses of farmers, which may not be free from bias or prejudice of the farmers.
- The study had confronted with other limitations such as cost, technology resources, and time.

However, a deliberate and focused effort was made to carry out the study in a comprehensive and exploratory manner without any bias, to derive the findings with high academic and practical utility

Presentation of the study

The study is presented in five sections, each one designated as a chapter. The first chapter includes an introduction to the topic, the objectives, scope, and limitations of the study. In the second chapter, 'review of the literature', previous studies related to the current research are reviewed, and the findings are enlisted. The next chapter deals with the research methodology, *i.e.*, sampling, research design, variables used, and statistical tools adopted to obtain the results are briefly described. The fourth chapter, ' results and discussion', gives a comprehensive idea about the salient findings of the study. The fifth chapter of the thesis put forth the ‘summary and conclusion’ drawn from the study, followed by the bibliography.

Review of Literature

CHAPTER 2
REVIEW OF LITERATURE

There should be a clear understanding of the research problem to be undertaken and a conceptual framework should be planned before the commencement of any research. For this purpose, it was felt necessary to review and study how difficult researchers conducted, analysed, inferred, and presented their studies previously. These literatures paved a path for the present study and helped the researcher to develop a proper methodology to take up the research. Most relevant and recent literature have been cited from available scientific sources related to present research. The literatures reviewed for the study have been presented under the following headings:

2.1. Profile of farmers

2.2. ICT utilisation of the farmers

2.3. m-Readiness of the farmers

2.4. Factors affecting m-readiness and ICT utilisation of farmers

2.5. Constraints in the use of ICTs in agriculture

2.6. Cultivation under polyhouse

2.7. Information needs of polyhouse farmers

2.8. Training needs of polyhouse farmers

2.9. Constraints faced by polyhouse farmers

2.10. Designing m-tools in agriculture

2.11. End-user assessment of the developed m-tool

2.1. Profile of the farmers

Singh and Singh (2018) reported in their study among farmers using mobile phones that, majority (53.50 %) of the farmers belonged to the category of 35-50 years, followed by those with less than 35 years (34.00 %). A smaller number of farmers were above 50 years (12.5%). The data regarding distribution of farmers according to their achievement motivation indicated that 17.50 per cent farmers had low level of achievement motivation. The farmers with high achievement motivation were around 18 per cent. As high as 63.50 per cent farmers were in the category of medium achievement motivation.

Demographic profile of the respondents showed that 34.40 per cent and 33.30 per cent farmers belonged to the age group of 25 to 35 and 36 to 45 years respectively. As few as, 10.90 per cent farmers were below 25 years and nearly one fifth of the respondents (21.9) were above 45 years. The farming experience in the study was categorised in to four groups *viz.*, 1–5 years, 6–10 years, 11–15 years, above 15 years. Most of the farmers belonged to the third category with a farming experience of 11 to 15 years (33.33 %) and those who had very less experience were few in number (12.00 %). While change resistance was considered, young and educated farmers tend to adopt an innovation without much resistance. (Aldosari *et al.*, 2019)

The age of the farmers ranged from 28 to 65 years, with an average age of 40.43 years. It was found that a decent number of farmers (33.6 %) were young, and more than half (54.60 %) of them were found to be middle aged and 11.4 per cent of respondents belonged to old aged category. All the respondents were small holder farmers with a farm size less than one hectare and an average size of 0.48 hectare. (Hasan *et al.*,2019)

2.2. ICT utilisation of farmers

Syiem and Raj (2015) analysed the usage of ICTs by the farmers. The results revealed that mobile phone was the most frequently (71.60 %) used ICT tool followed by television (50.00 %) and Radio (38.3 %). YouTube (5.83 %) and Computer (1.66 %) were the least used information gathering tools among the respondents. Farmers used ICTs mainly for checking availability of inputs (Mobile -27.49 %; TV - 34.06 %; Radio - 18.29 %), Quality of inputs (Mobile -35.00 %; TV - 6.83 %; Radio - 10.00 %), Market price of inputs (Mobile - 9.12 %; Internet - 5.16 %), and Marketing of produce (Mobile - 45.00 %)

John and Barclay (2017) studied ICT utilization and effects among rural farming community. The detailed analysis of the various factors affecting ICT utilisation indicated that there was a positive correlation between amount of consumed farm related information and extent of phone usage (r = 0.20), extent of television viewing (0.24), extent of radio usage (0.19) and extent of internet usage (0.207). Structural equation model developed was found to be statistically fit with very high regression values.

A study conducted by Asif *et al.* (2017) for assessing the factors affecting the use of mobile phones by farmers, certain findings have been made. Seventy per cent of the farmers used mobile phones very less and 30 per cent of them moderately used it, whereas none of them belonged to the high category. The study concluded that the use of mobile phones for gathering agricultural information gathering was very low in the study area. The multiple regression analysis of the data showed that the age and social participation of the respondents had significant effect on the use of mobile phones.

Matto (2018) has drawn certain findings in his study regarding the use of ICTs for accessing information in agriculture. Out of all the respondents only five percent of respondents use their mobile phones to communicate with extension agencies or any other sources to collect information related to agriculture. Among ICTs, radio is leading in terms of usage as it is used very often by 37.50 per cent farmers. Twenty percent of the respondents have either frequently or rarely used TV, whereas less only than 10 per cent of the respondents know the use of mobile phones.

Some observations were made by Deepika *et al.* (2020) on the knowledge and use of ICTs in agriculture and allied sectors. Television was the most common ICT tool used by the farmers in which 97 per cent of then are frequent users. All the respondents used mobile phones, out of which 40 per cent of them had a mobile phone with internet connection. Out of 50 per cent radio users, only nine percent used it in a regular basis. Seventeen per cent of the sample respondents owned a computer or laptop in their family. But none of them had a laptop with internet connection. Only two per cent of the respondents used service providers or kiosks for their needs.

2.3. m-Readiness of farmers

O' Malley *et al.* (2005) defined mobile learning as any kind of learning that occurs when consuming, interacting with generating information, facilitated through a compact digital portable device that the individual carries on a regular basis, has reliable connectivity and fits in a pocket or purse.

Agwu *et al.* (2008) in the study undertaken at Nigeria, revealed that 43.30 per cent respondent farmers had medium or high level of knowledge of ICTs while only 41 percent had awareness about various ICT tools.

Islam and Gronlund (2011) found out that facilitating conditions, tech-service attributes, tech-service promotion, social influence, demographic factors, individual characteristics, perceived usefulness, perceived ease of use and behavioral intensions are the factors influencing the use of mobile phones among farmers in Bangladesh

Chhachhar and Hassan (2013) told that mobile phones play a vital role in the developing countries for the enhancement of farmers' income through proper connectivity to markets, easy, quick and suitable way to communicate and get appropriate answers of respective problems.

. Kale *et al.* (2015) defined m-Agriculture as the dissemination of agriculture related information and services through mobile communications technology, in particular mobile phones, smartphones, and tablet devices

Asif *et al.* (2017) revealed that lack of mobile servicing centres, high cost of mobiles and unavailability of electricity are the major factors which pull back farmers from the use of mobile phones. They also suggested the Government to provide ample infra structure in rural areas to promote the use of ICTs and the extension workers to encourage them by giving awareness and expertise in using mobile phones for information gathering among farmers cultivating vegetables.

Economic intelligence unit's (EIU) (2017) ranking of technological readiness for the period 2013-2017 indicated that Finland ranked first among all countries and Libya the least; while India's ranking was 47. At the same time their forecast for the next six years predicted that Australia will be the most e-ready nation at the end of 2022 and India's rank will be 42 at the same time.

Kailash *et al.* (2017) identified that the poor connectivity, economic instability, high-cost internet services and lack of updated information were some of the reasons behind the reduced used of mobiles among farmers in India.

Kumar *et al.* (2017) studied the impact of mobile based advisory services among farmers. Data about mobile usage pattern indicated that 73 per cent of the respondents used simple phones and the rest of the respondents had smart phones. Among the sample only 11 per cent of farmers were using mobile phones for agricultural purposes, whereas 10.34 per cent utilised the phone for e-marketing. Twelve percent of them used it for contacting extension personnel.

Bhagyalakshmi *et al.* (2018) mentioned that majority of the respondents had medium accessibility towards the use of Information and Communication Technology tools in agricultural information dissemination (55.60 %) followed by low (24.60 %) and high (19.80 %).

Koyu *et al.* (2018) defined e-readiness as a physical, literacy and motivational readiness of farmers to use ICTs in the agricultural information system. In the study, individual e-readiness were categorised in to five dimensions namely; availability at personal level, elementary ICT expertise, internet expertise, software literacy expertise and motivational dynamics. The mean scores of the dimensions were 17.33, 14, 17, 40, 63.75 respectively. The higher motivation level and lower expertise level indicates that there was a dire need to give the farmers proper training on the usage of ICTs.

Pandey *et al.* (2018) stated that telecommunication facilities, especially mobile phones had the ability to provide an answer to the present scenario of information asymmetry in sectors like agriculture and bridge the gap between researchers and farmers.

Vankudothu *et al.* (2018) constructed a composite index to measure the level of e-readiness of the farmers comprising of six indicators namely e-awareness, e-skill, e-ownership, e-accessibility, e-frequency of use and e-willingness.

2.4. Factors affecting m-readiness and ICT utilisation of farmers

Falola and Adewumi (2012) delineated factors affecting mobile telephony among farmers for agricultural purposes. The analysis of data indicated that age, farm income, household size, association and education are significantly related to mobile telephony where all variables associated positively except age.

Syiem and Raj (2015) conducted a study to assess the tribal farmers' access and usage of ICTs for agricultural purposes. They examined the socio-demographic factors and their association with usage of ICTs. The results indicated that variables such as age education, cosmopoliteness, social participation and attitude towards ICTs were significantly associated with usage of ICTs at one per cent level of significance and annual income at five per cent level of significance.

Kafura *et al.* (2016) conducted correlation analysis to find out the factors affecting the extent of ICT utilisation among farmers. The results revealed that age, education, farming experience, annual income, innovativenes and cosmopoliteness at one percent level of significance.

Aldosari *et al.* (2019) through *Chi*-square analysis, concluded that the personal attributes such as age and education have significant association with the ICT usage, with special reference to radio and television usage among farmers. It was further explained that the relation of ICT usage with age was having a negative pattern and with education it showed a positive relation. It can be inferred that youth tends to gather more information using modern technologies whereas aged farmers tend to collect information personally. The author suggested to educate farmers so that adoption of modern technologies will be made possible which eventually helps flourish agriculture sector.

The correlation analysis was performed by Naik *et al.* (2020) to find out the factors affecting attitude towards ICT usage among farmers. It was reflected in the study that education, land holding, experience in farming, experience in usage of ICT tools, possession of ICT tools, annual income, training undergone, social participation, extension contact, innovativeness, economic orientation, risk orientation, scientific orientation, cosmopoliteness are significantly correlated with attitude towards ICTs.

2.5. Constraints in the use of ICTs in Agriculture

According to Agwu (2008) out of the twenty possible constraints listed in the study, eight constraints found to be important. According to the mean scores (x) the most important to least important constraints were lack of internet access in the rural area, erratic power supply, poor finance, poor communication network, high cost of ICTs hard ware, lack of sufficient trained computer personnel, high cost of ICTs software and lack of communication infrastructure on which ICTs depend, respectively.

Syiem and Raj (2015) delineated the constraints in utilizing ICTs by farmers using Garrett ranking technique. The major constraints faced by farmers were lack of confidence in operating ICTs, erratic power supply and low network availability in the region. The farmers were less aware of the benefits of ICTs in farming sector and they lacked skill and ICT literacy to handle those tools. Among aged respondents, attitude barriers negatively influenced ICT usage. Some farmers faced financial barriers to buy, maintain and repair ICTs. The study reported lack of proper training and non-delivery of information in vernacular are also among major problems faced by the farmers.

Study conducted by Asif *et al.* (2017) stated that lack of servicing center, expensive mobile set, electricity problem, high cost of repairing and mobile phone operating problem were major problems faced by vegetable cultivating farmers. Most of the farmers faced medium level problems (97.10 %) in using mobile phone while only 2.90 per cent of farmers faced severe problems. But, none of them belonged in the category with low problems.

Lack of feedback (93.33% respondents) and unavailability of information in vernacular (90.00% respondents) were the most important constraints according to Shanthya and Elakkiya (2017) in a study conducted to analyse constraints faced by farmers in using ICTs. Among the respondents 86.66 per cent lacked the skills in using ICTs. More than three fourth of farmers (80.00 %) expressed their difficulty to clear agriculture related doubts while using ICTs and cyberphobia was a major constraint faced by 76.66 per cent of farmers.

Luqman *et al.* (2019) used the mean value to rank the factors influencing the use of ICTs in agriculture among farmers in Pakistan. The power failure, language barriers and limited knowledge and skill in using ICT were the most important factors affecting the use of ICT. Whereas, the result also indicated that irrelevant content, network issues and illiteracy were the factors which has least affected the use of ICTs among the farmers.

Anand *et al.* (2020) identified 14 constraints which were relevant to the ICT usage among the farmers. Constraint analysis was conducted to identify the most and least important constraints through mean score measurement and ranking methods. The researchers identified that insufficient power supply was the major constraint hindering them to use majority of modern ICTs. It was followed by slow/ poor internet connection the area. About 85 per cent respondents felt that they lack knowledge in accessing and utilizing ICTs for agriculture, which makes it the third important constraint among 14. It was evident from the data that the health problems and language barriers did not restrict majority of the farmers from using ICTs as these constraints were marked as the least important constraints.

There were several constraints identified which restricts farmers from using ICTs. Un availability of relevant information, non-access to user friendly ICTs, lack of awareness, and infrastructural limitations were major constraints pointed out by the farmers ranking from one to four, respectively in the order of importance. Lack of trainings, non-availability of timely information and inadequate ICT facilities within the village were other constraints faced by farmers. (Mishra *et al.*, 2020).

2.6. Cultivation under polyhouse

Chakraborthy and Sethi (2015) analysed the prospects of vegetable cultivation under polyhouses. It was noted that, cost of production in the initial season od cultivation under polyhouse is around Rs. 2235/ sq.m, whereas the B:C ratio calculated was about 1.48.

Pandiri (2018) presented data of the polyhouse cultivation of crops, majority of the farmers (95.00 %) owned only one polyhouse unit in the state. All the farmers received assistance in the form of subsidy from government for construction of polyhouse. Most of the farmers chose gerbera, carnation, cucumber and tomato crops for cultivation under polyhouse.

Franco *et al.* (2018) noted that capsicum, cowpea cucumber and tomato were highly cultivated crops under polyhouse. The average total cost of polyhouse construction including equipments (G.I. pipe, polythene sheet, labour, shade net and structure and sheet and micro irrigation) was around Rs. 2,56,000 where, Rs. 74,256 was beneficiary contribution and rest of the money (Rs. 1,81,656) for construction was availed as subsidy. The benefit cost ratio with subsidy was 2.17 and without subsidy was 0.83.

According to the study conducted by Mehta (2020), the major crops cultivated under polyhouses were cucumber, tomato, capsicum and beans. Out of which cucumber gave the highest yield of 38.07 quintals/ 10 cents, followed by tomato and capsicum with yields 31.17 quintals and 21.92 quintals, respectively.

Among the farmers practicing protected cultivation, 10.23 per cent of farmers opted for naturally ventilated polyhouses. Only as low as 0.25 per cent of vegetable farmers cultivated under a medium cost polyhouse with fan and pad cooling system. Among the crops cultivated, Rose, Carnation, Gerbera, Capsicum, tomato and cucumber ranked highest positions (Prakash *et al.*, 2020).

2.7. Information needs of polyhouse farmers

A study was conducted by Reddy *et al.* (2011) to find out information needs of farmers. Quality input availability (37.22 %), pest and disease management (26.11 %), updated weather and market information (22.78 %), government schemes (22.22 %), and farm mechanisation (21.11 %) were found to be major needs of farmers which can be provided with the help of suitable ICTs.

Daramola *et al.* (2016) identified that information on finance (Rank 1), market related information (Rank 2), harvesting and post-harvest operations related information (Rank 3), pre-planting (Rank 4) and post planting operations related information (Rank 5) were needed by vegetable farmers. The ranks were calculated using relative importance index (RII).

Mahindarathne and Min (2018) analysed information need and seeking pattern of farmers under changing information environment. As high as 73.70 per cent farmers needed information moderately. At the same time 11.80 per cent farmers needed information to a high extent. But 14.5 per cent farmers were in low need of information. Standardised Information Needs Index (SINI) was computed in order to rank the information needs of farmers according to their relative importance. Marketed related, crop production related, environmental, climate and policy related, new technology related, training and development related information needs ranked I, II, III, IV, and V respectively.

Rawal and Ansari (2019) identified six subheads or stages related to agricultural activities with which the farmers' information needs were assessed; *viz,* pre-sowing stage, sowing stage, growing stage, harvesting stage, post-harvest stage and government policies and schemes. It was evident from the data that, all the farmers needed information on Govt. policies and schemes. It was followed by information need on post-harvest and growing stages (85.00 %). Eighty per cent farmers needed information on pre-sowing stage, whereas 71.88 farmers wanted to know more about sowing stage. Most of the farmers knew about harvesting stage; there by only 47.50 per cent of farmers asked for the information regarding the stage.

Nurrifqhi *et al.* (2019) designed and developed a user-centered mobile application for agricultural information dissemination. The software requirement of farmers was assessed using a three-point continuum namely normal, excited and expected on the increasing degree of their need. Seed information, pest information, fertilizer information, cultivation information, weather information, and planting calendar came under normal category. They were excited about machine information, production centre, suitability of varieties, and agrotechnology information. Land suitability, consultation information, and agricultural needs were expected benefits from the mobile application.

2.8. Training needs of polyhouse farmers

Yekinni and Oguntade (2015) stated that among women farmers cultivating vegetables, lack of training or skill is observed. Weighted score (WS) was assigned for each area according to the response from farmers where they need expertise. Training was required mainly on controlling pest and diseases (WS =190.7), followed by fertilizer application (WS = 184.1), post-harvest practices (WS = 181.6), and nursery management (WS=175.9). Relatively a smaller number of respondents asked for training in seed selection, bed preparation and bush clearing.

Daramola *et al.* (2016) conducted a study on challenges and information needs of vegetable farmers. They suggested that the government, non-government organisations and extension agents should coordinate and come forward to conduct training programmes for the farmers on various aspects of vegetable cultivation.

In 2017, Hena analysed the factors affecting non-adoption polyhouses. One of the important factors contributing towards the problem was lack of technical and practical knowledge on polyhouse farming among farmers. They did not receive enough technical guidance from the part of officials concerned. Training was not sufficient to take up the polyhouse farming as a new practice.

Ghanghas (2018) concluded in the study that majority of the farmers (93.33 %) who took up polyhouse farming received only short duration training *i.e.,* 3 to 7 days, which was found to be insufficient as the practice was different from the traditional method which most of the farmers are experienced at. The authors also recommended to conduct long duration vocational skill development and training programmes to make more farmers to take up polyhouse farming.

The farmers who are involved in polyhouse cultivation expressed their training and skill development needs regarding various aspects in vegetable and flower cultivation. Their needs were sorted and analysed through Garret's ranking method, and found that the farmers needed training to improve agronomic skills, pest and disease management, nursery raising, repair and maintenance, and fertilizer application through drip (Prakash *et al.*, 2020).

2.9. Constraints faced by polyhouse farmers

In 2004, Sanwal *et al.* conducted a study to understand problems and prospects of polyhouse cultivation. High cost and non-availability of construction material for polyhouse establishment were the two major factors limiting the adoption of polyhouse technology for commercial cultivation. The structural design of the polyhouse in varying agro-climate of the region was not standardised. Lack of awareness among farmers regarding to possibilities of protected vegetable production and lack of major research works on protected vegetable farming were other major problems leading to reluctance in adoption of the technology by farmers in the region.

In the study conducted by Pragjibhai (2011) among the greenhouse farmers, it was observed that majority of the farmers (91.07 %) felt the cost of greenhouse establishment was very high. Eighty-two per cent of the farmers were having inadequate knowledge on polyhouse cultivation of crops. Improper marketing facility was a major constraint among 56.55 per cent farmers.

Smitha *et al.* (2016) studied the constraints faced by greenhouse farmers. In the study it was found that high initial establishment cost, lack of proper market facility and reasonable prices for greenhouse produce, non-availability quality inputs in needed quantity for greenhouse plants, non-availability of credit in time, lack of proper guidance and extension services were the major constraints faced by farmers in adoption of greenhouse technology.

Prabhakar *et al.* (2017) conducted a study at Maharashtra and Karnataka to demarcate the constraints in adoption of polyhouse. They found that farmers were challenged with environmental, technical, labour related, economic and market related constraints. The comparative study indicated that the major constraints faced by farmers were different in both the states. In Karnataka, the major constraints were the water scarcity, lack of proper scientific knowledge high initial investment, fluctuation in market prices, and high labour costs. Whereas in Maharashtra, low soil fertility status, limited power supply, lack of adequate and timely disbursement of loan, existence of middlemen malpractice, and scarcity of skilled labourers in peak season were the main problems related to polyhouse cultivation.

According to research conducted by Kumar *et al.* (2017), it was found 92.50 per cent of the polyhouse farmers were hesitant to adopt polyhouse due to the short lifespan of the polythene sheet. Pest, disease, and nematode infestation were the main problem faced by 90 per cent of farmers. Farmers were facing difficulty due to high cost of fertilizer (82.50 %) and planting material (77.50 %). Lack of availability of construction material (77.50 %), problems due to weather fluctuations (62.50 %), fear of technology failure (60.00 %) were other constraints met by the polyhouse farmers.

Ghanghas (2018) conducted a study to delineate the problems and prospects of polyhouse cultivation. It was reflected in the study that all the farmers confronted with the serious problem of population explosion of minute sucking pests and diseases in the polyhouse. Whereas, constraints like high cost of cold chain transportation and frequent wind and hailstorm occurrence were problems faced by 94 and 92 per cent farmers respectively. Simultaneously, other problems challenging the polyhouse farmers were high cost of hybrid seeds (92.00 %), lack of knowledge on value addition process (90.00 %), lack of cold storage facilities in the locality (88.00 %), high establishment cost (86.00 %).

Wayua *et al.* (2020) studied the challenges faced by greenhouse farmers which led to more than 30 per cent failed greenhouses in Kenya. The research pointed out that the main constraints in greenhouse farming were the fast spread of pests and diseases (27.10 %), inadequate supply of water (23.10 %), high costs of inputs for greenhouse cultivation (17.20 %) and lack of information on greenhouse farming technology (9.50 %).

2.10. Designing m-Tools and Agriculture

According to the report presented by World Bank in the year 2012, there are a lot of benefits of popularising mobile based tools in agriculture, *esp.* mobile applications. The use of mobile tools of agriculture can assist farmers through better information transfer in a worthy, needy, and timely manner, better and accurate connectivity to agricultural extension services, enhancing the linkage between market and distribution networks, and increased access to funding sources.

Husain *et al.* (2016) suggested that whenever any ICT tools are developed it should be based in the needs and preferences of the end user. It was also opined in the study that such tools will be user friendly, interactive and effective among the stakeholders.

The fast evolution of mobile telephony and the introduction of mobile aided information services paved ways to overcome present asymmetry of information in the field of agriculture. There is a huge gap between the accessibility and delivery of agricultural inputs and agricultural infrastructure that can bridged by the modern ICTs. Mobile phones are easy and handy tool and simple to operate for people who are not well aware of different ICTs. Currently, various mobile based applications have come up for the purposes like diseases and pest diagnosis and control, farm management apps , location-based information, market data access, and weather information. Farmers would be more benefitted if all the information gets availed in a single bundle. (Patel and Patel, 2016)

Kumar and Karthikeyan (2019) stated that it is need of the hour to design and develop various mobile apps for farmers and agriculture extension workers for the overall prosperity in the field of agriculture. The study also suggests that the applications must be designed in such a way that it should be location specific, time bound, accurate and brief, with no language barriers, provision of group interaction, easy entry and exit, innovative and attractive, diagnostic and the users should be able to learn without boundaries.

There is a growing interest in agriculture based mobile apps and a very limited number are available now. It is also important that designing of mobile app should involve user-centered processes for engaging users in app development. The assessment of mobile app emphasised the need for providing certified, timely, and localised information for specific agricultural activities. Mobile apps can deliver essential information for agriculture, such as market information, and environmental principles; assist farming activities, such as disease management; and provide expert consultation and education. (Costopoulou *et al.*, 2020)

2.11. End-user assessment of m-tool

A web-based decision-supporting system was developed by Norasma *et al.* (2013) for paddy planting management. User satisfaction study was conducted among farmers and extension personnel after the launch of decision support system. The questionnaire consisted 10 questions on, easiness of use, problems faced while using system, easiness in understanding, clarity of information, searching and finding information in website, support in their decision making, attractiveness of interface, easiness to read and clarity of information through colours, texts, and photos and their overall satisfaction in using website. The results of end user assessment denote that 70 per cent farmers found the decision support system effective and it makes them more efficient to make decision on paddy planting.

BSI (The British Standards Institution) released a set of criteria/ standards in 2014 and latest modification was done in the year 2020 regarding software evaluation. International Standards named this as Systems and software Quality Requirements and Evaluation (SQuaRE) and has the goal of creating a framework for the evaluation of software product quality.

A study was taken up by Govind *et al.* (2017) to assess usefulness of mobile service 'Intelligent Advisory Service for Farmers' among the registered users. Eleven statements formed the questionnaire for end-user assessment of the service. It included statements regarding accuracy, reliability, completeness, simplicity, and understandability of information, whether the information motivates to adopt the service, suitability of language, problem solving ability, knowledge gain, effect on productivity and cost and time effectiveness through the service. Medium to high level of perception was found among the users after analysing their response through questionnaire.

Koshy and Husain (2017) developed a methodology to conduct an end user evaluation of organizational web portal for Directorate of Research of Kerala

Agricultural University. The web interface was evaluated on the basis of its homepage, navigation, site organisation, links and labels and readability.

The methodology for evaluation of 'AgroFarm' app was done in two stages. The first stage involved heuristic evaluation with the involvement of experts (non-user evaluation) analytically inside laboratory and the second stage involved non laboratory inquiry method of evaluation with the involvement of users. The heuristic questionnaire involved statements regarding technical side such as, errors, real-time changes occurring in the system due to feedback, languages, consistency in the use of terminology and semantics. The user evaluation involved questions on five dimensions such as general impression of the user, screen, terminology, and communication with the system, learning of use and system capabilities (Pliakoura *et al.*, 2018).

Zhai *et al.* (2020) attempted to technically analyse 13 agricultural decision support system through a comprehensive survey on various decision supporting systems (DSS) for agriculture. The analysis was based on their accessibility (suitability of Graphical User Interface (GUI)), scalability (scope of adding additional components in DSS), interoperability (ability to works with components outside the DSS), uncertainty and dynamic factors (ability to control unexpected changes during run time), re-planning (replan the changes in agriculture over time and generating new information), expert knowledge (accuracy and timely information), prediction and forecast (prediction of uncertainties in agriculture such as market price and cost) and analysis on historical information (analysing historical data to generate future plan such as consumer preferences and the like.) based on SQuaRE standard of ISO (International Standards Organisation). The three-star criterion was followed to rate the decision support system where, the maximum of three star indicates best and single star indicates their worst performance.

Methodology

CHAPTER 3

METHODOLOGY

Methods and procedures followed in the study are described in this chapter. Appropriate data collection tools and analytical methods were employed in the study and the details are presented under following subheads.

3.1. Locale of the study

3.2. Selection of sample

3.3. Design of the study

3.4. Operationalisation and measurement of variables

3.5. Development of m-tool

3.6. End-user evaluation of the m-app

3.7. Statistical tools used for data analysis

3.1. Locale of the study

The State of Kerala is the locale of the study.

3.1.1. Kerala State

Kerala is situated in the south western end of the Indian subcontinent. Kerala lies between the Arabian Sea in the West and the Western Ghats in the East with an area of 38863 sq. km. geographically located between northern latitude of 8°.17'.30" N and 12°. 47'.40" N and east longitudes 74°.27'.47" E and 77°.37'.12" E. Geographically Kerala is divided in east- west direction into three parts- Highland, Mid plains, and coastal areas.

Kerala experiences a tropical climate, as it is located near the equator. There are three types of seasons in Kerala- June-September , South-West monsoon

(*Edavappathy*), October-December, North-East monsoon (*Thula Varsham*) and summer season (March- May).

In terms of agro- climatic conditions, Kerala has a warm and humid climate with a heavy and long drawn monsoon. The typical vegetables grown are beans (cowpea, cluster beans, broad beans), gourds, pumpkins, cabbage, cauliflower, cucumber, and tomatoes.

The hi-tech agriculture scheme was launched in the year 2012 for promotion of protected cultivation. Initially, 21 hi-tech greenhouse demonstration units (demo models) with a total financial assistance of Rs. 96.77 lakhs were prepared by adopting the design prepared by Kerala Agriculture University (KAU). Later, a total of 557 farmers across the State had availed themselves of government assistance of ₹23.09 crore to construct polyhouses. The flagship scheme implemented by the State Horticulture Mission, Kerala provides assistance of up to 75 per cent of the unit cost for the beneficiaries. The major vegetable crops cultivated under polyhouses in Kerala are Salad cucumber, Yard long bean, Chilli, Leafy vegetables, Capsicum, Cole crops, Gourds, and Melons.

Figure 1. The map of Kerala representing the locale of study

Plate 1. Information and data collection from Sri. Sivaraman. M, Pazhayannur, Thrissur District

Plate 2. Information and data collection from Sri. Ramkumar T., Elanad, Thrissur District

Plate 3. Information and Data collection from Sri. Vijay Motha, Nedumangadu, Thiruvananthapuram District

Plate 4. Information and data collection from Sri. Francis C, Adatt, Thrissur District

Plate 5. Salad cucumber cultivation of Dr. Antony K, Anthikkad,

Plate 6. Chilli cultivation of Sri. Rajesh P, Thiruvilwamala, Thrissur District

Thrissur District

3.2. Selection of sample

Two districts each from north, central, and south Kerala were selected based on the number of farmers involved in vegetable cultivation in polyhouse (High range districts were excluded). The six districts selected were: Kozhikode, Malappuram, Thrissur, Ernakulam, Alappuzha, and Thiruvananthapuram. The data for identifying the districts were collected from the Department of Agricultural Development and Farmers' Welfare, Kerala and State Horticultural Mission, Kerala. It is as follows

Table 3.1. Number of polyhouses in 12 districts of Kerala

Sl. No.	District	Number of polyhouses
1	Thiruvananthapuram*	**77**
2	Kollam	22
3	Pathanamthitta	37
4	Kottayam	44
5	Alappuzha*	**45**
6	Ernakulam*	**75**
7	Thrissur*	**90**
8	Palakkad	57
9	Malappuram*	**50**
10	Kozhikode*	**34**
11	Kannur	16
12	Kasaragod	11

*Selected districts

A total of 240 farmers constituted the sample for the study. Four commonly and successfully cultivated vegetable crops under polyhouse in Kerala *viz,* Yard long bean, Salad cucumber, Chilli and Amaranthus were identified. Farmers were selected through a random sampling procedure. From every selected district, 10 farmers each cultivating/ who had already cultivated each of the above vegetable crops in the previous years were included in the sample (4 crops x 10 farmers x 6 districts) as shown in Fig. 2.

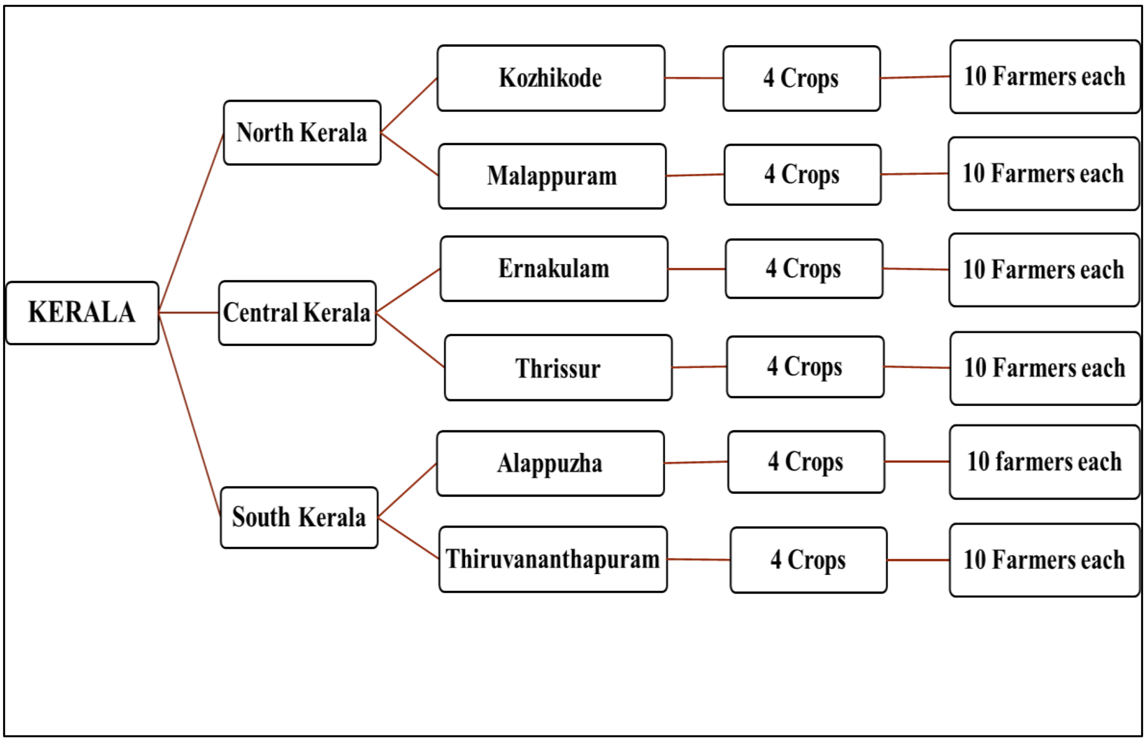


Figure 2. Pictorial representation of selection of sample

3.3. Design of the study

'Ex-post facto' research design was followed for the study as the events under the study had already taken place. Kerlinger (1964) defined ex-post facto research as the research in which the independent variable or variables have already occurred and in which the researcher starts with the observation of a dependent variable or variables. As the events have already taken place at a certain point of time, the researcher did not have any direct control over the variables in the study.

3.4. Selection, operationalisation, and measurement of variables

The variables which are found important to meet the objectives of the study were selected after extensive literature review and discussion with experts and observations made by the researcher. A total of 21 variables were included in the study. There were 19 independent variables and two dependent variables. The dependent variables selected were: ICT utilisation and m-Readiness of the polyhouse farmers.

The operationalisation and measurement of the variables are as follows:

3.4.1. Age

Age of a polyhouse farmer was measured by calculating the time elapsed between date of birth and the time of survey. The respondents were included in either one of the following categories based on their chronological age (Govt. of India, 2011).

Sl. No.	Age (years)	Category	Score
1	Less than 30	Young	1
2	30 to 59	Middle aged	2
3	60 and above	Old	3

3.4.2. Gender

Gender is operationally defined as the state of being male, female, or other gender (Transgender) of the respondents. The following nominal classification was assigned according to the gender identity of the polyhouse farmers included in the study. The scoring done is used to indicate categories.

Sl. No.	Gender	Score
1	Male	1
2	Female	2
3	Transgender	3

3.4.3. Education

Education is operationalised as the level of highest completed educational qualification at the time of data collection, reported by a respondent. It was classified based on classification by MHRD (Ministry of Human Resource Development), Govt. of India, 2015 with slight modifications.

Sl. No.	Level of education	Scores
1	Illiterate	0
2	Primary	1
3	Secondary	2
4	Higher secondary	3
5	Undergraduate	4
6	Post graduate and above	5

3.4.4. Family size

Family size in the study referred to the number of members in the family of the respondents. It was measured by directly asking the farmer. The size of the family was categorised in to five groups based on the number of members as per the classification given by UN (United Nations), 2017.

Sl. No.	Category	Score
1	1 person	1
2	2 members	2
3	3 to 5 members	3
4	6 to 8 members	4
5	9 members and above	5

3.4.5. Land holding

Land holding is operationally defined in the study as the area of land owned by the farmers (in ha). Certain modifications were made in the land holding classification in Govt. of India, 2019 and used for the study. The land holding of farmers were categorised as follows:

Sl. No.	Category	Size (in hectares)	Scores
1	Marginal	≤1.0	1
2	Small	1.01 to 2.0	2
3	Semi-medium	2.01 to 4.0	3
4	Medium	4.01 to 10.0	4
5	Large	>10.0 ha	5

3.4.6. Farming experience

Farming experience is defined operationally as the number of years the polyhouse farmers were involved in agricultural activities. The classification done by Brumfield and Ozkaan (2018) was used in the study. It is as follows:

Sl. No.	Category	Experience (years)	Score
1	Low	Up to 5	1
2	Medium	6 to 10	2
3	High	>10 years	3

3.4.7. Family income

Family income is defined as the money (in Rupees) earned by the family of polyhouse farmers in a year from agricultural as well as non-agricultural sources. The classification done by NCAER (National Council of Applied Economic Research), (2017) was used for the study.

Sl. No.	Category	Income (Rs. in lakhs/Year)	Score
1	Low	< 1.8	1
2	Medium	1.8 to 3.4	2
3	High	> 3.4	3

3.4.8. Innovativeness

Innovativeness is operationally defined as the relative rate at which the respondent adopted a new technology or a practice. Four statements were formed which indicated four levels of innovativeness as suggested by Danhof (1949) and adopted by Priya (2014) and (Kumari, 2016), which are as follows:

Sl. No.	Statements	Score
1	I am not interested to adopt new technologies (Drone)	0
2	I prefer to wait and take my own time (Fabian)	1
3	After I had seen other people tried successfully (Imitator)	2
4	As soon as it is brought to my knowledge (Innovator)	3

The respondents were allowed to select one statement among the four statements which was most appropriate in describing their innovativeness and is given the corresponding score. The first statement indicates the least innovative (Drone) farmer and the fourth statement indicates the most innovative one (Innovator).

3.4.9. Mass media exposure

Here mass media exposure is referred as the extent to which the polyhouse farmers are exposed to different mass media sources. The classification adopted by Chauhan and Kansal (2014), Dash *et al.* (2017) with slight modification was used in this study. The scoring procedure is as follows:

Sl. No.	Type of mass media	Score
1	Newspapers	0 to 6 (Depending on the number of mass media used)
2	Magazines	
3	Agricultural publications	
4	Leaflets/ folders	
5	Radio	
6	Television	

The scores varied from zero (if they are not exposed to any type of mass media) to six (if the respondents are using all the mentioned types of mass media).

The scores of frequencies of use varied from zero to four as shown below.

Sl. No.	Frequency of use	Score
1	Never	0
2	Rarely	1
3	Sometimes	2
4	Often	3
5	Always	4

The total score of mass media exposure was obtained by adding the scores of numbers of mass medium they use and frequency of use. The possible score range was zero to ten.

3.4.10. Social participation

It is the degree to which the respondent was involved in an organisation and its functions either as a member or office bearer. The procedure adopted to measure the social participation in this study was as followed by Gurubalan (2007), Shilpa (2013) and Neshva (2013). The scoring is done as follows:

Sl. No.	Social Participation	Category	Item score
1	Membership	No membership	0
		Membership in one organisation	1
		Membership in more than one organisation	2
		Office bearer in one organisation	3
		Office bearer in more than one organisation	4
2	Frequency of participation in activities	Never	0
		Occasionally	1
		Regularly	2

The final score was obtained by adding the score of the type of membership and the score of the frequency of participation. The possible score range was zero to six.

3.4.11. Achievement motivation

Achievement motivation was operationally defined as the need for success or accomplishment of a polyhouse farmer. It is a behavioural trait characterised by high level of endurance and consistency for meeting high standards of achievement. The scale developed by Rani (1985), modified by Kumar (1986), and used by Gorakh (2020) was used with required modifications in the study. The scale consists of six statements where all the statements are positive. The measurement was done on a five-point scale ranging from 'strongly agree' to 'strongly disagree' with a score from four to zero as shown below.

Responses	Scores				
	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
Statements	4	3	2	1	0

3.4.12. Change resistance

It is defined as the disapproval or reluctance shown by the farmers towards a change that is occurring or about to occur with them or their community. The scale developed by Sreeja (2013) with slight modifications was used in the study. The scale consists of six statements where two statements are positive and four statements are negative. The measurement was done on a five-point scale ranging from 'strongly agree' to 'strongly disagree'. The scoring of positive and negative statements is done as follows:

Sl. No.	Responses	Scores				
		Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1	Positive statements	4	3	2	1	0
2	Negative statements	0	1	2	3	4

The maximum possible score obtained would be 24 and minimum score would be zero.

3.4.13. e-Literacy trainings attended

In the study, e-Literacy trainings refer trainings on any ICT tools (training on usage of smart phones, computer, and internet usage and other ICT tools.) attended by polyhouse farmers. Each training attended by the farmers was given a score of one and zero score was given if the farmer had not undergone any training. The procedure developed by Chitra (2015) and followed by Kumari (2016) was adopted for the study.

3.4.14. ICT utilisation

ICT utilisation was operationally defined as the extent of utilisation of ICT tools and services by the polyhouse farmers. This was measured in terms of the frequency and purpose of using various ICTs for acquiring latest and relevant information for either agricultural or non-agricultural purposes at the time of investigation. The scale developed by Hassan *et al.* (2011), followed by Kumari (2016) was used with slight modification to measure frequency of utilisation. Ten tools and services were listed out and frequency is measured on a five-point scale.

Frequency of utilisation of ICTs	**Scores**				
	Always	Often	Sometimes	Rarely	Never
Tools	4	3	2	1	0

The general purpose of using ICTs was also measured by asking the farmers whether they are using it for agricultural, non-agricultural or both purposes . The scoring done was as follows.

Purpose	**Scores**
Non-agricultural Purposes	1
Agricultural Purposes	2
Both	3

Purpose of usage of ICTs was measured by slightly modifying a scale developed by Syiem and Raj (2015). Nine purposes where ICTs could be used were listed out and measured on a five-point scale. The scoring was done as follows:

Purpose of utilisation of ICTs in Agriculture	Scores				
	Always	Often	Sometimes	Rarely	Never
Tools	4	3	2	1	0

The final scores of ICT utilisation were obtained by adding the scores of ICT utilisation, general purpose of ICT use and the purpose of ICT use in agriculture.

3.4.15. Constraints in the use of ICTs

The problems faced by farmers in using ICTs were measured by modifying the scale constructed by Boniface *et al.* (2019). Constraints were analysed by listing out 13 statements. Then the polyhouse farmers were asked to rate each of the listed constraints on a five-point scale, as follows, based on the importance of the constraints.

Constraints	Scores				
	Very important	Fairly important	Important	Slightly important	Not important
Statements	4	3	2	1	0

The final scores of the constraints were worked out by dividing the total score obtained for each statement with the total number of respondents *i.e.*, 240. The maximum possible score obtained could be four and minimum could be zero.

$$Score = \frac{\sum Scores\ obtained\ for\ each\ statement}{Number\ of\ respondents}$$

3.4.16. Polyhouse cultivation behaviour of farmers

The details of polyhouse cultivation by the respondent farmers were collected by direct interrogation. The variables and procedure used to identify the polyhouse details are given below.

3.4.16.1. Type of polyhouse

There were usually two types of polyhouses in Kerala *viz.*, naturally ventilated and climate controlled. The type of polyhouse in which they are cultivating or has already cultivated vegetables were noted down by either through observation or direct questioning.

3.4.16.2. Area of polyhouse

It is the total area (in square metres) under the polyhouse. The area of polyhouse was collected by directly asking the farmers.

3.4.16.3. Construction material

It denotes the material with which the frame and covering material of the polyhouse is made. The data was collected by directly asking the farmers or by direct observation.

3.4.16.4. Source of construction material

The information was collected by asking the respondents directly, regarding the company or the dealers from when the construction material for polyhouse was purchased.

3.4.16.5. Cost of construction of polyhouse

The total cost of construction of polyhouse including the cost of additional facilities was calculated by asking the farmers about the initial cost and the equipment-wise money spent on polyhouse.

3.4.16.6. Cost of cultivation under polyhouse

It is the variable cost involved in vegetable cultivation under polyhouse in the last cultivated season. Practice/item-wise cost involved was asked and the total variable cost involved was worked out.

3.4.16.7. Subsidy availed

It is the amount of subsidy availed by a polyhouse farmer through government sponsored schemes to encourage the polyhouse cultivation. It is expressed as the percentage of construction cost of polyhouse.

3.4.16.8. Income from polyhouse

It is the income obtained from marketing the vegetables cultivated under polyhouse. It has been worked out by collecting the details of crop-wise yield (in Kilograms) and the average price (in Rupees) obtained per kilograms in the previous cultivated season.

Income (in Rupees) = Yield (in kg) X Price per kg (in Rupees)

3.4.17. Trainings attended

In the study, trainings attended by the farmers on polyhouse cultivation was examined. A score of one was given to those who attended training and 'zero' was given if the farmer had not undergone any training. The procedure developed by Chitra (2015) and followed by Kumari (2016) was used here.

3.4.18. Constraints in cultivation in polyhouse

It refers to the problems faced by farmers regarding cultivation of vegetables under polyhouse. An arbitrary scale was developed for the study with the help of subject matter experts and extensive literature review. In this study, various possible constraints in different aspects of polyhouse cultivation were listed out (20 constraints under five different sub headings) and farmers were asked to rate it according to the relative importance on a five-point scale given below.

Constraints	**Scores**				
	Very important	Fairly important	Important	Slightly important	Not important
Statements	4	3	2	1	0

The final scores of the constraints were worked out by dividing the total score obtained for each statement with the number of respondents *i.e.*, 240. The maximum score obtained could be four and minimum could be zero.

$$Score = \frac{\sum Scores\ obtained\ for\ each\ statement}{Number\ of\ respondents}$$

3.4.18. Information needs of farmers

User-centred design of any ICT tool would help increasing the reach and usability of the developed tool. Here, vegetable wise information needs were assessed to make the m-tool user-centred. The possible areas of vegetable cultivation under polyhouse where farmers needed information about, from site selection to marketing of vegetables (Salad cucumber, Yard long bean, Chilli and Amaranthus, separately) were listed out after consultation with experts and thorough review of literature. The information need was assessed by asking farmers to rate the needs according to the relative importance of their requirement from not needed to highly essential on a five-point scale as follows.

Information needs	**Scores**				
	Highly essential	Essential	Needed	Slightly needed	Not needed
Statements	4	3	2	1	0

The final score of each item was obtained by working out the mean score of the particular item.

3.4.19. Training needs of farmers

Training needs	**Scores**				
	Highly essential	Essential	Needed	Slightly needed	Not needed
Statements	4	3	2	1	0

Training needs of farmers were assessed to understand their needs for skill and hands on training to cultivate vegetables under polyhouse. The possible skills needed for vegetable cultivation under polyhouse from seedling production to marketing of vegetables were listed out after consultation with experts and thorough review of literature. It was assessed by asking the farmers to rate the training needs according to their relative requirement from not needed to highly essential on a five-point scale as follows

The final score of each item was obtained by working out mean scores of the particular training need.

3.4.20. m-Readiness of farmers

m-Readiness was operationally defined as the preparedness and ability of farmers to use mobile phone-based technology. In this study, a scale was constructed to measure the m-readiness of the farmers by following the procedure given below .

3.4.20.1. Collection of items

Based on literature review and discussion with experts such as agricultural scientists, professors, and research scholars, a total of 159 statements reflecting the m-readiness of farmers were identified which were categorised in to four subheadings such as physical readiness, technological readiness, psychological readiness, and economic readiness. Physical readiness refers to the infrastructural preparedness to access and use mobile based technologies. Technological readiness refers to the knowledge and skill the user possesses to use mobile based technologies. Psychological readiness is operationally defined as the mental and emotional preparedness to use mobile based technologies and economical readiness can be defined as the extend to which the farmers can afford the use of mobile based technologies.

Due care was taken to cover all the dimensions of m-readiness. The statements were then edited using the criteria developed by Edwards (1957). Finally, 131 statements were identified, after deletion of statements which were ambiguous, irrelevant, and not conforming to the suggested criteria. There were 29, 42, 38, and 22 statements which represent physical, technological, psychological, and economic readiness of the farmers, respectively.

3.4.20.2. Item analysis

The statements were sent to a group of 55 judges comprising of experts such as agricultural scientists, professors, and research scholars. They were asked to judge the relevancy of the statements to measure the m-readiness of farmers on a five-point scale from one to five, where one represented irrelevancy of the statement and five indicated high relevancy. Among them, 34 judges returned the same of which four were incomplete/ unclear. So, responses from 30 judges were taken for the final measurement.

3.4.20.3. Kendall's coefficient of concordance

Kendall's coefficient of concordance (W) and mean value were computed to finalise the statements. W-value indicates the degree of association or agreement among different ranks, or scores assigned by the judges on different objects or attributes (Kendall *et al.*,1939; Kendall and Gibbon, 1990; Hardesty and Bearden, 2004).

$$W = \frac{12S}{m^2(N)(N^2-1)}; \quad 0 \leq W \leq 1$$

S : $\sum d_i^2$

d_i : $R_i - \bar{A}$, where R_i is the sum of ranks assigned to item *i* by *m* judges

m : Number of judges

N : Number of objects/ statements

Therefore, a W value close to one indicates high agreement among 30 judges. The mean rank obtained through Kendall's coefficient of concordance was used to select the most relevant statements.

Mean rank of each item and W value of each domain were worked out. The obtained mean ranks were arranged in descending order and 15 items with highest mean ranks were selected for the final scale.

After analysing the data, the Kendall's coefficient of concordance (W) value was found to be 0.759, 0.698, 0.740 and 0.691 for the categories of physical, technological, psychological, and economic readiness respectively. These high values indicate a good agreement among the judges. Based on the mean ranks obtained, 15 items having the highest values were selected from each of the four categories making an m-readiness scale consisting of 60 statements.

3.4.20.4. Validity of the scale

An instrument or a construct is said to be valid if it can measure what is intended or desired to measure. The validity of the scale was tested trough content validation method. Content validity refers to the degree to which an assessment tool is relevant to, and representative of, the construct it is designed to measure (Rusticus, 2014). As the statements were identified through extensive literature review and discussion with experts in the specific area, the present scale covered all the aspects regarding m-readiness. Based on this, it is assumed that the scale satisfied the content coverage. Thus m-readiness scale is said to be valid.

3.4.20.5. Reliability of the scale

Reliability of the scale is defined as the degree to which the measure of that construct is consistent or dependable. Here, Cronbach's alpha is used to measure the reliability of the scale. It measures the internal consistency of the scale (Cronbach, 1951). It was calculated as:

$$\alpha = \frac{N\bar{c}}{\bar{v} + (N-1)\,\bar{c}}$$

Where, α : Cronbach's alpha value

N : Number of items

$\bar{c}$: Average inter item correlation

$\bar{v}$: Average variance

Cronbach's alpha (α) value less than 0.6 indicates a poor/unacceptable level of reliability. A value of more than 0.7 is considered acceptable (Taber, 2018). The obtained α value in the study was 0.990 which indicates excellent reliability of the construct. Hence, the scale is said to be reliable.

3.4.20.6. Administration of the scale

The final scale consisted of 60 statements. It was presented to the respondents in four different categories, *i.e.,* physical, technological, psychological, and economic readiness with 15 statements in each of the categories. The respondents were instructed to mention their opinion in the form of agreement or disagreement towards the statement on a five-point scale from zero to four, where zero indicating complete disagreement and four indicating strong agreement. The final m-readiness score of a farmer was worked out by calculating the sum of the scores obtained in each category. Domain wise readiness score was calculated by dividing the total score obtained for each statement with the maximum score *i.e.,* four.

3.5. Development of the m-App

The vegetable-wise information needs on four crops were prioritised according to the responses made by the farmers. Accordingly, the content was created and the prototype of the mobile app for vegetable cultivation under polyhouse was made. The app consists information on the four vegetable crops namely, salad cucumber, yard long bean, chilli and amaranthus. The sequential information from the selection of construction materials and construction of polyhouse to the harvesting and marketing of the produce is given in the tool. Apart from subject matter experts, exhaustive review of different literatures, ICAR websites, KAU- Package of practices handbook, TNAU Agritech portal, hand books published by State Horticultural Mission and other sources were referred to collect and organise the contents.

The App was developed using the most widely used, free and open-source Integrated Development Environment, Android studio. The app was written using Java and Kotlin as these are the mostly used programming languages in android platforms. The Operating System (OS) used was Windows 10 because it is uncomplicated and needs minimum requirement.

After the development, the app was evaluated by subject experts for technical errors in the content, overall design, layout, and other elements and appropriate corrections were made. For the fine tuning of the developed mobile app, it was subjected to an end-user assessment.

3.6. End-user evaluation of the m-App

A structured questionnaire was developed for the evaluation including various features of the app (41 items), grouped into seven different domains, *viz.*, design and layout, readability, contents, comprehension, navigation, user friendliness and general app features with 6, 6, 7, 6, 4, 6, and 6 items, respectively under each category. For the purpose of evaluation, a total of 30 polyhouse farmers who were using smartphones were selected through random sampling. The prototype of the app was shared with them through online mode. The response was collected on a five-point scale namely; very poor, poor, fair, good, and outstanding with scores zero, one, two, three and four, respectively.

After the assessment of the features of the mobile application, the respondents were asked to indicate the constraints they faced while using the app and suggestions there on to improve its efficiency. These were collected using open-ended questions.

3.7. Categorisation of respondents

Cumulative square root of frequency was used in the categorisation of the respondents under different variables.

3.8. Methods used for data collection

Keeping in view the objectives and variables of the study, an interview schedule was prepared by consulting experts and extensive literature review. The schedule was then administered to 30 non-sample respondents for pre-testing. Required corrections and modifications were made after pre-testing to develop the final interview schedule for the study.

3.9. Statistical tools used for data analysis

3.9.1. Frequency

Frequency distribution is representation of the number of respondents under each category on the scale of measurement. It helped the researcher to have a convenient glance at the entire data.

In this study frequency was used to understand the number of polyhouse farmers belonged within a given interval of variable category.

3.9.2. Percentage

It helped in the standardisation of the data which was given in frequencies and convenient method of representing data per hundred units.

In this study percentage was used to represent the frequency per hundred units.

3.9.3. Arithmetic mean

Arithmetic mean (M) was obtained by dividing the sum of all observation (N) by the number of observations (n).

Here, it was arithmetic mean was used to find the average value of different variables.

3.9.4. Cumulative square root of frequency

Cumulative square root of frequency was used in the categorisation of the respondents under different variables. It was obtained by computing the cumulative square root of the interval frequencies and dividing the range from 'zero' to 'maximum' cumulative square root frequency obtained by the desired number of strata/ categories (L). This creates L intervals of equal length on the scale of the cumulative square root frequency.

3.9.5. Spearman's correlation coefficient

Correlation coefficient is the statistical tool used to assess a possible linear association between two variables. In this study it was used to measure the linear relationship between dependent and independent variables.

$$r = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}}$$

where,

r = Correlation coefficient

x_i = Values of the x-variable in a sample

$\bar{x}$ = Mean of the values of the x-variable

y_i = Values of the y-variable in a sample

$\bar{y}$ = Mean of the values of the y-variable

3.9.6. Linear regression

Linear regression attempts to assign the relationship between two variables by fitting a linear equation to observed data. One variable is an explanatory/ independent variable, and the other is a dependent variable. A linear regression has an equation of the form $Y = a + bX$, where X is the independent/ explanatory variable and Y is the dependent variable.

Adjusted R^2 was also worked out. This value gave the percentage of variation explained by the independent variables that affect the dependent variables.

In this study, linear regression was used to understand the relationship between factors affecting dependent variables and dependent variables.

3.9.7. Binary logistic regression

A binomial or binary logistic regression predicts the probability that an observation or data falls into one of two categories of a dichotomous dependent variable/ exploratory based on one or more independent or predictor variables. The prediction equation is as follows.

$$E\,(Y/x_1, x_2, x_{3\ldots}, x_n) = \frac{\text{Exp}\ (b_0 + b1x1 + b2x2 + b3x3 + \cdots bixi}{1 + \text{Exp}\ (b_0 + b1x1 + b2x2 + b3x3 + \cdots bixi}$$

Here, Y is the dichotomous dependent variable with possible values of 0 and , ,x_1,$x_{2\ldots}$,x_i are independent variables, b_0, b_1, b_2, …, b_i are the estimated logistic regression coefficients and ‘i’ is the number of independent variables.

They are interpreted in terms of odds ratio. An odds ratio is a statistic that quantifies the strength of the association between two variables in the logistic regression. More clearly a unit change in the level of every independent variable, there will a change in dependent variable according to the odds ratio.

In the present study, binary logistic regression was used to quantify the relationship between independent variables with the dependent variables ‘m-readiness’ and ‘ICT utilisation’. Odds ratio was used to have an understanding on whether the farmer falls in above average or below average category of dependent variable if a unit increase in independent variable occurs.

3.9.8. Kruskal Wallis one way ANOVA test

Kruskal Wallis one way analysis of variance-test is used to assess whether the sample originated from the same distribution. It is used to compare two or more independent samples and determine whether the difference between the groups is statistically significant.

$$H = \frac{12}{N(N+1)} \sum_{j=1}^{k} \frac{R_{j^2}}{n_j} - 3(N+1)$$

k = number cases in j^{th} sample

N= $\sum n_j$, the number of cases in all sample combined

R=sum of ranks in the j^{th} sample

$\sum_{j=1}^{k}$ directs to sum over k samples

In this study, Kruskal Wallis test was used to compare the m-readiness and ICT utilisation of the six districts under study.

3.9.9. Kendall's coefficient of concordance

Kendall's coefficient of concordance value indicates the degree of association or agreement among different ranks, or scores assigned by the judges or respondents on different items. Here the test was used for finding the agreement between farmers regarding the information needs and training needs on polyhouse cultivation. The formula is as follows.

$$W = \frac{12S}{m^2(N)(N^2-1)}; \quad 0 \leq W \leq 1$$

S : $\sum d_i^2$

d_i : $R_i - \bar{A}$, where R_i is the sum of ranks assigned to item *i* by *m* judges

m : Number of judges

N : Number of objects/ statements

3.9.10. Factor analysis using principal component method

Factor analysis is a dimension-reduction technique that reduce the dimensionality of large data sets, by converting large set of variables into smaller number of factors that contains most of the information in the large set that allows easier interpretation. Principal component method is one of the most used approaches for factor reduction. In order to decide the factors which needs to be extracted, scree plot method using eigen values are used. All the components with eigen values of more than one is selected.

In this study factor analysis was used to reduce the dimensionality of variables affecting 'm-readiness' and 'ICT utilisation' to different factors.

Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

The results of the study are presented and discussed in detail in this Chapter under the following headings:

4.1. Personal profile of polyhouse farmers

4.2. ICT utilisation of polyhouse farmers

4.3. m-Readiness of polyhouse farmers

4.4. Details of polyhouse cultivation

4.5. Constraints in polyhouse cultivation

4.6. Vegetable wise information needs of polyhouse farmers

4.7. Training needs of polyhouse farmers

4.8. Design, development, and end-user assessment of m-app

4.1. Personal profile of polyhouse farmers

4.1.1 Age

Table 4.1. Distribution of polyhouse farmers according to age (N=240)

Sl. No.	Category	Frequency	Percentage
1	Young (less than 30 years)	0	0.00
2	Middle-aged (30 to 59 years)	184	76.67
3	Old (60 years and above)	56	23.33
	Total	**240**	**100.00**

The distribution of polyhouse farmers is given in Table 4.1. It is observed from the data that all the polyhouse farmers were either middle-aged or old aged. None of the farmers were young. Majority (76.67%) of the farmers were middle-aged, whereas the remaining (23.33%) of them were above 59 years of age. As there was no farmer in the young age category, it could be assumed that very less or no new farmers are taking up the practice of polyhouse cultivation. Poor generational renewal might be the reason for this trend. When unemployment is a burning issue globally, providing skills and vocational training on agriculture to rural youth would lift their confidence in farming and will be beneficial to the rural folk. Youngsters should be made aware of the advanced farming methods and thereby encouraging them to adopt hi-tech farming.

The results are in conformity with the studies conducted by Prakash *et al.* (2020) and Mahindarathne and Min (2018).

4.1.2. Gender

The results given in Table 4.2 clearly depicts that most of the polyhouse farmers were male (88.33%) and the rest 11.67 per cent of the farmers were females. Gender inclusiveness in hi-tech agriculture is still low even though the number of females outnumber the male population in Kerala state. Polyhouse cultivation being in a limited area, female farmers can easily undertake it. By developing solutions that are more inclusive, farmers could tap into a much larger market, consequently improving their income.

Table 4.2. Distribution of polyhouse farmers according to gender (N=240)

Sl. No.	Category	Frequency	Percentage
1	Female	28	11.67
2	Male	212	88.33
3	Transgender	0	0.00
	Total	**240**	**100.00**

The result is in accordance with the findings of Bakhsh *et al.* (2018), Tomar *et al.* (2016), and Hassan *et al.* (2011).

4.1.3. Education

Table 4.3. Distribution of polyhouse farmers according to education (N=240)

Sl. No.	Level of education	Frequency	Percentage
1	Illiterate	0	0.00
2	Primary	0	0.00
3	Secondary	40	16.67
4	Higher secondary	88	36.67
5	Graduation	104	43.33
6	Post-graduation and above	8	3.33
	Total	**240**	**100.00**

It is evident from Table 4.3 that all the farmers were literate having formal education of secondary level. Majority of the farmers completed graduation (43.33%). More than one third of polyhouse farmers were having higher secondary level of education (36.67%). Eight farmers (3.33%) were post-graduated.

Kerala state holds top rank in India with an effective literacy rate of 93.91 per cent. This reflects in the results of the present study also. Specifically, polyhouse cultivation requires wider exposure to print and digital media for which literacy is essential.

The conclusions obtained regarding the educational status is analogous with the findings of the study conducted by Prakash *et al* (2020) and Win and Htwe (2020).

4.1.4. Family size

Table 4.4. Distribution of polyhouse farmers according to family size (N=240)

Sl. No.	Family size	Frequency	Percentage
1	1 person	4	1.67
2	2 members	28	11.67
3	3 to 5 members	188	78.33
4	6 to 8 members	20	8.33

5	9 members and above	0	0.00
	Total	**240**	**100.00**

The results given in Table 4.4 point out that more than three fourth (78.33%) of the farmers had a family with three to five members. Less number of families (8.33%) have more than five members.

The modern family structure in Kerala state is mainly nuclear which consists of parents and one or two children. A similar pattern is observed in the study too.

Similar findings are observed in the study conducted by Tomar *et al.* (2016) and Yaseen *et al.* (2016).

4.1.5. Land holding

Table 4.5. Distribution of polyhouse farmers according to land holding (N=240)

Sl. No.	Category	Frequency	Percentage
1	Marginal (less than 1.0 ha)	148	61.67
2	Small (1.01 to 2.0 ha)	56	23.33
3	Semi-medium (2.01 to 4.0 ha)	28	11.67
4	Medium (4.01 to 10 ha)	4	1.67
5	Large (more than 10.01 ha)	4	1.66
	Total	**240**	**100.00**

Table 4.5 shows that 61.67 per cent of polyhouse farmers were marginal farmers, followed by 23.33 per cent of small farmers. Twenty-eight farmers (11.67%) owned land with area ranging from 2.01 to 4.0 hectares. Only 1.67 farmers possessed a land with size more than 10 hectares.

The scattered land pattern in Kerala limits the farmer to cultivate in larger areas. The lack of large land area can also be seen as a reason behind choosing protected cultivation. It is observed that the farmers who opt to cultivate under polyhouses tends to earn more through farming with less land area.

Kafura *et al.* (2016) specifies similar results in their study whereas, the finding of Aldosari *et al.* (2019) was in contrast with the present study.

4.1.6. Farming experience

Table 4.6. Distribution of polyhouse farmers according to farming experience (N=240)

Sl. No.	Category	Frequency	Percent
1	Low (Up to 5 years)	4	1.67
2	Medium (6 to 10 years)	44	18.33
3	High (more than 10 years)	192	80.00
	Total	**240**	**100.00**

As evidenced by Table 4.6, only a few farmers (1.67%) had low level of farming experience. Eighty per cent of farmers had experience with an involvement in agriculture for more than 10 years. A few farmers (18.33%) had medium level of experience in agriculture.

The experienced farmers tend to have more confidence in adopting newer technologies like polyhouse farming (Punera *et al.*, 2017). This was reflected in the present study also.

Prakash *et al.* (2020) and Ghanghas (2019) showed similar findings in their studies. But the studies by Kafura *et al.* (2016) and Aldosari *et al.* (2019) drew different conclusions regarding the farming experience of polyhouse farmers.

4.1.7. Family income

Table 4.7. Distribution of polyhouse farmers according to family income (N=240)

Sl. No.	Category	Frequency	Percent
1	Low (less than 1.8 lakhs/year)	4	1.67
2	Medium (1.8 lakhs to 3.4 lakhs/ year)	36	15.00
3	High (more than 3.4 lakhs/ year)	200	83.33
	Total	**240**	**100.00**

As detailed in Table 4.7, families of majority of the polyhouse farmers earned at least 3 lakh rupees per annum. Most of the polyhouse farmers (83.33%) earned family income of more than ₹3.4 lakhs annually. While families of 15 per cent polyhouse farmers earned income between ₹1.8 to 3.4 lakhs annually. Only 1.67 per cent were low earners.

It is evident that the initial investment for polyhouse construction and cultivation is much higher than traditional open farming system. Farmers with low income cannot afford that. This could be the likely reason that most of the famers belonged to either medium or higher income category.

The results of this study are in line with the findings of Hassan *et al.* (2011), Aldosari *et al.* (2019), Kafura *et al.* (2016).

4.1.8. Innovativeness

Table 4.8. Distribution of polyhouse farmers according to innovativeness

(N=240)

Sl. No.	Category	Frequency	Percentage
1	Drone	0	0.00
2	Fabian	8	3.33
3	Imitator	60	25.00
4	Innovator	172	71.67
	Total	**240**	**100.00**

The polyhouse farmers were grouped in to four categories *viz.*, drones (non-adopters), fabian (sceptical), imitator (adopting after other people tried) and innovators (first to adopt technologies) based on their innovativeness. A glance of Table 4.8 indicates that no ‘drones’ were present among polyhouse farmers. A very few farmers were ‘fabians’ (3.33%). One fourth of the polyhouse farmers (25 %) were ‘imitators’ who adopt technologies after seeing someone tried it successfully. In the present study, most of the polyhouse farmers were identified as ‘innovators’ and it was as high as 71.67 per cent.

The most probable reason for this high innovativeness would be their progressive approach in farming and it may very well serve as a determinant in adoption decision (Lu *et al.*, 2005). Undoubtedly, only innovative farmers will adopt newer technologies like hi-tech farming before most of the people in the society do.

The results are in accordance with the conclusions drawn by Ghanghas (2019) and Mahindarathne and Min (2018).

4.1.9. Mass media exposure

Table 4.9. Different mass media tools used by polyhouse farmers (N=240)

Sl. No.	Mass media	Frequency	Percentage
1	Newspapers	196	81.67
2	Magazines	124	51.67
3	Agricultural publications	112	46.67
4	Leaflets/ folders	88	36.67
5	Radio	44	18.33
6	Television	152	63.33

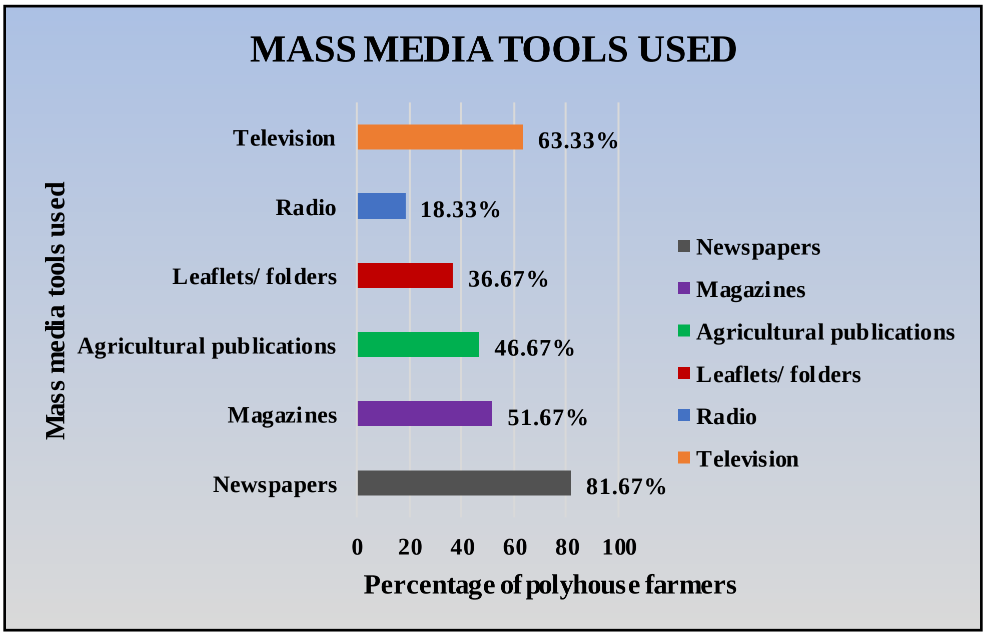


Figure 3. Mass media tools used by polyhouse farmers

The results given in Table 4.9 and Fig. 3 reveal that newspaper was the most popular mass media among the polyhouse farmers with 81.67 per cent of users. Around two third of the farmers (63.33%) used television for information gathering. It was also found that 124 farmers (51.67%) read magazines and 46.67 per cent farmers read different agricultural publications for getting farming related information. Only 36.67 per cent farmers read various brochures/ leaflets on agricultural practices. Radio was the least used mass media tool in agriculture by the polyhouse farmers which accounted to 18.33 per cent farmers.

During the past one and a half decade, almost all newspapers, especially the farmer columns had given high coverage on polyhouse farming. Also, they had highlighted several schemes of the NHM and SHM that comprised heavy subsidies for polyhouse cultivation (PPRI, 2018).

The results from the study conducted by Hassan *et al.* (2011), Tomar *et al.* (2016) is similar with that of this study, and Yaseen *et al.* (2016) reported a dissimilar result.

Table 4.10. Distribution of polyhouse farmers according to mass media exposure (N=240)

Sl. No.	Category	Frequency	Percentage
1	Low (less than 13.64)	28	11.67
2	Medium (13.65 to 18.89)	88	36.67
3	High (more than 18.89)	124	51.66
	Total	**240**	**100.00**

The Table 4.10 shows the mass media exposure of the polyhouse farmers. It can be observed from Table 4.10 that the majority of polyhouse farmers (51.66%) had a high exposure with mass media followed by medium exposure (36.67%) and low exposure (11.67%).

The likely reason of this distribution pattern is that the polyhouse farmers were highly educated and innovative which in turn encouraged them to get connected with information using various mass media. This indicates that, information should be disseminated through the media which is more commonly used by the farmers. Here it is evident that newspapers and television are popular among them and hence these tools can be exploited for transfer of technology. Being a highly subsidised technology, farming in polyhouses had occupied a high level of media space during the last 15 years.

The results are in conformity with Hassan *et al.* (2011) and is not in consonance with those of Tomar *et al.* (2016) and Kafura *et al.* (2016).

4.1.10. Social participation

Table 4.11. Distribution of polyhouse farmers according to social participation (N=240)

Sl. No.	Category	Frequency	Percentage
1	Low (less than 2.81)	24	10.00
2	Medium (2.81 to 4.5)	100	41.67
3	High (above 4.5)	116	48.33
	Total	**240**	**100.00**

Table 4.11 reveals that nearly half of the farmers (48.33%) had high social participation, while only 10 per cent farmers were showed low level of social participation. The number of farmers who moderately participated in social and organizational activities was 100 (41.67%).

There was atleast an organisation of polyhouse farmers functioning in each district. Besides this, most of the farmers involved in polyhouse vegetable cultivation were members of other farmer collectives and are actively participating in different activities of various organisations. Hi-tech farming methods require a lot of discussion among the farmers. So, also they participate in debates, workshops, seminars and the like to get updated with the technology.

Karat and Baby (2020) observed similar results in their study.

4.1.11. Achievement motivation

Table 4.12. Distribution of polyhouse farmers according to achievement motivation (N=240)

Sl. No.	Category	Frequency	Percentage
1	Low (up to 16.45)	56	23.34
2	Medium (16.45 to 19.51)	92	38.33
3	High (above 19.51)	92	38.33
	Total	**240**	**100.00**

Viewing the results in Table 4.12, it is obvious that the number of farmers with medium and high achievement motivation were same (38.33%). But only 23.34 per cent of farmers showed a low level of achievement motivation.

Polyhouse famers who are highly innovative, always aims at high profit and always set difficult goals to achieve more income. The shift from traditional farming explains their high achievement motivation.

Similar results were obtained in the studies of Swaroop (2016), Singh and Singh (2018) and Kumar *et al.* (2017).

4.1.12. Change resistance

Table 4.13. Distribution of polyhouse farmers according to change resistance (N=240)

Sl. No.	Category	Frequency	Percentage
1	Low (below 18.57)	120	50.00
2	Medium (18.57 to 21.52)	76	31.67
3	High (above 21.52)	44	18.33
	Total	**240**	**100.00**

It can be observed from Table 4.13 that half of the farmers had a positive outlook towards change (50.00%). Only 18.33 per cent farmers felt difficulty in accepting change. About 31.67 per cent of farmers fell in the medium category with respect to change resistance.

Polyhouse farming can be considered as a major shift from traditional agricultural practice of growing crops under open conditions. If they are adopting protected cultivation, it denotes their change acceptance, which in turn explains the result. Change proneness is an encouraging trend.

Shaheen *et al.* (2020) presented comparable results regarding change resistance in their study.

4.1.13. e-Literacy trainings attended

Table 4.14. Distribution of polyhouse farmers according to e-Literacy trainings attended (N=240)

Sl. No.	Category	Frequency	Percentage
1	Attended	8	3.33
2	Not attended	232	96.67
	Total	**240**	**100.00**

As seen from Table 4.14, only eight out of the 240 farmers (3.33%) attended at least one training programme. Whereas the rest 96.67 per cent of polyhouse farmers did not attend any e-literacy training.

Successful application of ICTs depends upon digital literacy of the people. The provision of e-literacy should target those without or who have limited access to internet. It has to be seriously noted that the number of need-based e-literacy trainings provided for farming communities are very less. If one traces the training provided for farmers by the line departments, there have been only a few e-literacy training programs organised in Kerala state. This trend needs serious rethinking. The concerned authorities should give emphasis on the digital liter acy of the farmers besides agriculture. In this regard regular campaigns should be launched to impart knowledge on the use of digital aids.

The result is in accordance with that of Kafura *et al.* (2016).

4.2. ICT utilisation of polyhouse farmers

4.2.1. ICT tools used

It is evident from the Table 4.15 that mobile phones are the most popular ICT gadgets among the farming community in Kerala with a score of 85 out of 100 and 78.33 per cent of the farmers use it for both agricultural and non agricultural purpose. Mobile based apps scored 78.75 out of 100 which makes it the next commonly used information gathering tool. A score of 78.33 indicates that the polyhouse farmers are familiar with the use of social media. Nearly three-fourth of the farmers utilise mobile apps for both farming and non farming purposes. The polyhouse farmers are well versed with websites and portals (Score = 66.25). Average scores obtained in case of laptops/ computers and email usage (Scores = 54.58 and 52.92, respectively) points to the moderate familiarity with the tools. Obviously laptops are not that common with the farmers. The usage of SMS services and call centers for information gathering is relatively low among farmers with below average scores of 40.42 and 32.50, respectively. Forty and sixty per cent of the farmers use SMS services and call centers, respectively for farming requirements. Farmers mainly used toll free number 1800-80-1551 to connect with Kisan Call Centres. Tablet is one of the most unpopular tools with a score of 27.50 out of 100. The lowest score obtained for Decision Support System (DSS)/ Specialised softwares (Score = 5.83) specifies that it is the least utilised tool by polyhouse farmers. A majority of the farmers (80%) are unaware of the use of it. Only 3.33 per cent of the farmers are using specialised softwares and DSS for agricultural purposes. It is quite unfortunate that the advantages of DSS are not popular among the farmers

The results depicts the importance and popularity of tools such as mobile phones, mobile apps, social media, and websites and portals among other ICT tools. An alternative to traditional agricultural extension services is to deliver agricultural information to farmers via low-cost information and communication technologies. The results in Table 4.15 ensures the technology providers that tools like mobile phones, social media, portals and the like can be utilised to deliver a wide range information along with financial services such as payments, credits, insurance, and savings. Information dissemination through appropriate methods using these tools should be popularised to improve knowledge and skill of farmers and thereby, adoption of innovations.

Syiem and Raj (2015), Tomar *et al.* (2016), and Srivasthava (2018) observed similar pattern in ICT usage among farmers.

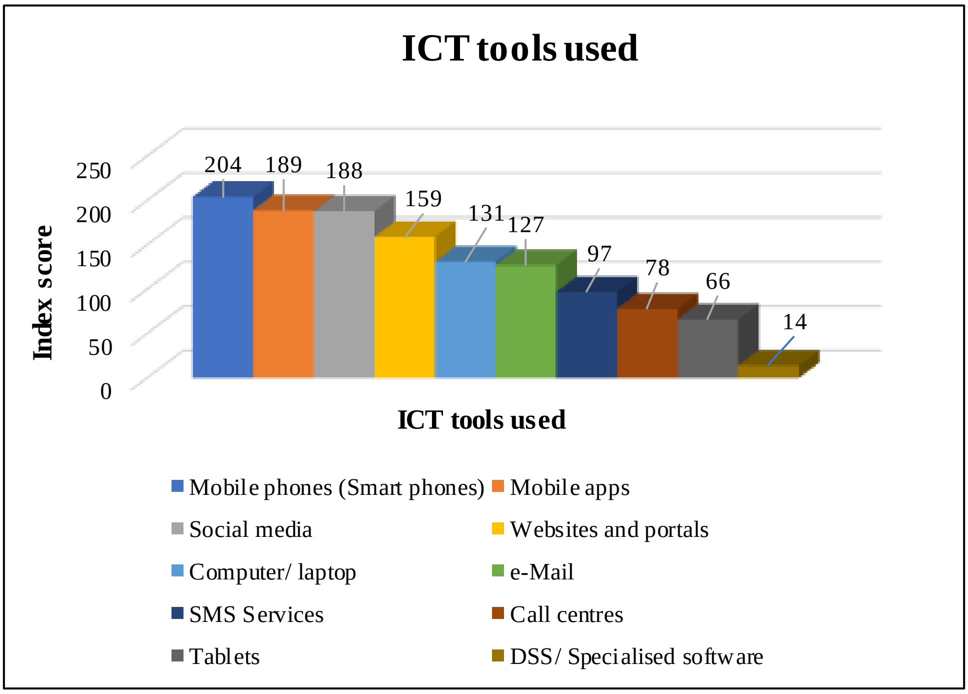


Figure 4. ICT tools used by polyhouse farmers

Table 4.15. ICT tools used by polyhouse farmers (N=240)

Sl. No.	ICT Tools	Score (Out of 100)	Agricultural purpose only		Non-agricultural purpose only		Both		Non users	
			Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
1	Mobile phones (Smart phones)	85.00	0	0.00	28	11.67	188	78.33	24	10.00
2	Mobile apps	78.75	12	5.00	16	6.67	172	71.67	40	16.67
3	Social media	78.33	8	3.33	24	10.00	168	70.00	40	16.67
4	Websites and portals	66.25	36	15.00	36	15.00	120	50.00	48	20.00
5	Computer/ laptop	54.58	12	5.00	100	41.67	64	26.67	64	26.67
6	e-Mail	52.92	12	5.00	104	43.33	60	25.00	64	26.67
7	SMS Services	40.42	96	40.00	76	31.67	28	11.67	40	16.67
8	Call centres	32.50	144	60.00	24	10.00	12	5.00	60	25.00
9	Tablets	27.50	28	11.67	60	25.00	28	11.67	124	51.67
10	DSS/ Specialised software	5.83	8	3.33	32	13.33	8	3.33	192	80.00

4.2.3. Purpose of using ICTs

Closely analysing Table 4.16 and Fig. 5, it can be understood that the main information collected through ICTs for polyhouse cultivation was plant protection followed by particulars on production practices with scores of 151 and 138, respectively. The next important purpose was quality input procurement for protected cultivation (score =133) and weather-related information (score = 104). Market related information was the next most needed information gathered with the help of ICTs. The scores of value addition and post-harvest of the produce were comparable (68 and 66, respectively) which makes it in the sixth and seventh mostly gathered knowledge through ICTs. Information and communication technology tools had not been used much while farmers collected information on credit and insurance and agricultural schemes and subsidies.

Some of the information on crop production and marketing such as market price, value addition, post-harvest handling of produce, credit and insurance, agricultural schemes and subsidies were not easily available to farmers. Such data and information should be provided to farmers through suitable ICT tools to help them in their decision making.

Table 4.16. Purpose of using ICTs by polyhouse farmers (N=240)

Sl. No.	Purpose	Score
1	Plant protection	151
2	Production practices	138
3	Procurement of quality inputs	133
4	Weather-related information	104
5	Market-related information	84
6	Value addition	68
7	Post-harvest handling of produce	66
8	Credit and insurance	61
9	Agricultural schemes and subsidies	34

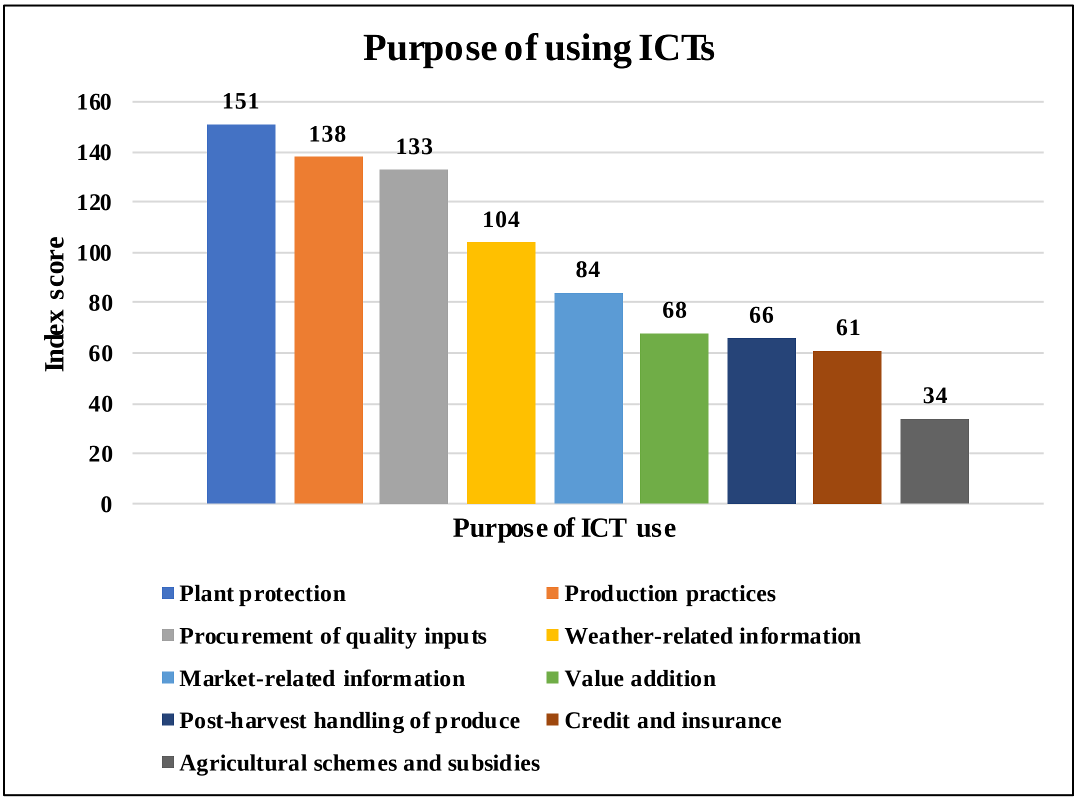


Figure 5. Purpose of using ICT tools by polyhouse farmers

Table 4.17. Distribution of polyhouse farmers according to ICT utilisation

(N=240)

Sl. No.	ICT utilisation	Frequency	Percentage
1	Low (Less than 33.45)	56	23.33
2	Medium (33.45 to 55.45)	96	40.00
3	High (More than 55.45)	88	36.67
	Total	**240**	**100.00**

Table 4.17 elucidates that more than one third of polyhouse farmers (36.67%) utilised ICTs to a higher extent and 40 per cent farmers used it in a moderate way. Less than one fourth (23.33%) of the polyhouse farmers' ICT utilisation scores were very less. As mentioned earlier, education, mass media contact and innovativeness can positively affect the ICT utilisation of farmers. Apart from all these, the infrastructural development in Kerala is much ahead than that of majority of the states in the country.

With high priority developmental concerns, the State has been in the forefront of ICT initiatives in the country (Palackal *et al.*, 2007).

The result of the present study shows similarity to the findings of Kabir (2015) and Naik *et al.* (2020) regarding the ICT usage among farmers.

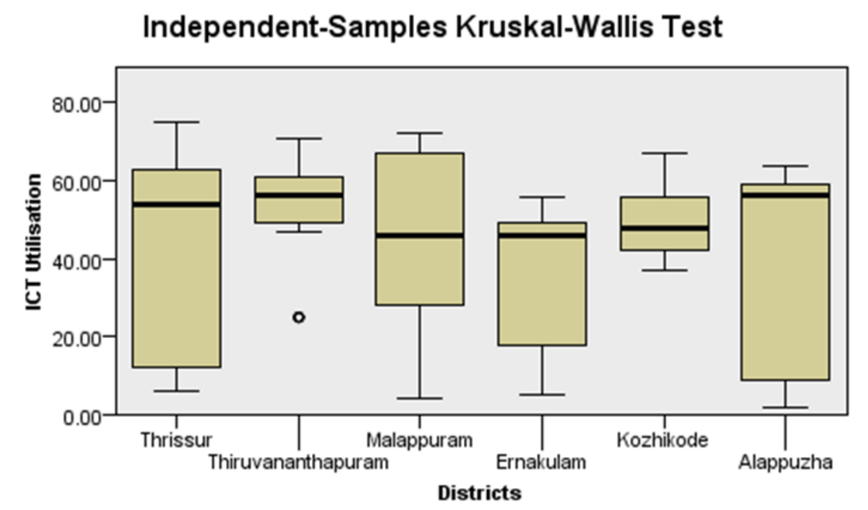
4.2.4. Comparison of ICT utilisation among districts

Kruskal Wallis one way test was used to compare the ICT utilisation among the six districts from which the data were collected. The results are shown in the Table 4.18. as well as in Fig. 6.

Fig. 6 depicts that the median values have slight variation from district to district. The significance at one per cent level indicates significant difference in ICT utilisation across six districts. The highest median value is of Thiruvananthapuram district, which shows that ICT utilisation was more among the farmers of this district. The position of the median of Ernakulam district is lower and it explains the lower ICT usage. The length of whiskers tells that the farmers with highest ICT utilisation was from Thrissur district and the lowest ICT utilisation was from Alappuzha.

Table 4.18. Comparison of ICT utilisation of polyhouse farmers among six districts (N=240)

Sl. No.	Districts	Sample size	Mean scores
1	Thiruvananthapuram	40	149.70
2	Thrissur	40	131.90
3	Malappuram	40	122.30
4	Kozhikode	40	120.50
5	Alappuzha	40	116.90
6	Ernakulam	40	81.70
	Total	**240**	



Total N	240
Test Statistic	20.808
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	.001

1. The test statistic is adjusted for ties.

Figure 6. Box plot indicating the district wise comparison of ICT utilisation by polyhouse farmers

Table 4.18. reveals that, the variation of mean ranks of ICT utilisation is significant across these groups at one per cent level of significance. That means the level of ICT utilisation is significantly different among the farmers of all these six districts. Polyhouse farmers in Thiruvananthapuram district showed high ICT utilisation followed by those from Thrissur district. Farmers from Alappuzha and Ernakulam showed lowest ICT utilisation.

4.2.5. Factors affecting ICT utilisation of polyhouse farmers

The relationship between ICT utilisation and profile characteristics of polyhouse farmers (such as age, education, land holding, annual income, family size, farming experience, innovativeness, social participation, mass media contact, achievement motivation, change resistance, e-literacy trainings received and ICT utilisation of farmers) were drawn using the assessment of Spearman's correlation coefficient. The results are given in the Table 4.19.

Table 4.19. Linear relationship between ICT utilisation and profile characteristics of polyhouse farmers (N=240)

Sl. No.	Independent variables	Correlation coefficient (r)
1	Age	-0.410**
2	Gender	-0.310
3	Education	0.323*
4	Land holding	0.023
5	Annual income	0.424**
6	Family size	-0.127
7	Farming experience	-0.326*
8	Innovativeness	0.552*
9	Social participation	0.398**
10	Mass media exposure	0.469**
11	Achievement motivation	0.345**
12	Change resistance	-0.531**
13	Trainings on mobile /ICT usage	-0.019

**Correlation is significant at 0.01 level (2 tailed)
*Correlation is significant at 0.05 level (2 tailed)

An overview of Table 4.19 gives a clear picture of the relationships existing between ICT utilisation and profile characteristics of farmers in the study. Education, annual income, innovativeness, social participation, mass media exposure, and achievement motivation showed a positive correlation with ICT utilisation and variables such as age, farming experience, and change resistance exhibited a negative correlation with ICT utilisation.

The results indicate that younger farmers are more ready to use modern technologies as an efficient information and communication tool. They are always open to new experiences and, in many circumstances, are not hesitant to accept new. At the same time, it is seen that the variable farming experience had negative effect on the use of mobile phone among farmers. The farmers with vast experience generally consist of older farmers, and younger farmers are usually less experienced. The inclination of youngsters towards most updated technology and confidence to use the tools are more, compared to older persons.

It is apparent from Table 4.19 that higher the education level of farmers, more will be their ICT utilisation. Education can boost the confidence and decision-making ability of farmers to adopt a new technology and capability to learn the skills to use it. Literate farmers have better awareness on the importance of ICT tools for farming purposes. Annual income makes the farmers economically capable for buying more sophisticated tools for obtaining information and effective communication. This might be the reason behind positive and significant relationship between ICT utilisation and annual income.

Innovativeness is an important factor which can decide the technology usage among farmers. More innovative farmers can quickly make positive decisions prior to the adoption of a new technology, and they accept changes for improvement. Here, one can see a positive correlation between innovativeness and ICT utilisation and a negative correlation between change resistance and ICT utilisation among farmers.

Social participation and mass media exposure improve relationship between farmers and thus their information seeking behaviour. The farmers may get updated with newer technologies and available tools. High achievement motivation improves the innovativeness, quest of knowledge, and skills among farmers. They tend to be more technologically and psychologically ready to use tools such as laptops, internet, and mobile apps.

Studies of Tomar *et al.* (2016), Kafura *et al.* (2016), and Mathews and Jadav (2020) showed similar pattern of relationship between the independent variables and ICT utilisation.

4.2.6. Chance to have an above average ICT utilisation

Computation of Spearman's correlation coefficient proved that most of the variables are significantly correlated with ICT utilisation. To get more insight on the effect of independent variables on dependent variable, ICT utilisation, binary logistic regression was performed. This analysis was meant to provide a clear understanding on the odds to have an above or below average ICT utilisation of the farmers when there is a unit increase in the independent variables such as age, education, land holding, annual income, family size, farming experience, innovativeness, social participation, mass media contact, achievement motivation, change resistance, e-literacy trainings attended. The summary of the results of binary logistic regression is given in Table 4.20.

Table 4.20. Odds ratios showing the chance to have above or below average ICT utilisation (N=240)

Sl. No.	Variables	B	S.E.	Wald	Sig.	Exp(B) (Odds ratio)	Probability
1	Age	-1.682	0.473	12.632	**0.000**	**0.186****	**0.16**
2	Gender	0.115	0.660	0.030	0.862	1.122	0.53
3	Education	-0.367	0.337	1.185	0.276	0.693	0.41
4	Land holding	-0.245	0.302	0.660	0.417	0.783	0.44
5	Annual income	0.119	0.411	0.084	0.773	1.126	0.53
6	Family size	-1.246	0.445	7.826	**0.005**	**0.288****	**0.22**
7	Farming experience	-1.448	0.353	16.848	**0.000**	**0.235****	**0.19**
8	Innovativeness	0.265	0.593	0.200	0.655	1.304	0.57
9	Social participation	1.602	0.447	12.864	**0.000**	**4.961****	**0.83**
10	Mass media exposure	1.440	0.356	16.365	**0.000**	**4.222****	**0.81**
11	Achievement motivation	0.221	0.359	0.379	0.538	1.247	0.55
12	Change resistance	-1.173	0.461	6.487	**0.011**	**0.309***	**0.24**

*Significant at five per cent level

**Significant at one per cent level

Table 4.20 reveals that the variables age, family size, farming experience, social participation, mass media exposure and change resistance showed significant relationship. From the odds ratio, it can be observed that there is 0.186 times chance that polyhouse farmer will fall in the category of below average ICT utilisation if a unit increase in age occurs. There is 0.288 times chance that the farmer will belong to below average ICT utilisation category if a unit increase in family size occurs. Similarly, there is 0.235 and 0.309-times chance that the farmer will fall in below average ICT utilisation if there is a unit increase in farming experience and change resistance occurs.

At the same time, there is 4.961 times chance that the farmer will belong in above average ICT utilisation category if there is a unit increase in social participation occurs. Similarly, there is 4.222 times chance that the farmer will belong in the category of above average ICT utilisation category if a unit increase mass media exposure occurs.

4.2.7. Factors affecting ICT utilisation

Factor analysis was performed to reduce the dimensionality of variables to small number of factors. Principal component method was used for the extraction of different factors in this study. Here, factors with eigen values of more than one were selected. A total of four variables with eigen values of more than one were extracted.

Table 4.21. Extraction of major factors of ICT utilisation

Sl. No.	Variables	Factors			
		1	2	3	4
		Information dynamics	Innovation orientation	Proficiency enhancement	Demographics
1	Social participation	0.824			
2	Mass media exposure	0.785			
3	Annual income	0.696			
4	Achievement motivation	0.548			

5	Change resistance		-0.772		
6	Innovativeness		0.742		
7	Age		-0.707		
8	Education			0.831	
9	Farming experience			-0.691	
10	Trainings attended on mobile phones/ ICTs			0.548	
11	Land holding				0.898
12	Family size				0.636
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalisation					

Table 4.22. Variance explained by components of ICT utilisation

Factors	Eigen value	Variance explained	
		Percentage	Cumulative Percentage
1	3.19	26.59	26.59
2	2.01	16.79	43.37
3	1.76	14.65	58.03
4	1.16	9.68	67.71

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.557
Bartlett's Test of Sphericity	Approx. Chi-Square	1081.230
	df	66
	Sig.	.000

Figure 7. KMO and Bartlett's test of factors of ICT utilisation

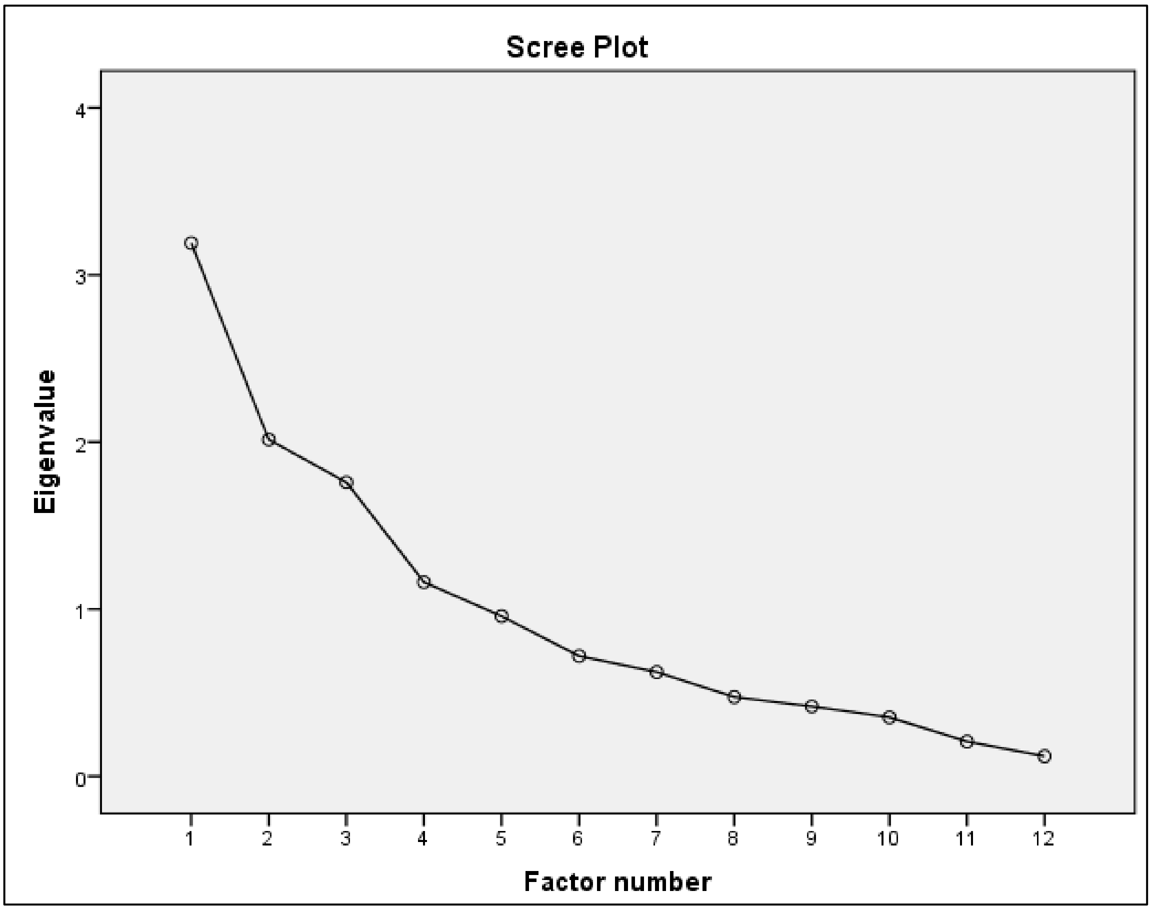


Figure 8. Scree plot confirming the extraction of four components of ICT utilisation with eigen value more than one

Factor 1: Information dynamics

The first factor included social participation, mass media exposure, annual income, and achievement motivation of farmers. Obviously, these are closely connected with the information exchange of farmers. Hence, these variables were grouped under the title information dynamics. The eigen value observed was 3.19. The percentage of variance explained by this factor alone was 26.59 which makes it the second most important variable.

Factor 2: Innovation orientation

The second factor consisted of variables namely, change resistance, innovativeness, and age. These three variables represent the inclination of the farmers towards a technology or innovation. Hence, they were grouped under the name 'innovation orientation'. The eigen value of the factor was 2.01 and the variance explained by this factor alone is 16.79 per cent out of total variance explained by these four factors *i.e.*, 67.71. Naturally, it is one of the most important factors affecting ICT utilisation of the farmers.

Factor 3: Proficiency enhancement

The third factor was proficiency enhancement, which comprised of education, farming experience, and trainings on ICTs/ mobile phones attended by farmers. These three variables can affect the knowledge and skill of farmers and thereby their confidence in using a newer technology. This factor had an eigen value of 1.76 and variance explained accounts about 14.65 per cent.

Factor 4: Demographics

The fourth factor was demographics which consisted of the data regarding land holding and family size of the farmer. These two variables contributed relatively less towards the ICT utilisation of farmers. The percentage of variance explained by this factor was 9.68. Logically these two variables would not have much bearing on adopting innovative technologies like ICTs.

The total variance explained by the above four factors was 67.66 per cent.

4.2.8. Effect of factors on ICT utilisation

Table 4.23. Effect of factors on ICT utilisation

Sl. No.	Factors	B (Regression coefficients)	Standardized Coefficients	t value	Sig.
1	Information dynamics	7.371	0.357	8.478	0.000
2	Innovation orientation	11.018	0.534	12.673	0.000
3	Proficiency enhancement	8.334	0.404	9.586	0.000
4	Demographics	-1.913	-0.093	-2.200	0.029

To have more insight on the effect of the four factors on the ICT utilisation of farmers, linear regression analysis between the factors and ICT utilisation was worked out. The results are given in Table 4.23. The effect of the factors; *viz.*, innovation orientation, information dynamics and proficiency enhancement were found to have a positive and significant effect on the dependent variable. At the same time, the factor demographics had a negative and significant effect on the dependent variable; ICT utilisation.

From a close perusal of the results of regression analysis between information dynamics and ICT utilisation, it can be inferred that there is a significant and positive effect. It also implies that a unit increase in the information dynamics can cause an increase in ICT utilisation by 7.371 units. Information gathering can have visible effect on the frequency and purpose of using ICTs by making farmers aware of the technology.

Meanwhile, ICT utilisation was found to increase by 11.018 units with a unit of increase of the factor, innovation orientation. The negative effect of change resistance and positive effect of innovativeness might have contributed to the higher B value of this factor.

Proficiency enhancing variables included education, farming experience, and mobile or ICT related trainings attended. It is clearly understood that these variables helped in the improvement of skill, knowledge, and confidence among the farmers leading to the adoption of better technologies. The regression analysis shows that a unit increase in the proficiency enhancement increases the ICT utilisation by 8.334 units. It was significant at one per cent level.

The regression analysis reveals that the demographic variables have a negative influence on the utilisation of ICTs. This means that the frequency and purpose of ICT usage increased when the family size and land holding of farmers got reduced. Even though the variables might not have a direct effect on ICT utilisation, the family size might have had a direct influence on per capita income and hence on their financial readiness to buy an improved ICT tool.

4.2.9. Constraints in the use of ICTs

Table 4.24. Constraints in the use of ICTs among polyhouse farmers (N=240)

Sl. No.	Constraints	Score		Rank
		Out of 4	Out of 100	
1	Lack of locally relevant information	2.10	52.50	1
2	Non availability of information in the vernacular	1.57	39.17	2
3	Lack of needed contents online	1.17	29.17	3
4	Lack of awareness about various ICT tools	1.03	25.83	4
5	Lack of enough time to spend on technologies	1.00	25.00	5
6	Lack of adequate skill	0.97	24.17	6
7	Technophobia	0.92	22.92	7
8	Lack of confidence and motivation to use ICT tools	0.87	21.67	8
9	High cost of the gadgets and associated accessories	0.85	21.25	9
10	No relative advantage over conventional information gathering methods	0.78	19.58	10
11	Existence of better alternatives	0.68	17.08	11
12	Lack of adequate services in the locality	0.65	16.25	12
13	Lack of proper infrastructure	0.37	9.17	13
W value: **0.482****				

Table 4.24 points out that farmers faced some problems hindering the use of ICTs. The score of 52.50 out of 100 indicates lack of locally relevant information was a moderately important constraint among polyhouse farmers. The below average scores (*i.e.*, less than 50) of constraints such as non-availability of information in the vernacular, lack of needed contents online, lack of awareness about various ICT tools, and lack of time and skill were the issues faced only by a few farmers . Most of the famers were confident in using ICTs (Score = 21.67) and the gadgets were affordable to majority of the farmers (Score = 21.25). Lack of adequate services in locality and proper infrastructure were the least concerned problems by polyhouse farmers. Kerala

is one of the states which shows rapid infrastructural development. The Kerala model of growth relies more on social changes which is supposed to trigger off rapid momentum of growth in various spheres of activity and it applies in the rural sector too (Jha and Tandon, 2019).

The results indicates that the ICT utilisation in agriculture may get increased if adequate and locally relevant information is given in the vernacular.

The Kendall's coefficient of concordance value was found to be 0.482 at one per cent level of significance which shows a fair agreement among farmers regarding their opinion about constraints in the use of ICTs.

4.3. m-Readiness

m-Readiness, in this study, was sub categorised in to four domains (physical readiness, technological readiness, psychological readiness and economic readiness) which explains the overall readiness for mobile usage among the farmers. The worked-out scores of each category were as follows. The maximum possible score was 60.

Table 4.25. Domain wise readiness scores of farmers (N=240)

Sl. No.	m-Readiness domains	Score
1	Physical readiness	50.95
2	Psychological readiness	47.95
3	Technological readiness	44.33
4	Economic readiness	44.17

The score of each category defines the preparedness and ability of farmers to use mobile phones in that particular aspect. In Table 4.25, it is seen that score of physical readiness was the highest among the four (Score=50.95), which means that the polyhouse farmers have good infrastructural conditions to use mobile phones. The most probable reason for this might be that Kerala State stands out with its high position in physical quality of life index. Also, the infrastructural development like mobile towers and good network even in rural areas of Kerala is good. The farmers could utilise the facilities available to make the best use of mobile phones for different purposes.

Psychological readiness of the farmers stood in the second position with a score of 47.95 out of 60. This indicates that the farmers are mentally prepared to use mobile phones. The score indicates the positive attitude of farmers towards the use of mobile phones. Mobile phone has become a popular tool and part of life among the farming community also. The farmers know the potential of mobile phones to gather information and for efficient communication. Even those who lack proper knowledge and skills on mobile phones are mentally prepared to use it.

Technological readiness indicates the knowledge and skill to use mobile phones for various purposes. The results reveal (score=44.33) that the farmers exhibited good skills in using mobile phones especially smartphones. It is evident from the study that most of the farmers are well educated with high level of innovativeness and less change resistance. These factors could explain their technological skill and knowledge on mobile phones.

Even though the position of economic readiness was last in the list, the score (44.17) indicated a fairly high economic readiness among the farmers. The farmers involved in the polyhouse cultivation were found to earn moderate to high income annually. This itself can be a reason of the economic readiness expressed by the farmers.

Table 4.26. Distribution of polyhouse farmers according to their m-readiness (N=240)

Sl. No.	m-Readiness of farmers	Frequency	Percentage
1	Low (less than 153.83)	52	21.67
2	Medium (153.85 to 205.67)	72	30.00
3	High (more than 205.67)	116	48.33
	Total	**240**	**100.00**

The distribution pattern of the farmers obtained after assessment of m-readiness is given in Table 4.26. It indicates that nearly half the farmers (48.33%) showed high m-readiness. Thirty per cent of them showed medium level of m-readiness. The low degree of m-readiness was exhibited by 21.67 per cent of farmers. The fast-growing cyber technology has made mobile phones a popular and useful information and communication device among the farmers. The high m-readiness can be explained by the technological growth in the area, high education level, and mass media exposure of the farmers apart from the usefulness, quick access to information sources, and easiness in using mobile phones rather than any other electronic gadget.

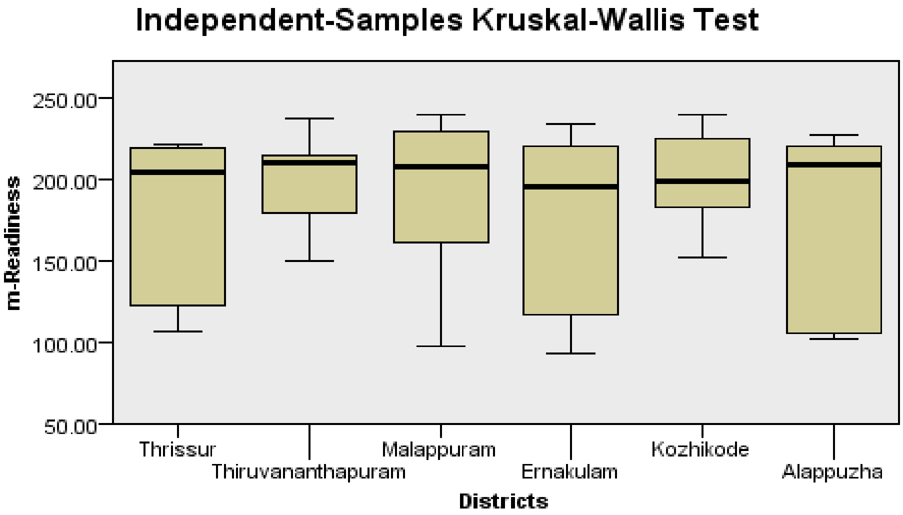
Deepika *et al.* (2020) and Ajayi *et al.* (2018) reported similar results in their studies regarding mobile phone usage.

4.3.1. Comparison of m-readiness among the selected districts of Kerala

Table 4.27. District wise m-readiness scores of polyhouse farmers (N=240)

Sl. No.	Districts	Sample size	Mean score
1	Malappuram	40	131.7
2	Kozhikode	40	126.1
3	Thiruvananthapuram	40	123.7
4	Thrissur	40	115.3
5	Alappuzha	40	113.9
6	Ernakulam	40	112.3
	Total	**240**	

Kruskal Wallis one way test was used to compare the m-readiness among the six districts of Kerala from where the data were collected. The results are shown in Table 4.27 as well as in Fig. 8.



Total N	240
Test Statistic	2.532
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	.772

1. The test statistic is adjusted for ties.
2. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

Figure 9. Box plot indicating the district wise comparison of m-readiness of polyhouse farmers

Fig. 8 reveals that, the variation of mean scores of m-readiness is insignificant across these groups. The level of m-readiness was same among the farmers of all these six districts. Mobile phones are one of the popular modes of information gathering and communication even among the common man and also among the rural folk. Only a few farmers in the study were found to be the non-users of mobile phones across the State.

4.3.2. Linear relationship between m-readiness and profile characteristics of polyhouse farmers

The relationship between m-readiness and profile characteristics of farmers (age, education, land holding, annual income, family size, farming experience, innovativeness, social participation, mass media contact, achievement motivation, change resistance, e-literacy trainings received and ICT utilisation of farmers) was drawn using the assessment of Spearman's correlation coefficient. The results are presented in Table 4.28.

Table 4.28. Linear relationship between m-readiness and profile characteristics of polyhouse farmers (N=240)

Sl. No.	Independent variables	Correlation coefficient (r)
1	Age	-0.448**
2	Gender	0.049
3	Education	0.341**
4	Land holding	0.121
5	Annual income	0.430**
6	Family size	-0.131*
7	Farming experience	-0.280**
8	Innovativeness	0.532**
9	Social participation	0.224**
10	Mass media exposure	0.115
11	Achievement motivation	0.337**
12	Change resistance	-0.594**
13	Trainings on mobile usage	0.136*
14	ICT utilisation	0.656**

**Correlation is significant at 0.01 level (2 tailed)

*Correlation is significant at 0.05 level (2 tailed)

An overview of Table 4.28 gives a clear picture of the relationships existing between m-readiness and profile characteristics of farmers in the study. Education, annual income, innovativeness, social participation, achievement motivation, trainings attended, and ICT utilisation showed a positive and significant correlation with m-readiness and variables *viz.*, age, family size, farming experience, and change resistance exhibited a negative and significant correlation with m-readiness.

The results indicate that younger farmers are more ready to use mobile phone as an efficient information and communication tool. At the same time, it is seen that the variable farming experience had a negative influence on the use of mobile phone among farmers. The farmers with vast experience generally consist of older people, whereas the younger farmers are obviously less experienced. The inclination of youngsters towards most updated technology and confidence to use the tools is more, compared to older polyhouse farmers. This is a trend not only among the farmers but among people of all walks of life as well.

It is apparent from the Table 4.28 that higher the education level of farmers, more would be the m-readiness. Education aids in familiarisation with technology and can boost the confidence and decision-making ability of farmers to adopt a new technology and capability to learn the skills to use it. Literate farmers naturally have better awareness on the importance of ICT tools for farming purposes. Annual income makes the farmers economically capable for buying more sophisticated tools for obtaining information and effective communication. This might be the reason behind the positive and significant relationship between m-readiness and annual income.

Farmers living in smaller families use mobile phones to a greater extent than those with larger families. As the number of members increases in a family, the expenditure may also increase. This may pave way in reducing the financial stability of the family and thereby, the reduction of economic readiness in using mobile phones. Innovativeness is an important factor which can decide the mobile usage among farmers. Innovative farmers can quickly make positive decision prior to the adoption of a new technology and they accept changes for improvement. Here, one can see a positive correlation of innovativeness and negative correlation of change resistance with m-readiness among farmers.

Social participation improves relationship between the farmers and thus the information seeking behaviour of the polyhouse farmers. Through this way, the farmers get updated with newer technologies and tools available. High achievement motivation can improve the innovativeness, quest of knowledge, and skills among farmers. They tend to be more technologically and psychologically ready to use tools such as mobile phones.

4.3.3. Chance to have an above average m-readiness

The Spearman's correlation coefficient worked out shows that most of the variables are significantly correlated with m-readiness. To have a deep insight on the effect of independent variables on the dependent variable, m-readiness, binary logistic regression was performed. This analysis was meant to provide a clear understanding of the chance of the farmer to fall in the above or below average category of m-readiness when a unit increase in the independent variables such as age, education, land holding, annual income, family size, farming experience, innovativeness, social participation, mass media contact, achievement motivation, change resistance, e-literacy trainings received, and ICT utilisation of farmers occurs. The result of the analysis is given in Table 4.29.

Table 4.29. Odds ratio showing the chance to have above or below average m-readiness (N=240)

Sl. No.	Variables	B	S.E.	Wald	Sig.	Exp(B) (Odds ratio)	Probability
1	Age	-0.314	0.193	2.659	0.103	0.730	0.42
2	Education	-0.461	0.999	0.213	0.644	0.630	0.39
3	Land Holding	0.950	0.505	3.534	0.060	2.585	0.72
4	Annual income	0.000	0.000	2.678	0.102	1.000	0.50
5	Family size	-2.123	1.200	3.130	0.077	0.120	0.11
6	Farming experience	0.056	0.111	0.251	0.617	1.057	0.517

7	Innovativeness	5.019	2.558	3.851	**0.050***	**151.283**	0.99
8	Social participation	1.178	1.004	1.376	0.241	3.247	0.76
9	Mass media exposure	-0.894	0.429	4.350	**0.037***	**0.409**	0.29
10	Achievement motivation	1.023	0.700	2.138	0.144	2.783	0.74
11	Change resistance	0.161	0.337	0.229	0.632	1.175	0.54
12	ICT utilisation	0.288	0.105	7.527	**0.006****	**1.334**	0.57
	*Significant at five per cent level **Significant at one per cent level						

Table 4.29 reveals that only the variables namely innovativeness, mass media exposure, and ICT utilisation are significant. From the odds ratio, it can be inferred that there is 151.28 times chance that the farmer will fall in above average m-readiness category if a unit increase in innovativeness occurs.

Looking at the odds ratio of mass media exposure, it can be observed that the value is less than one, which indicates an inverse relationship between mass media and m-readiness. From the odds ratio, it can be inferred that there is 0.409 times chance that the farmer will fall in below average m-readiness category if a unit increase in mass media exposure occurs.

ICT utilisation is an important variable that can have a direct effect on the mobile readiness of the farmers. In the binary logistic regression, the odds ratio shows that, there is 1.334 times chance that the farmer will fall in above average m-readiness category if a unit increase in innovativeness occurs. It is obvious that the technology friendliness can motivate the farmers to use the mobile phones for all possible purposes.

4.3.4. Factors affecting m-readiness

Factor analysis was performed to reduce the dimensionality of variables to small number of factors. Principal component method was used for the extraction of different factors in this study. Here, factors with eigen values more than one were selected. A total of four variables with eigen values more than one were obtained.

Table 4.30. Extraction of major factors of m-readiness (N=240)

Sl. No.	Variables	Factors			
		1	2	3	4
		Innovation orientation	Information dynamics	Proficiency enhancement	Demographics
1	Change resistance	0.819			
2	Innovativeness	0.778			
3	Age	-0.690			
4	ICT utilisation	0.687			
5	Social participation		0.806		
6	Mass media exposure		0.797		
7	Annual income		0.668		
8	Education			0.805	
9	Farming experience			-0.652	
10	Trainings on mobile usage			0.596	
11	Land holding				0.900
12	Family size				0.634
	Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.				

Table 4.31. Variance explained by components of m-readiness

Factors	Eigen value	Variance explained	
		Percentage	Cumulative Percentage
1	3.69	21.83	21.83
2	2.18	20.01	41.84
3	1.76	14.67	56.51
4	1.16	11.15	67.66

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.626
Bartlett's Test of Sphericity	Approx. Chi-Square	1304.102
	df	78
	Sig.	.000

Figure 10. KMO and Bartletts test of factors of m-readiness

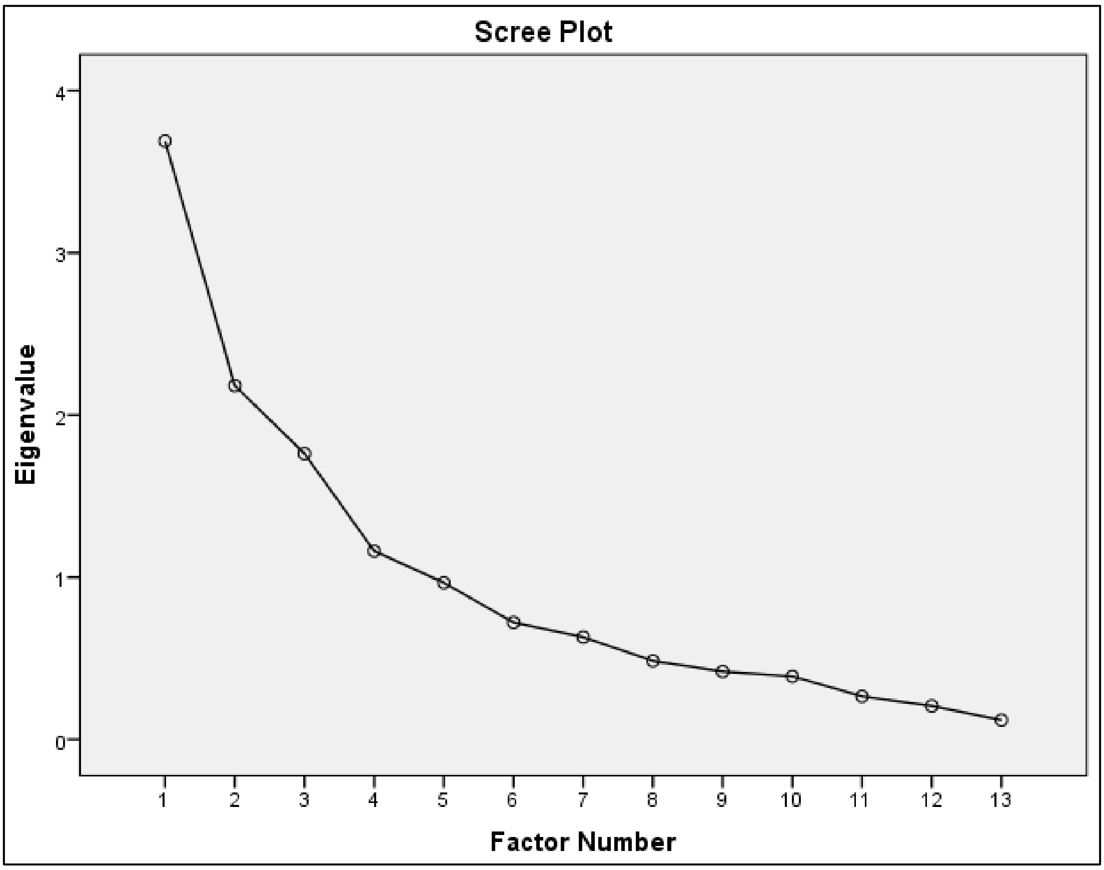


Figure 11. Scree plot explaining the extraction of components of m-readiness with eigen values above one

Factor 1: Innovation orientation

The rotated component matrix (Table 4.30) shows that the first factor consisted of variables namely, change resistance, innovativeness, age, and ICT utilisation. These four variables represent the inclination of the farmers towards a technology or innovation. Hence, it was grouped under the title innovation orientation. The eigen value of the factor was found to be 3.69. The variance explained by this factor alone is 21.83 per cent out of total variance explained by these four factors *i.e.,* 67.66 (Table 4.31). Therefore, it could be interpreted as one of the most important factors affecting m-readiness of the farmers.

Factor 2: Information dynamics

The second factor included social participation, mass media exposure, and annual income of farmers. These are closely connected with the information exchange of farmers. So, the variables were grouped under information dynamics. The eigen value observed was 2.18. The percentage of variance explained by this factor alone was 20.01 which makes it the second most important variable.

Factor 3: Proficiency enhancement

Third factor, proficiency enhancement comprised of education, farming experience, and trainings on ICTs/ mobile phones attended by farmers. These three variables can affect the knowledge and skill of farmers and thereby their confidence in using a newer technology. This factor has an eigen value of 1.76 and variance explained accounted for 14.67 per cent.

Factor 4: Demographics

The next factor was demographics which consisted of the data regarding land holding and family size of the farmer. These two variables contribute relatively less towards the m-readiness of farmers. The percentage of variance explained by this factor was 11.15.

The total variance explained by all the above four factors was 67.66 per cent.

4.3.5. Effect of factors on m-readiness

Table 4.32. Effect of factors on m-readiness

Sl. No.	Factors	B (Regression coefficients)	Standardized Coefficients	t value	Sig.
1	Innovation orientation	33.24	.752	25.615	0.000
2	Information dynamics	9.73	.220	7.498	0.000
3	Proficiency enhancement	18.79	.425	14.481	0.000
4	Demographics	-2.02	-.046	-1.560	0.120
	Adjusted R Square= 0.794**				

To have more insight on the effect of the four factors on the m-readiness of the farmers, linear regression analysis between the factors and m-readiness was worked out (Table 4.32). The effect of the factors; innovation orientation, information dynamics and proficiency enhancement were found to have a positive and significant effect on the dependent variable m-readiness. But the factor demographics have a negative and non-significant effect on the dependent variable.

Analysing the results of regression analysis between innovation orientation and m-readiness, it can be inferred that there is a significant and positive effect. It also implies that a unit increase in the innovation orientation can cause an increase in m-readiness by 33.24 units.

It is also observed from the results that the dependent variable-m-readiness increased by 9.73 units with a unit increase in the factor information dynamics. Information gathering can have visible effect on the m-readiness and its usage through making them aware of the technology.

Proficiency enhancing variables included education, farming experience in farming and mobile or ICT related trainings attended. It is clearly understood that these variables help in the improvement of knowledge, skill, and confidence among the farmers for the adoption of better technologies. The regression analysis shows that a unit increase in the proficiency enhancement increased the m-readiness by 18.79 units. It was significant at one per cent level.

The regression analysis revealed that the demographic variables did not influence m-readiness. That means the use of mobile phones does not depend on the family size and land holding of farmers.

In a predictive regression model, the adjusted R^2 indicates how well the data fits in the regression line. A higher R squared value indicates a better fit of the model. Here, the adjusted R^2 value as 0.794. This points out that 79.4 per cent of the variation in m-readiness can be explained by these four factors which shows a good fit of the regression model.

4.4. Polyhouse cultivation behaviour of farmers

4.4.1. Type of polyhouse

Table 4.33. Distribution of polyhouse farmers according to polyhouse type

(N=240)

Sl. No.	Type of polyhouse	Frequency	Percentage
1	Naturally ventilated	236	98.33
2	Climate controlled	4	1.67
	Total	**240**	**100.00**

From Table 4.33, it can be noticed that only 1.67 per cent of farmers had cultivated their crop under climate-controlled polyhouses. Except four polyhouse farmers, all were cultivating vegetables under naturally ventilated polyhouse (98.33%). The initial cost of climate-controlled polyhouses was much higher and were not affordable to many of the farmers compared to that of naturally ventilated polyhouses.

4.4.2. Area of polyhouse

Distribution of polyhouse farmers according to the area of polyhouse is given in Table 4.34.

Table 4.34. Distribution of polyhouse farmers according to area of polyhouse

(N=240)

Sl. No.	Area	Frequency	Percentage
1	Less than 500 m^2	200	83.33
2	500 to 1000 m^2	24	10.00
3	More than 1000 m^2	16	6.67
	Total	**240**	**100.00**

Majority of the polyhouse farmers (83.33%) owned a polyhouse less than 500 square meters of area. Ten per cent polyhouse farmers had a polyhouse of area in between 500 to 1000 m^2. Only 6.67 per cent cultivated in polyhouses of larger area (more than 1000 m^2). Construction of large polyhouses was reported unaffordable to most of the farmers. As polyhouse cultivation in Kerala is relatively new, only a very few farmers were ready to start with polyhouse cultivation in large areas.

4.4.3. Cost of construction

Table 4.35. Distribution of polyhouse farmers according to cost of construction of polyhouse (N=240)

Sl. No.	Area (Rs/ m^2)	Frequency	Percentage
1	Less than 1226	136	56.67
2	1226 or more	104	43.37
	Total	**240**	**100.00**

Most of the farmers constructed polyhouse at an average cost of Rs. 1226/m^2. More than half of the polyhouse farmers (56.67%) spent more than this average cost for construction of polyhouse. The maximum amount spent was 1968.75 /m^2. Exactly, 43.33 per cent of farmers constructed polyhouse with a cost less than the average cost incurred. The lowest amount spent for the polyhouse construction was Rs. 890/ m^2. The additional equipment used in the polyhouses varied from farmer to farmer. This was the reason for variation in the cost of construction.

4.4.4. Subsidy availed

Table 4.36. Distribution of polyhouse farmers according to subsidy availed (N=240)

Sl. No.	Subsidy availed	Frequency	Percentage
1	Less than 50 per cent	44	18.33
2	50 to 60 per cent	80	33.33
3	More than 60 per cent	116	48.34
	Total	**240**	**100.00**

The Kerala State Government and the Central Government have been providing subsidies through various schemes to encourage hi-tech farming in Kerala. The subsidy amount varied from 40 per cent to 75 per cent of the total construction cost incurred, according to the category of farmers and schemes through which the subsidies were allotted.

A total of 18.33 per cent of the farmers received a subsidy of less than 50 per cent of the total cost. As seen in table 4.36, 33.33 per cent of the farmers were credited with a subsidy of 50 to 60 per cent. Nearly half of the farmers (48.34%) received a financial support of more than 60 per cent of the cost incurred for construction of polyhouse. This has definitely acted as a motivator that promotes polyhouse cultivation in the state.

4.4.5. Construction material

All the farmers used five layered polyethylene film as the covering material and galvanised iron for constructing the frame of polyhouse. The covering material of the polyhouses of all the farmers were of 200 microns thickness and light transmission of about 85 to 90 per cent. These were the cost effective and most commonly available construction materials in Kerala.

4.4.6. Source of construction material

As per the information provided by the farmers, the major dealers who supplied materials for polyhouse construction were Poljo, Agriplast, Dinakara, and Green Care Kerala. Among these, most of the farmers had used the materials from the companies- Poljo and Agriplast. About 28.33 per cent of the farmers did not remember the names of dealers. There exists a gap in the brand specification of the materials. Farmers rarely care to like or dislike a specific brand. Instead, they accept the brands suggested by the constructer, or technician.

4.4.7. Cost of cultivation under polyhouse

The variable cost incurred by the farmers per square metre of area in a season was calculated and depicted in Table 4.31.

Table 4.37. Distribution of polyhouse farmers according to cost of cultivation in polyhouse (N=240)

Sl. No.	Cost of cultivation (Rs./ m^2/ season)	Frequency	Percentage
1	Less than 30	68	28.33
2	30 to 45	76	31.67
3	More than 45	96	40.00
	Total	**240**	**100.00**

A quick glance at Table 4.37 reveals that majority of the farmers (40%) spent at least Rs. 45/ m^2 of area per season as variable cost. Nearly one third (31.67%), spent a moderate level of Rs. 30 to 45/m^2 per season for various cultivation purposes. Similarly, 28.33 per cent of farmers incurred only a cost of less than Rs.30 per metre square. The average cost of construction was Rs. 45.22/m^2.

4.4.8. Income from polyhouse

Table 4.38. Distribution of polyhouse farmers according to income from polyhouse (N=240)

Sl. No.	Income (Rs./m^2 of land/ season)	Frequency	Percentage
1	Less than Rs. 300	60	25.00
2	Rs. 300-500	136	56.67
3	More than Rs. 500	44	18.33
	Total	**240**	**100.00**

Table 4.38 shows the distribution of polyhouse farmers according to the income from polyhouse. The income from polyhouse vegetable cultivation was in the range of Rs. 300-500/m^2 per season for more than half of the farmers (56.67%). One fourth (25.00%) of the farmers gained an income of only less than Rs.300/m^2/season. However, 18.33 farmers gained an income of more than Rs. 500/m^2/season. The average income of farmers from polyhouse vegetable cultivation was Rs. 426.72/m^2.

It is observed that lack of proper knowledge on polyhouse affected the efficiency in production. The income of farmers from the polyhouse can be increased by providing timely information and necessary trainings as and when required.

Besides the agronomic practices inside a polyhouse, basic trainings are required on the hardware part of polyhouse construction.

4.4.9. Trainings attended on polyhouse cultivation

Table 4.39. Distribution of polyhouse farmers according to trainings attended on polyhouse cultivation (N=240)

Sl. No.	Trainings on polyhouse	Frequency	Percentage
1	Attended	232	96.67
2	Not attended	8	3.33
	Total	**240**	**100.00**

A lion's share of the farmers (96.67%) attended trainings on polyhouse cultivation. Only 3.33 per cent of the polyhouse farmers did not attend any training. They either followed their fellow farmers or depended on skilled workers for the purpose. There were training programmes conducted by Kerala Agricultural University, Department of Agriculture and Farmers' welfare, Kerala, and Indian Institute of Horticultural Research, Bengaluru. Some of the farmers got opportunities to get field trips to successful polyhouses at Pune and Hyderabad. The researcher felt that the contents of the training programmes should be need based rather than a pre fixed syllabus. The continued use of agricultural technologies at grassroots level requires significant capacity building exercises, demonstrations and on-site training.

4.5. Constraints in polyhouse cultivation

The constraints in polyhouse cultivation were analysed under five domains. Under physical constraints, the most important issue faced by the farmers was the lack of skilled labour (Score = 61.67). Labour scarcity is getting worse in Kerala since the last three decades and now for most of the skilled and unskilled works. Farmers are depending on migrant workers. Farmers, with his family members can do many crucial works in the installation of polyhouse as well as cultural practices, by undergoing training. It is evident that, there is a problem in getting labourers who are specifically skilled to work in polyhouses. Table 4.40 indicates that, unavailability of quality input, is a moderate problem for the polyhouse farmers (Score = 47.08)

Table 4.40. Constraints in polyhouse cultivation (N=240)

Sl. No.	Constraints	Score		Rank
		Out of 4	Out of 100	
1	**Physical constraints**			
	Lack of availability of skilled laborers	2.47	61. 67	1
	Unavailability of quality inputs	1.88	47.08	2
	Water scarcity	0.96	24.17	3
	Limited/ irregular electric power supply	0.78	19.58	4
2	**Management-related constraints**			
	High occurrence of pest, diseases, and physiological disorders under polyhouse	3.28	82.08	1
	Difficulty in maintaining polyhouse	2.91	72.92	2
	Inadequate guidance from the part of concerned officials	2.91	72.92	3
	Difficulties in following package of practices for vegetable cultivation under polyhouse	2.0	50.00	4
	Lack of knowledge on vegetable cultivation under polyhouse	1.18	29.58	5
3	**Economic constraints**			
	High cost for repair and maintenance	3.06	76.67	1
	High wage of skilled workers in polyhouse	2.68	67.08	2
	Non-availability of credit in time	2.10	52.50	3
	Low income/profit from polyhouse	1.61	40.42	4
	Poor yield and low quality of produce	1.51	37.92	5
4	**Marketing related constraints**			
	Price fluctuations	2.91	72.92	1
	Lack of awareness regarding marketing and export of the produce	2.13	53.33	2
	Inadequate storage facilities	2.03	50.83	3
	Inadequate post-harvest handling facilities	1.9	47.50	4
5	**Policy related constraints**			
	Unavailability of insurance in case of damage	1.71	42.92	1
	Mis-utilising subsidy	0.76	19.17	2
	W value = 0.357**			

A score of 24.17 shows that, water scarcity is not a major problem. It is observed that, some of the farmers cultivating in coastal soils complained about the unavailability of quality of irrigation water due to severe problems with minerals and salinity. A few farmers faced an issue with electric power supply. Kerala state is one among the top infrastructurally developed states of India. Government schemes were also there to support electrical power needs in agriculture, which too at subsidised rates for farming. So, the constraint regarding power supply is one of the least important issues faced by the farmers.

Many issues encountered by the farmers were related to the proper management of polyhouse and the crops. In protected cultivation, pests and diseases are the major complications if proper care is not taken. Actually, this has led farmers to discontinue polyhouse cultivation, even though there was initial enthusiasm. From the data it is clear that the farmers opined about this problem, which registered a high score of 82.08. Proper knowledge on management of pests, diseases, physiological disorders, manuring and the like under polyhouse conditions is vital for its success. Difficulty in maintaining polyhouse was another issue raised by the polyhouse farmers (Score = 72.92). Farmers reported that, after rainy season algal growth occurrence was severe which in turn restricted light entry in to the polyhouse. The structure made it difficult for the farmers to clean the polyhouse. So, proper guidance and training should be given to polyhouse farmers to eliminate such problems. Next major issue was inadequate guidance from the concerned officials (Score = 72.92). As polyhouse cultivation is relatively a newer practice to farmers, most of them did not know the polyhouse specific cultivation aspects and were not getting enough support and supervision. So, effective supervision and proper guidance by the extension officials are very much essential for its sustainability.

The farmers are in general accustomed with open cultivation practices. It is apparent that the farmers may face difficulties while following a different mode of farming. The difficulty in following package of practices and lack of knowledge on vegetable cultivation were the other constraints pointed out by the farmers with scores of 50 and 29.58, respectively.

The cost of construction and maintenance of polyhouse is high. The farmers need financial support to start cultivation in polyhouse. As polyhouses get older it is necessary to change the covering material. Regular cleaning is also costly and difficult. The results show that the cost of routine repair and maintenance of polyhouse was unaffordable to most of the farmers (Score = 76.67). The government has provided them with financial assistance in the initial years of cultivation. But farmers complained that they had not been getting it for the last few years. The second important economic constraint was the high wage of skilled workers. As noted earlier, the farmers lacked availability of skilled workers, and if they get one, the wage is high, moreover, the labourers hesitate to work in highly humid and warm climate under polyhouse (Score 67.08).

According to the farmers, financial assistance is a relief, indeed. But they complained that the government as well as financial institutions were not providing monetary aid on time and hence, some of the farmers stopped cultivation under polyhouse. Low income from polyhouse was found to be a moderately important constraint with a score of 40.42. Some farmers opined that, in the initial years, the yield was very high, but started to decline in later seasons due to high disease and pest occurrence and low maintenance of polyhouse. Quality of the produce was superior as opined by most of the polyhouse farmers. Still, some of the farmers raised the issue of poor-quality produce from polyhouse (Score=37.92), might be due to high incidence of pests and diseases.

Polyhouse cultivation involves high cost and therefore, farmers need to have a guaranteed income from the crops. But due to certain extrinsic and intrinsic factors, marketing remained a big constraint for them. Price fluctuation stood in first position (Score=72.92). Many farmers stressed that a steep decline in price was found at the end of the season for certain crops which fetched very low market price. Farmers stated that Kerala is not a good market for crops such as salad cucumber. Hence, another market must be aimed to earn more income. Many farmers had faced difficulties to find markets even though good yield and quality produce were obtained. Many of the polyhouse farmers were unaware of the procedures to export the produce (Score = 53.33). It is essential to give them awareness on different marketing arenas in and outside the locality. Moreover, the marketing and exporting procedures should be made simple for the farmers.

The yield obtained from polyhouse was much higher compared to the open cultivation if proper cultivation practices aewre followed. In polyhouse, the frequency of harvest was also more. Lack of proper post-harvest handling (Score = 47.50) and storage facilities (Score=50.83) led some of the farmers to find it difficult to keep these perishable products until they market it. Bigger schemes for storage, warehousing, cold chambers and the like are essential.

The monsoon in Kerala may affect the polyhouse adversely due to wind and heavy downpour. As polyhouse cultivation was not included under agricultural insurance scheme, compensation amount was not provided for farmers (Score = 42.92). But presently some banks have included hi-tech farming in the list of insurance. Subsidies up to 60 per cent are being provided to farmers for construction of polyhouse. It was observed that a few farmers are cultivating under the polyhouse for getting the subsidy. Once the subsidies are obtained, there was a tendency to stop this method of cultivation. (Score = 19.17).

4.6. Vegetable-wise information needs of polyhouse farmers

Salad cucumber, amaranthus, chilli, and yard long bean were the most cultivated vegetable crops under polyhouses in Kerala. Hence, information needs on these crops were assessed.

4.6.1. Information needs on salad cucumber cultivation in polyhouse

The Kendall's coefficient of concordance (W) was calculated between items under each category. This value, points-out the degree of agreement between the farmers in rating the information needs. The W value closer to one indicates higher agreement among the polyhouse farmers regarding that specific cultivation practice. A value closer to zero indicated lesser agreement. The results are presented below.

Table 4.41. Agreement among farmers on information needs on salad cucumber cultivation

Sl. No.	Items	W value
1	Design and construction of	0.073**

	polyhouse	
2	Hi-tech seedling procurement and production	0.055*
3	Crop layout and design	0.177*
4	Disinfection of polyhouse	0.046
5	Micro irrigation system	0.302**
6	Fertigation system	0.005
7	Cooling system	0.094**
8	Maintenance and repair of polyhouse	0.011
9	Pest and disease management	0.091**
10	Nutrient management	0.151**
11	Weed management	0.084**
12	Pollination	0.303**
13	Training and pruning	0.022
14	Harvesting of crop	0.087**
15	Marketing of produce	0.445**
16	Schemes and subsidies	NA#

**Significant at 0.01 level of significance

*Significant at 0.05 level of significance

Not applicable as only one item is included under the category

Table 4.41. indicates that the category-wise W values of 11 out of 16 practices showed significant agreement among the polyhouse farmers regarding their information needs. Coefficient of concordance value of nine categories (design and construction of polyhouse, micro irrigation system, cooling system, pest and disease management, nutrient management, weed management, pollination, harvesting and marketing of produce) showed significant concordance at one per cent level. Whereas, cultivation practices like hi-tech seedling procurement and production and crop layout and design were significant at five per cent level of significance. The significance of these categories indicates that the agreement on the information needs among the farmers was fair enough to arrange the statements as given in Table 4.42, according to their mean score. The W value of variables such as disinfection of polyhouse, fertigation system, maintenance and repair, training and pruning were insignificant at one per cent as well as at five per cent levels of significance. This points out that the needs of farmers differed with each other.

Under the section, schemes, and subsidies, since only one item was included, W value was inestimable.

The item-wise mean scores obtained was used to select the most important information needed by farmers. The mean scores were arranged in descending order under each category in order organise the items according to the need of farmers.

Table 4.42. Information needs of farmers on salad cucumber cultivation in polyhouse (N=240)

Sl. No.	Items	Mean scores (M)
1	**Design and construction of polyhouse**	
	Orientation of polyhouse	3.48
	Selection of site for polyhouse construction	3.47
	Selection of materials for construction of polyhouse	3.33
	Ridge height	3.27
	Gutter height	3.27
	Covering material	3.17
2	**Hi-tech seedling procurement and production**	
	Crop varieties suitable for hi-tech vegetable cultivation	3.28
	Seedling production	2.95
	Grafted seedling production	2.88
	Source of seeds	2.82
	Transplantation of seedlings	2.78
3	**Crop layout and design**	
	Soil analysis	3.12
	Training of the crops	2.97
	Bed preparation	2.65
	Spacing of the seedlings	2.48
	Planting in growbags and potting mixture	2.18
4	**Disinfection of polyhouse**	
	Disinfection of polyhouse	3.72
	Soil sterilization	3.60
	Fumigation	3.47
5	**Micro irrigation system**	
	Maintenance and repair of the irrigation system	3.88
	Operation of the irrigation system	3.77
	Drip irrigation	3.35
	Installation of irrigation system	3.20
6	**Fertigation system**	
	Fertilizers suitable for fertigation	3.77
	Calculation of fertilizer doses	3.75
	Maintenance of soil parameters	3.73

	Maintenance and repair of fertigation system	3.72
	Operation of fertigation unit	3.72
7	**Cooling system**	
	Maintenance and repair of fogger	1.95
	Operation of fogger	1.85
	Installation of fogger	1.72
8	**Maintenance and repair of polyhouse**	
	Maintaining weather parameters inside polyhouse	3.77
	Cleaning of covering material of polyhouse	3.73
	Changing the covering material of polyhouse	3.67
9	**Pest and disease management**	
	Symptoms of diseases and pest infestation	3.88
	Biocontrol agents against pest and diseases	3.70
	Method of application of biocontrol agents	3.48
	Traps used for pest control	3.40
	Plant protection chemicals	3.38
	Dosage of the chemicals	3.25
	Soil application of chemicals	3.15
	Foliar spray of the plant protection chemicals	3.13
10	**Nutrient management**	
	Deficiency symptoms	3.88
	Toxicity symptoms	3.78
	Stage and time of application of fertilizers	3.73
	Rate of application of fertilizers	3.63
	Bio fertilizers to be applied	3.57
	Soil application of fertilizers	3.57
	Chemical fertilizers to be applied	3.53
	Foliar application of chemicals	3.38
	Composting	3.07
11	**Weed management**	
	Stage of weeding	2.03
	Weed flora found in polyhouses	1.80
	Mechanical weeding	1.73
	Chemical weeding	1.48
12	**Pollination**	
	Knowledge about assisted pollination	2.03
	Beekeeping	0.97
	Maintenance of bee hives	0.87
	Stage of keeping hives	0.85
13	**Training and pruning**	
	Training methods	3.43
	Pruning methods	3.35
	Time of training / pruning	3.33
	Stage of training / pruning	3.33
14	**Harvesting of crop**	
	Method of harvesting	2.68

	Stage of harvesting	2.48
	Harvesting time	2.35
15	**Marketing of produce**	
	Market rate of vegetable	3.62
	Storage	2.52
	Packing	2.52
	Grading	2.48
16	**Schemes and subsidies**	3.55

The design and construction of polyhouse was an important domain needed for farmers as the practice of polyhouse cultivation was relatively new in Kerala. The data indicates that the most essential information needed by farmers regarding the design and construction was the orientation of the polyhouse (M = 3.48), as they knew that sunlight availability was very essential while growing vegetables under polyhouse. In Kerala, North-South orientation and layout is recommended. Farmers positioned selection of site for polyhouse construction in the next place under design and construction (M=3.47). As the topography and climate differed from place to place in the state, farmers found this as one of the most important information. Knowledge about the right construction material and its source is very important as far as polyhouse construction is considered. Due to this, the farmers placed it as the third most important information among design and construction aspects with a mean value 3.33. According to the farmers, information about ridge height and gutter height were equally needed while constructing a green house.

Traditionally majority of the farmers practiced seed exchange, or they depended upon local sources for seeds. But as we consider high valued crop production in a closed condition, farmers knew the importance of advanced method of seedling production, better and reliable sources of planting material procurement. Hence, they needed more information on hi-tech seedling procurement and production. The foremost information needed was about the crop varieties suitable for hi-tech vegetable cultivation , as most of the farmers were novices in salad cucumber cultivation. Hi-tech seedling production and seedling grafting were the next two important information needed by the farmers with mean value 2.95 and 2.88 respectively. As self-pollinated and hybrid seeds were not commonly available to most of the farmers, they marked the item, seed source as moderately important information requirement (M=2.82). Most of the experienced farmers were familiar with the practice of transplantation, without giving transplantation shock to the seedlings. But some farmers needed the procedure and practice of transplantation and hence it was the fifth most important need with a mean of 2.78.

Some of the farmers lacked knowledge on crop layout and design while cultivating salad cucumber under polyhouse. Soil analysis is one of the other important aspects while doing polyhouse cultivation. The data from farmers indicate that the information regarding soil analysis was essential for farmers and the mean score given was 3.12. The next most important information under crop layout and design was the training of the crops as farmers pointed out that salad cucumber needs specialised structures to grow properly under a polyhouse (M=2.97). The practice of bed preparation is different in polyhouse from that of open cultivation. So, the farmers had placed it in the third position under crop layout and design with a mean score of 2.65. Most of the farmers had knowledge about spacing of the seedlings. A few of the farmers who had less experience in cucumber cultivation required information on spacing of seedlings and thus, it was assigned with a mean score of 2.48. Majority of the farmers preferred to plant cucumbers on bare soil rather than grow bags. Very few farmers were curious about the practice of salad cucumber cultivation in grow bags. Therefore, it was placed at the bottom of the category, crop layout and design with the mean score 2.18.

The micro atmosphere in polyhouse is in such a way that, the pests and disease control is difficult if proper care is not taken. So, farmers opined that information on disinfection of polyhouse is very essential and they placed disinfection, soil sterilisation and fumigation at high ranks with mean scores of 3.72, 3.60 and 3.47 respectively.

Micro irrigation is an inevitable part in crop cultivation under greenhouse. The installation, operation and maintenance require proper knowledge. The information on maintenance and repair and operation of irrigation system was very essential for farmers and they have placed it in first two positions (Mean scores of 3.88 and 3.77 respectively). Even though the rank of installation of irrigation system was the lowest in the category, the mean scores indicates that farmers found the information a much needed one (M=3.20). Some of the farmers were aware of the general information on drip irrigation and remaining farmers needed the information and the computed mean score 3.35.

Fertigation is the best method of fertilizer application in salad cucumber cultivated under polyhouse. Most of the farmers were not familiar with operation and maintenance of the fertigation unit. The mean values of all the items under this category were above 3.70 which shows that the information was essential for farmers. Among different aspects under the category, farmers required information about fertilizers suitable for fertigation which was followed by calculation of fertilizer doses and the mean scores were 3.77 and 3.75, respectively. In Kerala, so far, a full proof fertigation system for cultivation of vegetables in polyhouses are yet to come out. Research and trials are required in this aspect. Maintenance of soil parameters was positioned next with mean score 3.73. Operation, maintenance, and repair of the fertigation unit were equally important to farmers (M=3.72).

Very few farmers needed information on cooling system and majority of farmers does not feel the need of foggers or any cooling equipment inside polyhouse. The data points out that, the calculated mean scores were less than two, which indicated that the information was least important for the farmers. The items were installation, operation, and maintenance and repair of the fogger and the M values were 1.72, 1.85 and 1.95 respectively. This might be due to the lack of awareness on the importance of cooling system in polyhouse.

Knowledge regarding the maintenance and repair of polyhouse is very crucial for farmers. Algal growth resulting in the restriction of sunlight availability to plants, leading to yield reduction is a major problem faced by polyhouse farmers in Kerala. The adverse climatic conditions such as heavy rainfall, wind, and high humidity result in damage of the polyhouse as well as creates difficulty in maintaining weather parameters inside polyhouse. So, the farmers knew the importance of proper cleaning and maintenance of polyhouse. The items listed under the category were maintenance of weather parameters inside the polyhouse, cleaning of covering material, and changing of the covering material. The assessed mean scores were 3.77, 3.73 and 3.67 which indicated their higher requirement of the information.

According to the farmers, in protected cultivation, the closed atmosphere and microclimate makes pest and disease management a difficult task compared to that of open cultivation. Hence, farmers were more curious about the proper management of pests and diseases. The priority was given to symptoms of disease and pest infestation (M=3.88) as early identification was the most important factor which helps to reduce the spread of pests and diseases. Many of the farmers were practicing organic methods of pest control initially. So, they were interested to know about different biocontrol agents (M=3.70) and the methods to apply those (M=3.48). Apart from the use of biocontrol agents, farmers found that traps are also effective against pests. But they lack knowledge skill on that. So, they needed information about different insect traps and methods to use it (M=3.40). It is essential to have proper knowledge of chemicals while cultivating under polyhouse, for effective control of pests. Therefore, the polyhouse farmers marked items such as chemicals used, dosage of pesticides, soil, and foliar application of chemicals as highly crucial information with mean scores 3.38, 3.25, 3.15 and 3.13, respectively.

Fertilizer usage and its application in polyhouse is different from open cultivation. Most of the farmers lacked knowledge on different aspects of nutrient management, such as fertilizers used, doses, time of application and the like. Out of all the aspects regarding nutrient management, polyhouse farmers needed more information on deficiency and toxicity symptoms (mean value of 3.88 and 3.78, respectively). Only a few farmers knew about different chemical fertilizers used for salad cucumber under polyhouse, and others were unaware of that (M=3.53). They needed more insight on the stage and time of application as well as rate of application of fertilizers and the calculated mean scores of these items were found to be 3.73 and 3.63, respectively. It was also reflected from the scores that, soil application and foliar application of chemicals were much needed information with a mean score of 3.57 and 3.38, respectively. The data indicates that in case of nutrient management, farmers preferred chemical fertilizers rather than bio fertilizers for quick result. Integrated nutrient management and good agricultural practices (GAP) are now becoming popular among farmers and hence, they were more curious about the practice. It can be inferred that, the high mean scores of information needs regarding composting and bio fertilizer application (3.07 and 3.57, respectively) is the result of that awareness. Practical-oriented training classes are required for foliar application.

For from most of the polyhouse farmers, weed management was one of the least essential information needed by the polyhouse farmers. They opined that the weed control was possible without much difficulty. Majority of the polyhouse farmers were familiar with the weed flora found under polyhouse during salad cucumber cultivation and hence, very few farmers pointed it as a needed information (M=1.80). Relatively a higher number of farmers needed the information on the stage of weeding and the mean score was 2.03. The data also shows that management of weeds through mechanical method (M=1.73) was preferred by most of the farmers to chemical methods (M=1.48). Being in a confines area, manual weed control is easier when compared to open cultivation.

A vast majority of the farmers used self-pollinating seeds inside polyhouse. Only a very few farmers required information on the natural pollination aided by honeybees and other insects and the values were less than one. A slightly higher number of farmers needed information on hand pollination and other artificial crossing methods which can be possible under greenhouse (M=2.03). Farmers, in general were not interested in knowing the information about pollination. This might be due to their lack of awareness on artificial pollination and also due to the perceived complexity of the method, as they have not got any skill training in this.

The farmers realised that the training and pruning are critical aspects while cultivating salad cucumber in protected conditions. Training structures are needed to divert the crop to climb up and utilising vertical space properly under a polyhouse and about which they were less aware of. Along with the details of training and pruning methods, the stage of training and pruning was also found to be essential for the farmers. The respective mean scores of training methods, pruning methods, time of training and pruning and stage of training and pruning were 3.43, 3.35, 3.33 and 3.33. Here also skill trainings are required to take advantages of training and pruning.

Generally, farmers were familiar with harvesting procedures. But in protected cultivation, vertical growth of the plant makes the procedures a bit difficult. Hence, some farmers opined that, the process will be easier if they get more information on harvesting methods (M=2.68). Salad cucumber cultivation is a new practice among the farmers in Kerala, and hence, some of the farmers were unaware of stage of harvesting (M=2.48). Some farmers who were new to farming, required information on the time of harvest of salad cucumber under polyhouse (M=2.35).

Another key aspect regarding the cultivation of salad cucumber is about the market price. The crop is relatively new among the people of Kerala and many retail shopkeepers find it difficult to sell the produce also. So, marketing information regarding the crop was very essential among polyhouse farmers. The main information farmers required regarding the marketing was about the market rate of salad cucumber. Fluctuating market prices and difference in rates in various markets makes it difficult to sell the produce. Therefore, almost all the farmers marked it as an important information required for them. The calculated value was 3.62. Apart from this, all the aspects of marketing such as storage, packing and grading was moderately required for polyhouse farmers as they were familiar with the practices. But storage and packing had a relatively higher score of 2.52 each when compared to grading (M=2.48). The yield of salad cucumber obtained per day was very high in polyhouse and some farmers faced problem with storing and packing the bulk quantity of this vegetable. This might be the reason of giving more importance to storage and packing.

Initial investment to construct polyhouse is so high and most of the farmers reported that they cannot afford that. They pointed out that without any subsidies, loans or financial support polyhouse construction was impossible for them. So, they mentioned that the updated information on schemes and subsidies should be made available by the concerned authorities. The mean score of 3.55 indicated that the need is very essential.

4.6.2. Information needs on amaranthus cultivation in polyhouse

Table 4.43. Agreement among farmers on information needs on amaranthus cultivation in polyhouse

Sl. No.	Items	W value
1	Design and construction of polyhouse	0.073**
2	Hi-tech seedling procurement and production	0.206
3	Crop layout and design	0.072*
4	Disinfection of polyhouse	0.046
5	Micro irrigation system	0.302**
6	Fertigation system	0.005
7	Cooling system	0.094**
8	Maintenance and repair of polyhouse	0.011
9	Pest and disease management	0.290**
10	Nutrient management	0.151**
11	Weed management	0.084**
12	Harvesting of crop	0.187**
13	Marketing of produce	0.445**
14	Schemes and subsidies	NA#

**Significant at 0.01 level of significance

*Significant at 0.05 level of significance

Not applicable as only one item is included under the category

Table 4.43. indicates that the category-wise W values of 11 out of 16 practices showed significant agreement among the polyhouse farmers regarding their information needs. Coefficient of concordance value of nine categories (design and construction of polyhouse, micro irrigation system, cooling system, pest and disease management, nutrient management, weed management, pollination, harvesting and marketing of produce) showed significant concordance at one per cent level. Cultivation practices like hi-tech seedling procurement and production and crop layout and design were significant at five per cent level of significance. The significance of these categories indicates that the agreement on the information needs among the farmers was fair enough to arrange the statements as given in Table 4.44. according to their mean score. The W value of variables such as disinfection of polyhouse, fertigation system, maintenance and repair, training and pruning were insignificant at

one as well as five per cent level of significance. This points out that the needs of farmers differed with each other.

Under the section, schemes, and subsidies, since only one item was included, W value was inestimable.

The item-wise mean scores obtained was used to select the most important information needed by farmers. The mean scores were arranged in descending order under each category in order organise the items according to the need of the farmers.

Table 4.44. Information needs of farmers on amaranthus cultivation in polyhouse

(N=240)

Sl. No.	Items	Mean scores (M) (Out of 4)
1	**Design and construction of polyhouse**	
	Orientation of polyhouse	3.48
	Selection of site for polyhouse construction	3.47
	Selection of materials for construction of polyhouse	3.33
	Ridge height	3.27
	Gutter height	3.27
	Covering material	3.17
2	**Hi-tech seedling procurement and production**	
	Crop varieties suitable for hi-tech vegetable cultivation	2.93
	Seedling production	2.75
	Source of seeds	2.62
	Transplantation of seedlings	2.15
3	**Crop layout and design**	
	Soil analysis	3.12
	Bed preparation	2.55
	Spacing of the seedlings	2.06
4	**Disinfection of polyhouse**	
	Disinfection of polyhouse	3.72
	Soil sterilization	3.60
	Fumigation	3.47
5	**Micro irrigation system**	
	Maintenance and repair of the irrigation system	3.88
	Operation of the irrigation system	3.77
	Drip irrigation	3.35
	Installation of irrigation system	3.20
6	**Fertigation system**	
	Fertilizers suitable for fertigation	3.77
	Calculation of fertilizer doses	3.75

	Maintenance of soil parameters	3.73
	Maintenance and repair of fertigation system	3.72
	Operation of fertigation unit	3.72
7	**Cooling system**	
	Maintenance and repair of fogger	1.95
	Operation of fogger	1.85
	Installation of fogger	1.72
8	**Maintenance and repair of polyhouse**	
	Maintaining weather parameters inside polyhouse	3.77
	Cleaning of covering material of polyhouse	3.73
	Changing the covering material of polyhouse	3.67
9	**Pest and disease management**	
	Symptoms of diseases and pest infestation	3.88
	Biocontrol agents against pest and diseases	3.70
	Method of application of biocontrol agents	3.48
	Traps used for pest control	3.40
	Plant protection chemicals	3.38
	Dosage of the chemicals	3.25
	Soil application of chemicals	3.15
	Foliar spray of the plant protection chemicals	3.13
10	**Nutrient management**	
	Deficiency symptoms	3.75
	Toxicity symptoms	3.65
	Stage and time of application of fertilizers	3.63
	Rate of application of fertilizers	3.61
	Bio fertilizers to be applied	3.56
	Soil application of fertilizers	3.56
	Chemical fertilizers to be applied	3.47
	Foliar application of chemicals	3.21
	Composting	3.07
11	**Weed management**	
	Stage of weeding	2.03
	Weed flora found in polyhouses	1.80
	Mechanical weeding	1.73
	Chemical weeding	1.48
12	**Harvesting of crop**	
	Method of harvesting	2.55
	Stage of harvesting	2.43
	Harvesting time	2.21
13	**Marketing of produce**	
	Market rate of vegetable	3.62
	Storage	2.52
	Packing	2.52
	Grading	2.08
14	**Schemes and subsidies**	3.55

The polyhouse farming is a relatively recent practice in Kerala. Hence, the design and construction of polyhouses were essential elements that farmers must consider. Farmers needed information about the orientation of polyhouse (M = 3.48), according to the research. This may be because the farmers know that sunshine availability and preventing shadow are critical while producing vegetables in polyhouse. In Kerala, North-South orientation and layout are recommended. Farmers ranked site selection for polyhouse construction as the second most important factor in design and construction (M=3.47). Farmers considered this to be one of the most crucial pieces of knowledge because geography and climate varied from place to place in the state. When it comes to polyhouse construction, knowing where to find the correct source and what materials to use for construction is crucial. As a result, with a mean value of 3.33, polyhouse farmers ranked it as the third most significant information among design and construction characteristics. When building a green house, knowledge on ridge height and gutter height is equally important, according to the polyhouse farmers. The next most important factor is the choice of covering material. The farmers gave it a higher mean value (M=3.17), indicating that it is an important need for them.

Amaranthus seedling procurement and production was not an essential information needed by farmers. Without using hybrid seeds, the crops gave promising yield to farmers. The mean scores pointed out that the information needed on crop varieties suitable for hi-tech vegetable cultivation scored less. The conventional method of seedling production was followed in the crop. So, it scored only 2.75. As the farmers used locally available varieties to get profit from the polyhouse amaranth cultivation, they were aware of the source of seeds. Hence, a low mean score of 2.62. Transplantation of the seedlings is a familiar procedure for farmers and most of them had the skill to do the procedure without giving transplantation shock to the seedlings. So, majority of the farmers didn’t require information on this.

While cultivating amaranthus in a polyhouse, many of the farmers lacked knowledge on crop layout and design. One of the most significant parts of growing amaranthus in a polyhouse is soil analysis. Farmers indicated that soil analysis information was important to them, with a mean score of 3.12. Bed preparation was the information least required by the farmers, with a mean score of 2.55. Most of the farmers were familiar with seedling spacing. Few of the polyhouse farmers who had less experience on amaranthus cultivation opined that they needed more information on spacing of seedlings.

The micro atmosphere in polyhouse is in such a way that, the pest and disease control is difficult if proper care is not taken. So, farmers opined that information on disinfection of polyhouse is very essential and they placed disinfection, soil sterilisation and fumigation at high ranks with mean scores of 3.72, 3.60 and 3.47 respectively.

Micro irrigation is an inevitable part in crop cultivation under greenhouse. The installation, operation and maintenance require proper knowledge. The information on maintenance and repair and operation of irrigation system was very essential for farmers and they have placed it in first two positions (Mean scores of 3.88 and 3.77 respectively). Even though the rank of installation of irrigation system was the lowest in the category, the mean scores indicates that farmers found the information a much needed one (M=3.20). Some of the farmers were aware of the general information on drip irrigation and remaining farmers needed the information and the computed mean score 3.35.

Fertigation is the best method of fertilizer application in salad cucumber cultivated under polyhouse. Most of the farmers were not familiar with operation and maintenance of the fertigation unit. The mean values of all the items under this category were above 3.70 which shows that the information was essential for farmers. Among different aspects under the category, farmers required information about fertilizers suitable for fertigation which was followed by calculation of fertilizer doses and the mean scores were 3.77 and 3.75, respectively. In Kerala, so far, a full proof fertigation system for cultivating vegetables in polyhouse is yet to come out. Research and trials are required in this aspect. Maintenance of soil parameters was positioned next with mean score 3.73. Operation, maintenance, and repair of the fertigation unit were equally important to farmers (M=3.72).

A very few farmers needed information on cooling system and majority of farmers does not feel the need of foggers or any cooling equipment inside polyhouse. The data points out that, the calculated mean scores were less than two, which indicated that the information was least important for the farmers. The items were installation, operation, and maintenance and repair of the fogger and the M values were 1.72, 1.85 and 1.95, respectively. This might be due to the lack of awareness on the importance of cooling system in polyhouses.

The knowledge regarding the maintenance and repair of polyhouse is very crucial for farmers. Algal growth resulting in the restriction of sunlight availability to plants, leading to yield reduction is a major problem faced by polyhouse farmers in Kerala. The adverse climatic conditions such as heavy rainfall, wind, and high humidity. result in damage of the polyhouse as well as creates difficulty in maintaining weather parameters inside polyhouse. So, the farmers knew the importance of proper cleaning and maintenance of polyhouse. The items listed under the category were maintenance of weather parameters inside the polyhouse, cleaning of covering material, and changing of the covering material. The assessed mean scores were 3.77, 3.73 and 3.67 which indicated their higher requirement of the information.

According to the farmers, in protected cultivation, the closed atmosphere and microclimate makes pest and disease management a difficult task compared to that of open cultivation. Hence, farmers were more interested about the proper management of pests and diseases. The priority was given to symptoms of disease and pest infestation (M=3.88) as early identification was the most important factor which helps to reduce the spread of pests and diseases. Many of the farmers were practicing organic methods of pest control initially. So, they were interested to know about different biocontrol agents (M=3.70) and the methods to apply those (M=3.48). Apart from the use of biocontrol agents, farmers found that traps are also effective against pests. But they lacked knowledge and skill on that. So, they needed information about different insect traps and methods to use it (M=3.40). It is essential to have proper knowledge of chemicals while cultivating under polyhouse, for effective control of pests. Therefore, the polyhouse farmers marked items such as chemicals used, dosage of pesticides, soil, and foliar application of chemicals as highly crucial information with mean scores 3.38, 3.25, 3.15 and 3.13, respectively.

The fertilizer usage and its application in polyhouse is different from open cultivation. Most of the farmers lacked knowledge on different aspects of nutrient management, such as fertilizers used, doses, time of application, and the like. Out of all the aspects regarding nutrient management, polyhouse farmers needed more information on deficiency and toxicity symptoms (mean value of 3.75 and 3.65, respectively). Only a few farmers knew about different chemical fertilizers used for amaranthus under polyhouse, and others were unaware of that (M=3.47). They needed more insight on the stage and time of application as well as rate of application of fertilizers and the calculated mean scores of these items were found to be 3.63 and 3.61, respectively. It was also reflected from the scores that, soil application and foliar application of chemicals were much needed information with a mean score of 3.56 and 3.21, respectively. The data indicates that in case of nutrient management, farmers preferred chemical fertilizers rather than bio fertilizers for quick result. Integrated nutrient management and good agricultural practices (GAP) are now becoming popular among farmers and hence, they were more curious about the practice. It can be inferred that, the high mean scores of information needs regarding composting and bio fertilizer application (3.07 and 3.56, respectively) is the result of that awareness. Practical-oriented training classes are required for foliar application.

As per the response from most of the polyhouse farmers, weed management was one of the least essential information needed by the polyhouse farmers. They opined that the weed control was possible without much difficulty. Majority of the polyhouse farmers were familiar with the weed flora found under polyhouse during salad cucumber cultivation and hence, very few farmers pointed it as a needed information (M=1.80). Relatively a higher number of farmers needed the information on the stage of weeding and the mean score was 2.03. The data also shows that management of weeds through mechanical method (M=1.73) was preferred by most of the farmers to chemical methods (M=1.48). Being in a confined area, manual weed control is easier when compared to open cultivation.

Generally, farmers were familiar with harvesting procedures. But in protected cultivation, the methods are little different. Hence, some farmers opined that, the process will be easier if they get more information on harvesting methods (M=2.55). As some farmers are new to farming, they were unaware of the stage of harvesting (M=2.43). Some farmers who were new to farming, required information on the time of harvest of amaranth under polyhouse (M=2.21).

Another key aspect regarding the cultivation under polyhouse is about the market price. The hi-tech cultivation is relatively new among the people of Kerala. So, marketing information was very essential among polyhouse farmers. The main information farmers required regarding the marketing was about the market rate of the crop. Fluctuating market prices and difference in rates in various markets makes it difficult to sell the produce. Therefore, almost all the farmers marked it as an important information required for them. The calculated value was 3.62. Apart from this, all the aspects of marketing such as storage, packing and grading was moderately required for polyhouse farmers as they were familiar with the practices. But storage and packing had a relatively higher score of 2.52 each when compared to grading (score of 2.08). The surplus yield of amaranthus obtained per day was high in polyhouse and some farmers faced problem with storing and packing the bulk quantity of this vegetable. This might be the reason of giving more importance to storage and packing.

Initial investment to construct polyhouse is more and most of the farmers reported that they cannot afford that. They pointed out that without any subsidies, loans or financial support polyhouse construction was difficult for them. So they mentioned that, updated information on schemes and subsidies should be made available by the concerned authorities. The mean score of 3.55 indicated that the need is very essential.

4.6.3. Information needs on chilli cultivation in polyhouse

Table 4.45. Agreement among farmers on information needs on chilli cultivation in polyhouse

Sl. No.	Items	W value
1	Design and construction of polyhouse	0.073**
2	Hi-tech seedling procurement and production	0.188*
3	Crop layout and design	0.210*
4	Disinfection of polyhouse	0.046
5	Micro irrigation system	0.302**
6	Fertigation system	0.005
7	Cooling system	0.094**
8	Maintenance and repair of polyhouse	0.011
9	Pest and disease management	0.335**
10	Nutrient management	0.141**
11	Weed management	0.041**
12	Pollination	0.289**
13	Training and pruning	0.121
14	Harvesting of crop	0.212**
15	Marketing of produce	0.445**
16	Schemes and subsidies	NA#

**Significant at 0.01 level of significance

*Significant at 0.05 level of significance

Not applicable as only one item is included under the category

Table 4.45. indicates that the category-wise W values of 11 out of 16 practices showed significant agreement among the polyhouse farmers regarding their information needs. Coefficient of concordance value of nine categories (design and construction of polyhouse, micro irrigation system, cooling system, pest and disease management, nutrient management, weed management, pollination, harvesting and marketing of produce) showed significant concordance at one per cent level. Whereas cultivation practices like hi-tech seedling procurement and production and crop layout and design were significant at five per cent level of significance. The significance of these categories indicates that the agreement on the information needs among the farmers was fair enough to arrange the statements as given in Table 4.46. according to their mean score. The W value of variables such as disinfection of polyhouse, fertigation system, maintenance and repair, training and pruning were insignificant at one per cent as well as at five per cent levels of significance. This points out that the needs of farmers differed with each other.

Under the section, schemes, and subsidies, since only one item was included, W value was inestimable.

The item-wise mean scores obtained was used to select the most important information needed by farmers. The mean scores were arranged in descending order under each category in order organise the items according to the need of farmers.

Table 4.46. Information needs of the farmers on chilli cultivation in polyhouse

(N=240)

Sl. No.	Items	Mean scores (M)
1	**Design and construction of polyhouse**	
	Orientation of polyhouse	3.48
	Selection of site for polyhouse construction	3.47
	Selection of materials for construction of polyhouse	3.33
	Ridge height	3.27
	Gutter height	3.27
	Covering material	3.17
2	**Hi-tech seedling procurement and production**	
	Crop varieties suitable for hi-tech vegetable cultivation	3.28
	Grafted seedling production	3.12
	Seedling production	2.96
	Source of seeds	2.82
	Transplantation of seedlings	2.78
3	**Crop layout and design**	
	Soil analysis	3.12
	Bed preparation	3.08
	Spacing of the seedlings	2.85
	Planting in growbags and potting mixture	2.79
	Training of the crops	2.44
4	**Disinfection of polyhouse**	
	Disinfection of polyhouse	3.72
	Soil sterilization	3.60
	Fumigation	3.47
5	**Micro irrigation system**	
	Maintenance and repair of the irrigation system	3.88
	Operation of the irrigation system	3.77
	Drip irrigation	3.35
	Installation of irrigation system	3.20
6	**Fertigation system**	
	Fertilizers suitable for fertigation	3.77
	Calculation of fertilizer doses	3.75
	Maintenance of soil parameters	3.73

	Maintenance and repair of fertigation system	3.72
	Operation of fertigation unit	3.72
7	**Cooling system**	
	Maintenance and repair of fogger	1.95
	Operation of fogger	1.85
	Installation of fogger	1.72
8	**Maintenance and repair of polyhouse**	
	Maintaining weather parameters inside polyhouse	3.77
	Cleaning of covering material of polyhouse	3.73
	Changing the covering material of polyhouse	3.67
9	**Pest and disease management**	
	Symptoms of diseases and pest infestation	3.89
	Biocontrol agents against pest and diseases	3.72
	Method of application of biocontrol agents	3.50
	Traps used for pest control	3.42
	Plant protection chemicals	3.39
	Dosage of the chemicals	3.31
	Soil application of chemicals	3.18
	Foliar spray of the plant protection chemicals	3.17
10	**Nutrient management**	
	Deficiency symptoms	3.88
	Toxicity symptoms	3.78
	Stage and time of application of fertilizers	3.73
	Rate of application of fertilizers	3.63
	Bio fertilizers to be applied	3.57
	Soil application of fertilizers	3.57
	Chemical fertilizers to be applied	3.53
	Foliar application of chemicals	3.38
	Composting	3.07
11	**Weed management**	
	Stage of weeding	2.03
	Weed flora found in polyhouses	1.80
	Mechanical weeding	1.73
	Chemical weeding	1.48
12	**Pollination**	
	Knowledge about assisted pollination	2.54
	Beekeeping	0.97
	Maintenance of bee hives	0.87
	Stage of keeping hives	0.85
13	**Training and pruning**	
	Training methods	3.22
	Pruning methods	3.17
	Time of training / pruning	3.15
	Stage of training / pruning	3.15
14	**Harvesting of crop**	
	Method of harvesting	2.68

	Stage of harvesting	2.48
	Harvesting time	2.35
15	**Marketing of produce**	
	Market rate of vegetable	3.62
	Storage	2.52
	Packing	2.52
	Grading	2.48
16	**Schemes and subsidies**	3.55

The design and construction of polyhouse are important factors needed for farmers as the practice of polyhouse cultivation is relatively new in Kerala. The data indicate that the most essential information needed by farmers regarding the design and construction was the orientation of the polyhouse (M = 3.48), as they knew that sunlight availability is very essential while growing vegetables under polyhouse. In Kerala North-South orientation and layout are recommended. Farmers positioned selection of site for polyhouse construction in the next place under design and construction (M=3.47). As the topography and climate differs from place to place in the state, farmers found this as one of the most important information. Knowledge about the right construction material and its source is very important as far as polyhouse construction is considered. Due to this, the farmers placed it as the third most important information among design and construction aspects with a mean value 3.33. According to the respondent farmers, information about ridge height and gutter height were equally needed while constructing a green house.

Traditionally majority of the farmers practiced seed exchange, or they depended upon local sources for seeds. But as we consider high valued crop production in a closed condition, farmers knew the importance of advanced method of seedling production, better and reliable sources of planting material procurement. Hence, they needed more information on hi-tech seedling procurement and production. The foremost information needed was about the crop varieties suitable for hi-tech vegetable cultivation , as most of the farmers were novices in chilli cultivation (M=3.28). Hi-tech seedling production and seedling grafting were the next two important information needed by the farmers with mean values 2.96 and 3.12 respectively. As self-pollinated and hybrid seeds were not commonly available to most of the farmers, they marked the item, seed source as moderately important information requirement (M=2.82). Most of the experienced farmers were familiar with the practice of transplantation, without giving transplantation shock to the seedlings. But some farmers needed the procedure and practice of transplantation and hence it was the fifth most important need with a mean of 2.78.

Some of the farmers lacked knowledge on crop layout and design while cultivating chilli under polyhouse. Soil analysis is one of the other important aspects while doing polyhouse cultivation. The data from farmers indicate that the information regarding soil analysis was essential for farmers and the mean score given was 3.12. The practice of bed preparation is different in polyhouse from that of open cultivation. So, the farmers had placed it in the second position under crop layout and design with a mean score of 3.08. Most of the farmers had knowledge about spacing of the seedlings. A few of the farmers who had less experience in chilli cultivation required information on spacing of seedlings and thus, it was assigned with a mean score of 2.85. Majority of the farmers preferred to plant chilli on bare soil rather than grow bags. Very few farmers were curious about the practice of chilli cultivation in grow bags. Therefore, it was placed at the bottom of the category, crop layout and design with the mean score 2.79. In crop layout and design, training of the crops was least important information needed in chilli crop (M=2.44).

The micro atmosphere in polyhouse is in such a way that, the pest and disease control is difficult if proper care is not taken. So, farmers opined that information on disinfection of polyhouse is very essential and they placed disinfection, soil sterilisation and fumigation at high priority with mean scores of 3.72, 3.60 and 3.47 respectively.

Micro irrigation is an inevitable part in crop cultivation under greenhouse. The installation, operation and maintenance require proper knowledge. The information on maintenance and repair and operation of irrigation system was very essential for farmers and they have placed it in first two positions (Mean scores of 3.88 and 3.77 respectively). Even though the rank of installation of irrigation system was the lowest in the category, the mean scores tell us that farmers found the information a much needed one (M=3.20). Some of the farmers were aware of the general information on drip irrigation and remaining farmers need the information and the computed mean score 3.35.

Fertigation is the best method of fertilizer application in chilli cultivated under polyhouse. Most of the farmers are not familiar with operation and maintenance of the fertigation unit. The mean values of all the items under this category were above 3.70 which shows that the information is essential for farmers. Among different aspects under the category, farmers required information about fertilizers suitable for fertigation which was followed by calculation of fertilizer doses and the mean scores were 3.77 and 3.75, respectively. in Kerala, so far, a full proof fertigation system for cultivation of vegetables in polyhouse is yet to come out. research and trials are required in this aspect. Maintenance of soil parameters was positioned next with mean score 3.73. Operation, maintenance, and repair of the fertigation unit were equally important to farmers (M=3.72).

A very few farmers needed information on cooling system and majority of farmers doesn’t feel the need of foggers or any cooling equipment inside polyhouse. The data points out that, the calculated mean scores were less than two, which indicated that the information was least important for the farmers. The items were installation, operation and maintenance and repair of the fogger and the M values were 1.72, 1.85 and 1.95 respectively. this might be due to the lack of awareness on the importance of cooling system in polyhouse.

The knowledge regarding the maintenance and repair of polyhouse is very crucial for farmers. Algal growth resulting in the restriction of sunlight availability to plants, leading to yield reduction was a major problem faced by polyhouse farmers in Kerala. The adverse climatic conditions like heavy rainfall, wind, and high humidity. results in damage of the polyhouse as well as creates difficulty in maintaining weather parameters inside polyhouse. So, the farmers knew the importance of proper cleaning and maintenance of polyhouse. The items listed under the category were maintenance of weather parameters inside the polyhouse, cleaning of covering material, and changing of the covering material. The assessed mean scores were 3.77, 3.73 and 3.67 which indicated their higher requirement of the information.

According to the farmers, in protected cultivation, the closed atmosphere and microclimate makes pest and disease management a difficult task compared to that of open cultivation. Hence, farmers are more curious about the proper management of pests and diseases. The priority was given to symptoms of disease and pest infestation (M=3.89) as early identification is the most important factor which helps to reduce the spread of pests and diseases. Many of the farmers are practicing organic methods of pest control initially. So, they were interested to know about different biocontrol agents (M=3.72) and the methods to apply those (M=3.50). apart from the use of biocontrol agents, farmers found that traps are also effective against pests. but they lack knowledge and skill on that. So, they needed information about different insect traps and methods to use it (M=3.42). It is essential to have proper knowledge of chemicals while cultivating under polyhouse, for effective control of pests. Therefore, the polyhouse farmers marked items such as chemicals used, dosage of pesticides, soil, and foliar application of chemicals as highly crucial information with mean scores 3.39, 3.31, 3.18 and 3.17, respectively.

The fertilizer usage and its application in polyhouse is different from open cultivation. Most of the farmers lack knowledge on different aspects of nutrient management, such as fertilizers used, doses, time of application. Out of all the aspects regarding nutrient management, polyhouse farmers wanted more information on deficiency and toxicity symptoms (mean value of 3.88 and 3.78, respectively). Only a few farmers knew about different chemical fertilizers used for chilli under polyhouse, and others were unaware of that (M=3.53). They needed more insight on the stage and time of application as well as rate of application of fertilizers and the calculated mean scores of these items were found to be 3.73 and 3.63, respectively. It was also reflected from the scores that, soil application and foliar application of chemicals were much needed information with a mean score of 3.57 and 3.38, respectively. The data indicates that in case of nutrient management, farmers prefer chemical fertilizers rather than bio fertilizers for quick result. Integrated nutrient management and Good Agricultural Practices (GAP) are now becoming popular among farmers and hence, they were more curious about the practice. It can be inferred that, the high mean scores of information needs regarding composting and bio fertilizer application (3.07

and 3.57, respectively) was the result of that awareness. Practical-oriented training classes are required for foliar application.

As per the response from most of the polyhouse farmers, weed management was one of the least essential information needed by the polyhouse farmers. They opined that the weed control was possible without much difficulty. Majority of the polyhouse farmers were familiar with the weed flora found under polyhouse during chilli cultivation and hence, very few farmers pointed it as a needed information (M=1.80). Relatively a higher number of farmers needed the information on the stage of weeding and the mean score was 2.03. The data also showed that management of weeds through mechanical method (M=1.73) was preferred by most of the farmers to chemical methods (M=1.48). Being in a confined area, manual weed control is easier when compared to open cultivation.

A vast majority of the farmers used self-pollinating seeds inside polyhouse. A very few farmers required information on the natural pollination Aided by honey bees and other insects and the values were less than one. A slightly higher number of farmers needed information on hand pollination and other artificial crossing methods which can be possible under greenhouse (M=2.54). Farmers, in general were not interested in knowing the information about pollination. this might be due to their lack of awareness on artificial pollination and also due to the perceived complexity of the method helloas they have not got any skill training in this.

The farmers realise that the training and pruning are critical aspects while cultivating chilli in protected conditions. Training structures are needed to divert the crop to climb up and utilising vertical space properly under a polyhouse and about which they were less aware of. Along with the details of training and pruning methods, the stage of training and pruning was also found essential among the farmers. The respective mean scores of training methods, pruning methods, time of training and pruning and stage of training and pruning were 3.22, 3.17, 3.15 and 3.15. Here also skill trainings are required to take advantage of training and pruning.

Generally, farmers were familiar with harvesting procedure. But in protected cultivation, vertical growth of the plant makes the procedure little difficult. Hence, some farmers opined that, the process will be easier if they get more information on harvesting methods (M=2.68). Chilli cultivation is a new practice among the farmers in Kerala, and hence, some of the farmers were unaware of stage of harvesting (M=2.48). Some farmers who were new to farming, required information on the time of harvest of chilli under polyhouse (M=2.35).

Another key aspect regarding the cultivation of chilli is about the market price. The crop is relatively new among the people of Kerala and many retail shopkeepers find it difficult to sell the produce also. So, marketing information regarding the crop is very essential among polyhouse farmers. The main information farmers required regarding the marketing was about the market rate of chilli. Fluctuating market prices and difference in rates in various markets makes it difficult to sell the produce. Therefore, almost all the farmers marked it as an important information required for them. The calculated value was 3.62. Apart from this, all the aspects of marketing such as storage, packing and grading was moderately required for polyhouse farmers as they were familiar with the practices. But storage and packing had a relatively higher score of 2.52 each when compared to grading (score of 2.48). The yield of chilli obtained per day is very high in polyhouse and some farmers faced problem with storing and packing the bulk quantity of this vegetable. This might be the reason of giving more importance to storage and packing.

Initial investment to construct polyhouse is so high and most of the farmers reported that they cannot afford that. They pointed out that without any subsidies, loans or financial support polyhouse construction is impossible for them. So they mentioned that updated information on schemes and subsidies should be made available by the concerned authorities. The mean score (3.55) indicated that the need was very essential.

4.6.4. Information needs on cultivation of yard long bean in polyhouse

Table 4.47. Agreement among farmers on information needs on yard long bean cultivation in polyhouse

Sl. No.	Items	W value
1	Design and construction of polyhouse	0.073**
2	Hi-tech seedling procurement and production	0.055*
3	Crop layout and design	0.238*
4	Disinfection of polyhouse	0.046
5	Micro irrigation system	0.302**
6	Fertigation system	0.005
7	Cooling system	0.094**
8	Maintenance and repair of polyhouse	0.011
9	Pest and disease management	0.221**
10	Nutrient management	0.151**
11	Weed management	0.084**
12	Pollination	0.303**
13	Training and pruning	0.214
14	Harvesting of crop	0.087**
15	Marketing of produce	0.445**
16	Schemes and subsidies	NA#

**Significant at 0.01 level of significance
*Significant at 0.05 level of significance
Not applicable as only one item is included under the category

Table 4.47. indicates that the category-wise W values of 11 out of 16 practices showed significant agreement among the polyhouse farmers regarding their information needs. Coefficient of concordance value of nine categories (design and construction of polyhouse, micro irrigation system, cooling system, pest and disease management, nutrient management, weed management, pollination, harvesting and marketing of produce) showed significant concordance at one per cent level.

Cultivation practices like hi-tech seedling procurement and production and crop layout and design were significant at five per cent level of significance. The significance of these categories indicates that the agreement on the information needs among the farmers was fair enough to arrange the statements as given in Table 4.48. according to their mean score. The W value of variables such as disinfection of polyhouse, fertigation system, maintenance and repair, training and pruning were insignificant at one per cent as well as at five per cent levels of significance. This points out that the needs of the farmers differed with each other.

Under the section, schemes, and subsidies, since only one item was included, W value was inestimable.

The item-wise mean scores obtained was used to select the most important information needed by farmers. The mean scores were arranged in descending order under each category in order organise the items according to the need of farmers.

Table 4.48. Information needs of the farmers on yard long bean cultivation in polyhouse (N=240)

Sl. No	Items	Mean scores (M)
1	**Design and construction of polyhouse**	
	Orientation of polyhouse	3.48
	Selection of site for polyhouse construction	3.47
	Selection of materials for construction of polyhouse	3.33
	Ridge height	3.27
	Gutter height	3.27
	Covering material	3.17
2	**Hi-tech seedling procurement and production**	
	Crop varieties suitable for hi-tech vegetable cultivation	3.28
	Seedling production	2.95
	Grafted seedling production	2.88
	Source of seeds	2.82
	Transplantation of seedlings	2.78
3	**Crop layout and design**	
	Soil analysis	3.12
	Training of the crops	3.05
	Bed preparation	2.65
	Spacing of the seedlings	2.56

	Planting in growbags and potting mixture	2.24
4	**Disinfection of polyhouse**	
	Disinfection of polyhouse	3.72
	Soil sterilization	3.60
	Fumigation	3.47
5	**Micro irrigation system**	
	Maintenance and repair of the irrigation system	3.88
	Operation of the irrigation system	3.77
	Drip irrigation	3.35
	Installation of irrigation system	3.20
6	**Fertigation system**	
	Fertilizers suitable for fertigation	3.77
	Calculation of fertilizer doses	3.75
	Maintenance of soil parameters	3.73
	Maintenance and repair of fertigation system	3.72
	Operation of fertigation unit	3.72
7	**Cooling system**	
	Maintenance and repair of fogger	1.95
	Operation of fogger	1.85
	Installation of fogger	1.72
8	**Maintenance and repair of polyhouse**	
	Maintaining weather parameters inside polyhouse	3.77
	Cleaning of covering material of polyhouse	3.73
	Changing the covering material of polyhouse	3.67
9	**Pest and disease management**	
	Symptoms of diseases and pest infestation	3.90
	Biocontrol agents against pest and diseases	3.81
	Method of application of biocontrol agents	3.64
	Traps used for pest control	3.42
	Plant protection chemicals	3.38
	Dosage of the chemicals	3.25
	Soil application of chemicals	3.15
	Foliar spray of the plant protection chemicals	3.13
10	**Nutrient management**	
	Deficiency symptoms	3.88
	Toxicity symptoms	3.78
	Stage and time of application of fertilizers	3.75
	Rate of application of fertilizers	3.67
	Bio fertilizers to be applied	3.59
	Soil application of fertilizers	3.59
	Chemical fertilizers to be applied	3.56
	Foliar application of chemicals	3.38
	Composting	3.07

11	**Weed management**	
	Stage of weeding	2.03
	Weed flora found in polyhouses	1.80
	Mechanical weeding	1.73
	Chemical weeding	1.48
12	**Pollination**	
	Knowledge about assisted pollination	2.03
	Beekeeping	0.97
	Maintenance of bee hives	0.87
	Stage of keeping hives	0.85
13	**Training and pruning**	
	Training methods	3.56
	Pruning methods	3.56
	Time of training / pruning	3.42
	Stage of training / pruning	3.42
14	**Harvesting of crop**	
	Method of harvesting	3.05
	Stage of harvesting	3.01
	Harvesting time	2.49
15	**Marketing of produce**	
	Market rate of vegetable	3.62
	Storage	2.52
	Packing	2.52
	Grading	2.48
16	**Schemes and subsidies**	3.55

The design and construction of polyhouse are important factors needed for farmers as the practice of polyhouse cultivation is relatively new in Kerala. The data indicate that the most essential information needed by farmers regarding the design and construction was the orientation of the polyhouse (M = 3.48), as they knew that sunlight availability is very essential while growing vegetables under polyhouse. In Kerala North to South orientation and layout are recommended. Farmers positioned selection of site for polyhouse construction in the next place under design and construction (M=3.47). As the topography and climate differed from place to place in the state, farmers found this as one of the most important information. Knowledge about the right construction material and its source is very important as far as polyhouse construction is considered. Due to this, the farmers placed it as the third most important information among design and construction aspects with a mean value 3.33. According to the respondent farmers, information about ridge height and gutter height were equally needed while constructing a green house.

Traditionally majority of the farmers practiced seed exchange, or they depended upon local sources for seeds. But as we consider high valued crop production in a closed condition, farmers knew the importance of advanced method of seedling production, better and reliable sources of planting material procurement. Hence, they needed more information on hi-tech seedling procurement and production. The foremost information needed were about the crop varieties suitable for hi-tech vegetable cultivation , as most of the farmers were novices in yard long bean under polyhouse. Hi-tech seedling production and seedling grafting were the next two important information needed by the farmers with mean values 2.95 and 2.88 respectively. As self-pollinated and hybrid seeds were not commonly available to most of the farmers, they marked the item, seed source as moderately important information requirement (M=2.82). Most of the experienced farmers were familiar with the practice of transplantation, without giving transplantation shock to the seedlings. But some farmers needed the procedure and practice of transplantation and hence it was the fifth most important need with a mean of 2.78.

Some of the farmers lacked knowledge on crop layout and design while cultivating yard long bean in polyhouse. Soil analysis is one of the other important aspects while doing polyhouse cultivation. The data from farmers indicated that the information regarding soil analysis was essential for farmers and the mean score given was 3.12. The next most important information under crop layout and design was the training of the crops as farmers pointed out that yard long bean needs specialised structures to grow properly under a polyhouse (M=3.05). The practice of bed preparation is different in polyhouse from that of open cultivation. So, the farmers had placed it in the third position under crop layout and design with a mean score of 2.65. Most of the farmers had knowledge about spacing of the seedlings. A few of the farmers who had less experience in yard long bean cultivation required information on spacing of seedlings and thus, it was assigned with a mean score of 2.56. Majority of the farmers preferred to plant yard long bean on bare soil rather than grow bags. Very few farmers were curious about the practice of yard long bean cultivation in grow bags. Therefore, it was placed at the bottom of the category, crop layout and design with the mean score 2.24.

The micro atmosphere in polyhouse is in such a way that, the pests and disease control is difficult if proper care is not taken. So, farmers opined that information on disinfection of polyhouse is very essential and they placed disinfection, soil sterilisation and fumigation at high ranks with mean scores of 3.72, 3.60 and 3.47 respectively.

Micro irrigation is an inevitable part in crop cultivation under greenhouse. The installation, operation and maintenance require proper knowledge. The information on maintenance and repair and operation of irrigation system was very essential for farmers and they have placed it in first two positions (Mean scores of 3.88 and 3.77 respectively). Even though the rank of installation of irrigation system was the lowest in the category, the mean scores tell us that farmers found the information a much needed one (M=3.20). Some of the farmers were aware of the general information on drip irrigation and remaining farmers need the information and the computed mean score 3.35.

Fertigation is the best method of fertilizer application in yard long bean cultivated in polyhouse. Most of the farmers are not familiar with operation and maintenance of the fertigation unit. The mean values of all the items under this category were above 3.70 which shows that the information is essential for farmers. Among different aspects under the category, farmers required information about fertilizers suitable for fertigation which was followed by calculation of fertilizer doses and the mean scores were 3.77 and 3.75, respectively. In Kerala so far a full proof fertigation system for cultivation of vegetables in polyhouse is yet to come out. Research and trials are required in this aspect. Maintenance of soil parameters was positioned next with mean score 3.73. Operation, maintenance, and repair of the fertigation unit were equally important to farmers (M=3.72).

A very few farmers needed information on cooling system and majority of farmers does not feel the need of foggers or any cooling equipment inside polyhouse. The data points out that, the calculated mean scores were less than two, which indicates that the information was least important for the farmers. The items were installation, operation and maintenance and repair of the fogger and the M values were

1.72, 1.85 and 1.95 respectively. This might be due to the lack of awareness on the importance of cooling system in polyhouse.

The knowledge regarding the maintenance and repair of polyhouse is very crucial for farmers. Algal growth resulting in the restriction of sunlight availability to plants, leading to yield reduction is a major problem faced by polyhouse farmers in Kerala. The adverse climatic conditions like heavy rainfall, wind, and high humidity. result in damage of the polyhouse as well as creates difficulty in maintaining weather parameters inside polyhouse. So, the farmers know the importance of proper cleaning and maintenance of polyhouse. The items listed under the category were maintaining weather parameters inside the polyhouse, cleaning of covering material, and changing of the covering material. The assessed mean scores were 3.77, 3.73 and 3.67 which indicated their higher requirement of the information.

According to the farmers, in protected cultivation, the closed atmosphere and micro climate makes pest and disease management a difficult task compared to that of open cultivation. Hence, farmers are more curious about the proper management of pests and diseases. The priority was given to symptoms of disease and pest infestation (M=3.90) as early identification is the most important factor which helps to reduce the spread of pests and diseases. Many of the farmers are practicing organic methods of pest control initially. So, they were interested to know about different biocontrol agents (M=3.81) and the methods to apply those (M=3.64). Apart from the use of biocontrol agents, farmers found that traps are also effective against pests. But they lacked knowledge and skill on that. So, they needed information about different insect traps and methods to use it (M=3.42). It is essential to have proper knowledge of chemicals while cultivating under polyhouse, for effective control of pests. Therefore, the polyhouse farmers marked items such as chemicals used, dosage of pesticides, soil, and foliar application of chemicals as highly crucial information with mean scores 3.38, 3.25, 3.15 and 3.13, respectively.

The fertilizer usage and its application in polyhouse is different from open cultivation. Most of the farmers lacked knowledge on different aspects of nutrient management, such as fertilizers used, doses, and time of application. Out of all the aspects regarding nutrient management, polyhouse farmers needed more information on deficiency and toxicity symptoms (mean value of 3.88 and 3.78, respectively). Only a few farmers knew about different chemical fertilizers used for yard long bean under polyhouse, and others were unaware of that (M=3.56). They needed more insight on the stage and time of application as well as rate of application of fertilizers and the calculated mean scores of these items were found to be 3.75 and 3.67, respectively. It was also reflected from the scores that, soil application and foliar application of chemicals were much needed information with a mean score of 3.59 and 3.38, respectively. The data indicates that in case of nutrient management, farmers preferred chemical fertilizers rather than bio fertilizers for quick result. Integrated nutrient management and Good Agricultural Practice (GAP) are now becoming popular among farmers and hence, they were more curious about the practice. It can be inferred that, the high mean scores of information needs regarding composting and bio fertilizer application (3.07 and 3.59, respectively) is the result of that awareness. Practical oriented training classes are required for foliar application

As per the response from most of the polyhouse farmers, weed management is one of the least essential information needed by the polyhouse farmers. They opined that the weed control was possible without much difficulty. Majority of the polyhouse farmers were familiar with the weed flora found under polyhouse during yard long bean cultivation and hence, very few farmers pointed it as a needed information (M=1.80). Relatively a higher number of farmers needed the information on the stage of weeding and the mean score was 2.03. The data also shows that management of weeds through mechanical method (M=1.73) was preferred by most of the farmers to chemical methods (M=1.48). Being in a confined area, manual weed control is easier when compared to open cultivation.

A vast majority of the farmers used self-pollinating seeds inside polyhouse. A very few farmers required information on the natural pollination aided by honey bees and other insects and the values were less than one. A slightly higher number of farmers needed information on hand pollination and other artificial crossing methods which can be possible under greenhouse (M=2.03). Farmers, in general were not interested in knowing the information about pollination. This might be due to their lack of awareness on artificial pollination and also due to the perceived complexity of the method as they have not got any skill training in this.

The farmers realised that the training and pruning were critical aspects while cultivating yard long bean in protected conditions. Training structures are needed to divert the crop to climb up and utilising vertical space properly under a polyhouse and about which they were less aware of. Along with the details of training and pruning methods, the stage of training and pruning was also found essential among the farmers. The respective mean scores of training methods, pruning methods, time of training and pruning and stage of training and pruning were 3.56, 3.56, 3.42 and 3.42. here also skill trainings are required to take advantage of training and pruning.

Generally, farmers were familiar with harvesting procedure. But in protected cultivation, vertical growth of the plant makes the procedure a bit difficult. Hence, some farmers opined that, the process will be easier if they get more information on harvesting methods (M=3.05). Yard long bean cultivation is a new practice under hi-tech cultivation among the farmers in Kerala, and hence, some of the farmers were unaware of stage of harvesting (M=3.01). Some farmers who are new to farming, required information on the time of harvest of yard long bean under polyhouse (M=2.49).

Another key aspect regarding the cultivation of yard long bean was about the market price. So, marketing information regarding the crop was very essential among polyhouse farmers. The main information farmers required regarding the marketing was about the market rate of yard long bean. Fluctuating market prices and difference in rates in various markets makes it difficult to sell the produce. Therefore, almost all the farmers marked it as an important information required for them. The calculated value was 3.62. Apart from this, all the aspects of marketing such as storage, packing and grading was moderately required for polyhouse farmers as they are familiar with the practices. But storage and packing have a relatively higher score of 2.52 each when compared to grading (score of 2.48). The yield of yard long bean obtained per day was very high in polyhouse and some farmers faced problem with storing and packing the bulk quantity of this vegetable. This might be the reason of giving more importance to storage and packing.

Initial investment to construct polyhouse is so high and most of the farmers reported that they cannot afford that. They pointed out that without any subsidies, loans or financial support polyhouse construction is impossible for them. So, they mentioned that, the updated information on schemes and subsidies should be made available by the concerned authorities. The mean score (3.55) indicated that the need is very essential.

4.6.5. Prioritised information needs

In Table 4.49, comparison of the information needs of polyhouse farmers on different crops is given. The information needs, which were highly essential (HE) and essential (ES), were prioritised to develop content for the m-App.

Table 4.49. Comparison of the priorities of the information needs of polyhouse farmers on selected crops

Sl. No	Items	Salad Cucumber	Amaranthus	Chilli	Yard Long Bean
1	**Design and construction of polyhouse**				
	Orientation of polyhouse	HE*	HE*	HE*	HE*
	Selection of site for polyhouse construction	HE*	HE*	HE*	HE*
	Selection of materials for construction of polyhouse	HE*	HE*	HE*	HE*
	Ridge height	HE*	HE*	HE*	HE*
	Gutter height	HE*	HE*	HE*	HE*
	Covering material	HE*	HE*	HE*	HE*
2	**Hi-tech seedling procurement and production**				
	Crop varieties suitable for hi-tech vegetable cultivation	HE*	ES*	HE*	HE*
	Seedling production	ES*	ES*	HE*	ES*
	Grafted seedling production	ES*	ES*	ES*	ES*
	Source of seeds	ES*	ES*	ES*	ES*
	Transplantation of seedlings	ES*	ES*	ES*	ES*
3	**Crop layout and design**				
	Soil analysis	HE*	HE*	HE*	HE*
	Training of the crops	ES*	NN	HE*	HE*
	Bed preparation	ES*	ES*	ES*	ES*

	Spacing of the seedlings	ES*	ES*	ES*	ES*
	Planting in growbags and potting mixture	ES*	NN	ES*	ES*
4	**Disinfection of polyhouse**				
	Disinfection of polyhouse	HE*	HE*	HE*	HE*
	Soil sterilisation	HE*	HE*	HE*	HE*
	Fumigation	HE*	HE*	HE*	HE*
5	**Micro irrigation system**				
	Maintenance and repair of the irrigation system	HE*	HE*	HE*	HE*
	Operation of the irrigation system	HE*	HE*	HE*	HE*
	Drip irrigation	HE*	HE*	HE*	HE*
	Installation of irrigation system	HE*	HE*	HE*	HE*
6	**Fertigation system**				
	Fertilisers suitable for fertigation	HE*	HE*	HE*	HE*
	Calculation of fertiliser doses	HE*	HE*	HE*	HE*
	Maintenance of soil parameters	HE*	HE*	HE*	HE*
	Maintenance and repair of fertigation system	HE*	HE*	HE*	HE*
	Operation of fertigation unit	HE*	HE*	HE*	HE*
7	**Cooling system**				
	Maintenance and repair of fogger	N	N	N	N
	Operation of fogger	N	N	N	N
	Installation of fogger	N	N	N	N
8	**Maintenance and repair of polyhouse**				
	Maintaining weather parameters inside polyhouse	HE*	HE*	HE*	HE*
	Cleaning of covering material of polyhouse	HE*	HE*	HE*	HE*
	Changing the covering material of polyhouse	HE*	HE*	HE*	HE*
9	**Pest and disease management**				
	Symptoms of diseases and pest infestation	HE*	HE*	HE*	HE*
	Biocontrol agents against pests and diseases	HE*	HE*	HE*	HE*
	Method of application of biocontrol agents	HE*	HE*	HE*	HE*
	Traps used for pest control	HE*	HE*	HE*	HE*
	Plant protection chemicals	HE*	HE*	HE*	HE*
	Dosage of the chemicals	HE*	HE*	HE*	HE*
	Soil application of	HE*	HE*	HE*	HE*

	chemicals				
	Foliar spray of the plant protection chemicals	HE*	HE*	HE*	HE*
10	**Nutrient management**				
	Deficiency symptoms	HE*	HE*	HE*	HE*
	Toxicity symptoms	HE*	HE*	HE*	HE*
	Stage and time of application of fertilisers	HE*	HE*	HE*	HE*
	Rate of application of fertilisers	HE*	HE*	HE*	HE*
	Bio fertilisers to be applied	HE*	HE*	HE*	HE*
	Soil application of fertilisers	HE*	HE*	HE*	HE*
	Chemical fertilisers to be applied	HE*	HE*	HE*	HE*
	Foliar application of chemicals	HE*	HE*	HE*	HE*
	Composting	HE*	HE*	HE*	HE*
11	**Weed management**				
	Stage of weeding	ES*	ES*	ES*	ES*
	Weed flora found in polyhouses	N	N	N	N
	Mechanical weeding	N	N	N	N
	Chemical weeding	N	N	N	N
12	**Pollination**				
	Knowledge about assisted pollination	ES*	NN	ES*	ES*
	Beekeeping	SN	NN	SN	SN
	Maintenance of beehives	SN	NN	SN	SN
	Stage of keeping hives	SN	NN	SN	SN
13	**Training and pruning**				
	Training methods	HE*	NN	ES*	HE*
	Pruning methods	HE*	NN	N	HE*
	Time of training/pruning	HE*	NN	N	HE*
	Stage of training/pruning	HE*	NN	N	HE*
14	**Harvesting of crop**				
	Method of harvesting	ES*	ES*	ES*	HE*
	Stage of harvesting	ES*	ES*	ES*	HE*
	Harvesting time	ES*	ES*	ES*	ES*
15	**Marketing of produce**				
	Market rate of vegetable	HE*	HE*	HE*	HE*
	Storage	ES*	ES*	ES*	ES*
	Packing	ES*	ES*	ES*	ES*
	Grading	ES*	ES*	ES*	ES*
16	**Schemes and subsidies**	HE*	HE*	HE*	HE*

*Prioritised items for the development of the m-App

HE - Highly Essential (Scores: 3.01-4.0) ES - Essential (Scores:2.01-3.0)
N - Needed (Scores:1.01 - 2.0) SN-Slightly Needed (Scores:0.01- 1.0)
NN - Not Needed (Score: 0)

It can be observed from Table 4.49 that all the items under 'design and construction', 'maintenance and repair of polyhouse', 'disinfection', 'micro-irrigation system', 'fertigation system', 'pest and disease management', and 'nutrient management' were considered as 'highly essential' by the farmers for all the crops (*viz.*, salad cucumber, amaranthus, chilli and yard long bean). The farmers opined that the information needs on 'hi-tech seedling procurement and production' was 'essential'. As training was not practised in amaranthus crop, farmers marked it as 'not-needed' information. All other information under 'crop layout and design' was essential for all four crops, according to polyhouse farmers.

Under 'weed management', 'stage of weeding' was marked as 'essential' information needed by the farmers. All other items under the heading were considered moderately essential or 'needed' for all crops. 'Pollination' was generally considered the 'slightly needed' information except for 'assisted pollination', which was reported as 'essential' for salad cucumber, chilli and yard long bean.

Polyhouse farmers considered the information about 'training and pruning' as 'highly essential' for salad cucumber and yard-long beans. At the same time, they marked it as a 'not needed' information as far as amaranthus cultivation was considered. In chilli cultivation, farmers pointed out that the information on 'training methods' was 'essential'. In contrast, all other items under this aspect were less essential for polyhouse chilli cultivation.

The information regarding the items, 'method of harvesting' and 'stage of harvesting' under the aspect 'harvesting of the crop' were observed as 'highly essential' information for yard-long bean cultivation by the farmers, while 'harvesting time' was perceived 'essential'. However, the information on all the three items was considered 'essential' for all other crops.

Under marketing of the produce, 'market rate of the vegetable' was marked as 'highly essential' information and 'storage', 'grading', and 'packing' were pointed out as ‘essential’ needs for all the four crops. Information on ‘Govt. schemes and subsidies’ was ‘highly essential’.

4.7. Training needs of farmers on polyhouse vegetable cultivation

The training needs of farmers are assessed and given in Table 4.49.

Table 4.50. Training needs of farmers on polyhouse vegetable cultivation (N=240)

Sl. No.	Items	Mean Score
1	**Hi-tech seedling procurement and production**	
	Grafted seedling production	2.83
	Seedling production	2.77
	Transplantation of seedlings	2.68
2	**Crop layout and design**	
	Seedbed preparation	2.62
	Planting in growbags and potting mixture	2.47
3	**Disinfection**	
	Disinfection of polyhouse	3.83
	Soil sterilization	3.82
	Fumigation	3.70
4	**Micro irrigation**	
	Maintenance and repair of the irrigation system	3.87
	Operation of the irrigation system	3.75
	Installation of irrigation system	3.10
5	**Fertigation**	
	Maintenance and repair of fertigation system	3.85
	Operation of fertigation unit	3.75
6	**Cooling system**	
	Operation of fogger	1.82
	Maintenance and repair of fogger	1.82
	Installation of fogger	1.70
7	**Maintenance and repair of polyhouse**	
	Cleaning of covering material of polyhouse	3.78
	Changing the covering material of polyhouse	3.75
8	**Pest and disease management**	
	Method of application of biocontrol agents	3.28
	Soil application of chemicals	2.83
	Foliar spray of the plant protection chemicals	2.83
9	**Nutrient management**	
	Soil application of fertilizers	2.85
	Composting	2.82
	Foliar application of chemicals	2.67
10	**Weed management**	

	Mechanical weeding	1.37
	Chemical weeding	1.22
11	**Pollination in crops**	
	Assisted pollination	2.17
	Maintenance of bee hives	0.90
	Beekeeping	0.88
12	**Training and pruning**	
	Training methods	3.17
	Pruning methods	3.15
13	**Harvesting methods**	**2.50**
14	**Marketing**	
	Storage	2.62
	Packing	2.60
	Grading	2.55

Training on hi-tech seedling procurement and production is mainly required in grafted seedling production (M=2.83). The seedling grafting is one of the latest technologies in crop improvement under polyhouse conditions. Farmers are curious about the practice and many of them asked to provide training on the same. The seedling production in general is in the second position (M=2.77). Transplanting method of planting is recommended in polyhouse than direct sowing method. So, the farmers must be properly trained in this aspect (M=2.68).

Crop layout and design is another broad aspect in polyhouse cultivation. Seed bed preparation is most demanded practice in which training should be given (M=2.62). As most of the farmers plants directly above the soil, growbag planting is usually seed as irrelevant aspect as far as training is considered. Hence, the mean score indicates that it is moderately needed part while opinions of farmers are considered (M=2.47). The maintenance of polyhouse and hygienic practices to protect crop from pests and diseases is very important. Here, the disinfection comes in to the play. From the mean score, it is evident that, farmers realise the importance of disinfection, soil sterilisation and fumigation inside polyhouse as the scores were high (M=3.83, 3.82, and 3.70, respectively).

Micro irrigation and fertigation are inevitable parts of polyhouse. Farmers' training need was high in these aspects as per the data. Maintenance and repair of irrigation system as well as fertigation system scored highest with M value 3.87 and

3.85, respectively. The need of training regarding the operation of the fertigation and irrigation systems were equally important (M=3.72). Installation of the system was not much needed as compared to the other aspects as most of the farmers tries to get it installed with the help of technicians. Still the score was above 3.0 (M=3.10).

As per the opinion of most of the farmers, the cooling system was not a necessity in their polyhouse. The scores assigned for the training needs of farmers on operation, maintenance and repair, and installation, were very low and scored 1.82, 1.82 and 1.70, respectively. Of all the aspects, the farmers requirement of hands-on practice in changing and cleaning covering material was found to be more. In a region like Kerala where, two monsoons are strong, the quality of the covering materials of polyhouse declines in a fast pace. Hence, farmers needed to get trained on cleaning and changing the covering materials (M=3.75, M=3.78, respectively).

The main constraints faced by the polyhouse farmers are regarding the destruction of crop due to pest and disease occurrence. Most of the farmers prefer to try organic methods of pest control initially and some polyhouse farmers don't have experience in this regard. Hence, the score of this item (M=3.28), indicates a high need for training among farmers. Soil and foliar application are common and mostly used technique by around half of the farmers. The remaining farmers requested to conduct trainings on the items (M=2.83). Similar pattern is shown in the results of nutrient management too. The soil application of fertilizer scored a mean value of 2.85, compositing scored 2.82 and the score of foliar application is 2.67. The values indicate moderate level of training needs.

The practice of weed management is not that different from the open cultivation. Most of the farmers could identify and remove the weeds, before affecting the crop stand. But a very few farmers needed training on mechanical and chemical weeding. As the pollinations does not occur naturally in polyhouse due to closed atmosphere, assistive method of pollination is commonly practiced method for fruiting. But nowadays, the availability of self-pollinated varieties is more. Hence, the score obtained was 2.17 which indicates a relatively less need of training. The scores of honey bee rearing for polyhouse cultivation scored very less (<1.0).

The crops such as salad cucumber and yard long beans grow in a vertical way under polyhouse. The crops should be properly trained and pruned to ensure proper growth of the crops. Most of the farmers required training on training as well as pruning the crops (mean scores of 3.17 and 3.15, respectively). The yield obtained from the polyhouse per unit area is very high compared to that in an open area. The frequent and high yield increases necessity of storage of these perishable products, in whicmany farmers lack skill (M=2.62). Packing and grading is another aspect which can fetch high price for the produce. Moderate score of the training needs indicates the requirement of skill development in these aspects (M=2.60 and 2.55, respectively).

4.8. Design, development and end user assessment of m-app

4.8.1. Design and development of m-app

The vegetable-wise information needs on four crops were prioritised according to the responses made by the farmers. Accordingly, the content was created and the prototype of the mobile app for vegetable cultivation under polyhouse was made. The app consists information on the four vegetable crops namely, salad cucumber, yard long bean, chilli and amaranthus. The sequential information from the selection of construction materials and construction of polyhouse to the harvesting and marketing of the produce is given in the tool. Apart from subject matter experts, exhaustive review of different literatures, ICAR websites, KAU- Package of practices handbook, TNAU Agritech portal, hand books published by State Horticultural Mission and other sources were referred to collect and organise the contents.

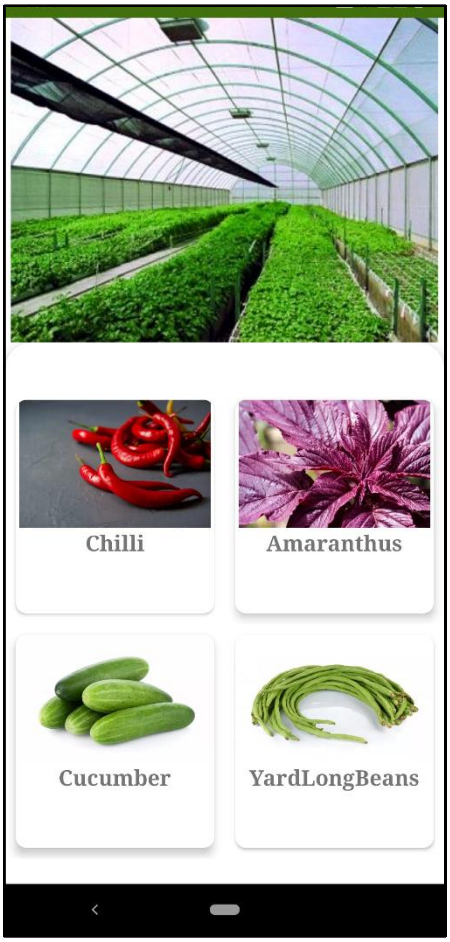
4.8.1.1 Language

The app is bilingual with information given in English as well as in the vernacular, Malayalam. The home screen looks like as given in Plate 7. It has the options to select the language which leads the users to the next screen from where they can select the crops.

Plate 7. Representation of screen 1-Selection of the language

4.8.1.2 Vegetables included

Presently the details of four crops which are popularly cultivated under polyhouses in Kerala are included in the app *viz*., salad cucumber, yard long bean, chilli and amaranthus. The crops with pictorial representation help the farmer for easy identification of the crops (Plates 8 and 9). Selection of the crop will lead to the next page where major cultivation aspects are given.



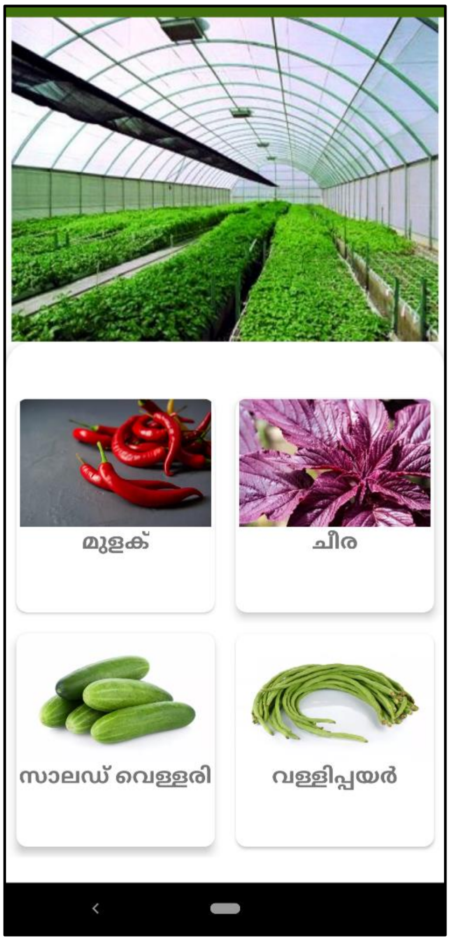


Plate 8. Representation of Screen 2-Selection of the crop (English)

Plate 9. Representation of Screen 2-Selection of the crop (Malayalam)

4.8.1.3 Cultivation aspects of the crops

Selection of the crops lead to screen 3, where the major cultivation aspects of the particular crop are listed out as broad groups as per general classification pattern. A total of 10 broad cultivation aspects are given as in Plate 10. This includes,

- Design and construction of polyhouse
- Hi-tech seedling procurement and production
- Crop canopy management
- Drip irrigation and fertigation
- Pollination in crops
- Plant protection
- Climate control in polyhouse

- Maintenance of polyhouse
- Harvesting and marketing of the vegetables
- Government schemes and subsidies for cultivation under polyhouse

Plate 10. Representation of screen 3 - Selection of major cultivation aspect

Selection of the needed cultivation aspect will navigate the user to the screen 4, where the sub groups are arranged logically. For instance, selecting ‘Plant protection’ will lead to the next screen which contains the subdomains of plant protection such as pests in crops, diseases in crops, and plant protection equipment. The representation of screen 4 is given in Plate 11 and 12.

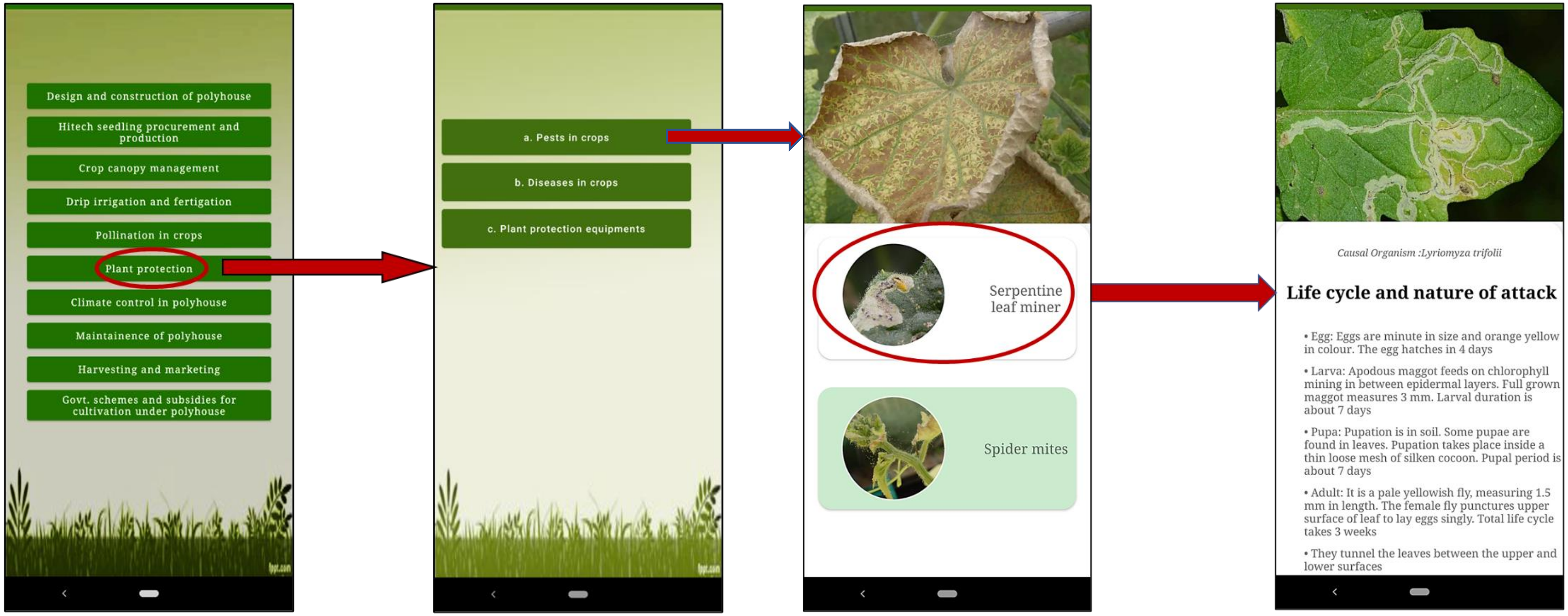


Plate 11. Representation of navigation from Screen-3 to 4, 4 to 5 and 5 to 6 (English)

Plate 12. Representation of navigation from Screen-3 to 4, 4 to 5 and 5 to 6 (Malayalam)

Selecting the required button from the fourth screen leads the user to screen 5. In certain links like 'Design and construction of polyhouse', screen 5 directly gives the detailed description of the required information. But in other cases, the user should navigate through one more screen which contains more specific clickable item to reach the needed content in screen 6 (Plate 11 and 12).

The content description is organised as text only and text with photos screen. Addition to the detailed information regarding design of polyhouse, pests, diseases, and deficiency symptoms, illustration/ photos are also given as slide show above the description (as in Plate 11 and 12) in order to have a clear understanding of the information given.

4.8.2. End user assessment of the developed m-App

The developed m-app was assessed with the help of end users *i.e.*, farmers. For the end user assessment of the development m-app 30 polyhouse farmers were selected. As described in the chapter 'methodology' the mean scores of each criterion was calculated. The result is presented below.

4.8.2.1 Assessment of the developed m-App

Table 4.51. Criteria-wise assessment of m-App (N=240)

Sl. No.	Criteria	Mean scores (M)
1	Navigation	3.37
2	Comprehension	3.22
3	User-friendliness	3.14
4	Contents	3.13
5	Readability	3.10
6	General app features	3.05
7	Design and layout	3.03

A glance at the criteria-wise scores of m-app, it is evident that mean score of the criteria navigation is the highest (M=3.37). This may be because, the farmers are already familiar with similar navigation pattern in other mobile apps and may have found that the navigation is appropriate for their use. Comprehension element has the next highest mean score of 3.22. The polyhouse farmers might have felt that the arrangement of the content, clarity, and easiness in understanding the information are according to their need.

A mean score of 3.14 indicates that the app is user friendly, a crucial criterion required for any mobile application. High mean scores of the elements; contents, and readability (M = 3.13 and 3.10, respectively) shows that the farmers are satisfied with these elements. Fairly high scores were obtained for general app features and design. Even though the mean scores showed high values, some of the attributes could be modified to increase the usability of the App. It is encouraging to note that all the first five criteria fetched good scores (between 3.10 to 3.37 out of four). Given time, the last two criteria namely 'general app features' and 'design and layout' can be further improved.

To have more insight on each parameter, the results of the attribute-wise evaluation are given in Table 4.51.

Table 4.52. Quality of attributes of each design element of the m-App as perceived by the end users (N=240)

Sl. No.	Attributes of each design element	Mean scores
1	**Design and layout**	
	Home screen appeal	3.13
	Colour combination	3.10
	Content grouping	3.03
	Overall appearance	2.97
	Positioning of icons	2.97
	Alignment	2.97
2	**Readability**	
	Font style	3.33
	Consistency of fonts	3.17
	Contrast between font and background	3.13
	Line length	3.03
	Font size	3.00
	Line spacing	2.93

Sl. No.	Attributes of each design element	Mean scores
3	**Contents**	
	Relevance of information	3.17
	Quality of pictures	3.17
	Adequacy of information	3.13
	Authenticity of information	3.13
	Usefulness of hyperlink to external websites	3.13
	Appropriateness of pictures	3.10
	Subject matter coverage	3.07
4	**Comprehension**	
	Logical arrangement of content	3.33
	Brevity of information	3.23
	Usefulness of information	3.23
	Simple language	3.23
	Clarity of information	3.17
	Easiness in understanding	3.13
5	**Navigation**	
	Easiness to navigate backwards	3.50
	Speed of navigation from page to page	3.43
	Touch screen functionality for navigation	3.30
	Easiness in identifying of clickable items and thumbnails	3.23
6	**User friendliness**	
	Easy to locate needed information	3.56
	Labels of the groups and subgroups	3.33
	Easiness of use	3.13
	Predictability of next screen	3.00
	User friendliness of interface	2.97
	Contents per page	2.83
7	**General app features**	
	Time taken to load a page	3.33
	Compatibility with device	3.23
	Time taken to open the app	3.13
	Size of app	3.10
	Free from errors while operating app	3.07
	Offline availability of required information	2.43

Taking the design and layout element, parameters such as home screen appeal, colour combination and content grouping showed high mean scores of 3.13, 3.10 and 3.03, respectively. Farmers were impressed with these attributes and they found it appropriate. Overall appearance of the app, positioning of the icons, and alignment scored moderate mean value of 2.97, each. These attributes could be modified.

Considering the items under readability, it is clear that farmers are satisfied with the font type and style and its consistency, colour contrast and line length as these items scored more than three out of four (3.33, 3.17 and 3.13, respectively). Farmers felt that the font size and line spacing could be modified for better reading experience. (M = 3.00 and 2.93). Refinement could be made by increasing the font size and line spacing to look it more readable.

As no other mobile tools are available specifically for polyhouse cultivation, the content given should be highly useful for the farmers. A glance on the responses of farmers on contents of the app points out that the farmers are satisfied with the content of the app. All the attributes scored high mean values of more than 3.0 out of 4. They opined that the information was relevant and adequate and believed that the information was authentic (M=3.17, 3.13 and 3.13, respectively). From the responses it is also understood that the photos and illustrations given were found to be appropriate and useful for the farmers (M=3.17). Farmers are satisfied with the subject matter coverage (M=3.07).

Items under comprehension of the information scored high mean values. Farmers are highly satisfied with the arrangement of the contents (M=3.33). They farmers responded that the information given were presented in simple, brief and is useful for them (Mean value of 3.23, each). The result also indicated a high mean score for clarity and easiness in understanding the contents of the app (M=3.17 and 3.13, respectively). For the time being there is no need of much modifications in comprehension related attributes of the developed app

Navigation is the most familiar feature for smart phone users. Most of the apps follow the same patten of navigation. Farmers responded with a high level of satisfaction in using navigation features of the app. The opined that they could easily find clickable items and navigation from page to page, forward and backward. This means that navigation is not at all complicated. All the items showed very high mean values (more than 3.20).

User-friendliness is a very important element in any ICT tool. In the present study this attribute scored high. While taking each attribute in to consideration, it is obvious that easiness in locating needed information has the highest mean score of 3.56 followed by labelling of groups and subgroups with a score 3.33. A mean score of 3.13 here indicates the easiness in using the mobile app. Predictability of next screen is an important factor to locate the needed content in the app. Moderate scores of user-friendliness of interface and contents per page (M=2.97 and 2.83) indicate the need for improvement of these features (M=2.97 and 2.83).

General app features indicate the technical features of the mobile app. The overall score points to a satisfactory opinion of polyhouse farmers regarding this. Most of the farmers used mobile phones with android operating system. Therefore, the compatibility is not a constraint. Farmers felt that the time taken to load the app as well as pages was less. So also, the size of the app is relatively small as it was easy to install. The app was devoid of errors and hence it is smooth to operate. Hyperlinks to external websites are available in the app to give farmers more insight on the market price of vegetables and government schemes and subsidies for polyhouse cultivation. As they require internet connectivity and data usage, Farmers felt a slight dissatisfaction regarding this feature as reflected from the apprehension. The mean score of this item was 2.43.

4.8.2.2. Constraints in the use of mobile app

The main constraints put forth by the farmers were the small font size and large contents per page. This has caused difficulty in reading the contents. Another constraint reported was the change in features of app while using dark mode theme in mobile phone. Some farmers opined that the sentences and technical terms given in the vernacular are bit complicated.

4.8.2.3. Suggestions for improving the m-App

The following suggestions were put forth by the polyhouse farmers to improve the m-app.

1. Since the m-app is found highly useful by the farmers , they suggested to include more crops in the m-app
2. Provision of contact details of successful polyhouse farmers and subject matter experts in the area
3. Provision of real time doubt clarification facility in the m-app

An overall perusal of the user assessment of the m-app developed as part of the study is really motivating. Overall, the farmers perceived the developed m-app as a very useful tool aiding in the vegetable cultivation under polyhouse.

Summary

CHAPTER 5

SUMMARY AND CONCLUSION

Hi-tech farming is gaining grip in Indian farming system. Polyhouse farming which is a subset of hi-tech farming is an alternate new system of crop production which reduces dependency on climatic factors along with economic use of water, fertilisers and other inputs necessarily needed for farming. In a state like Kerala where per capita availability of land is less and density of population is increasing, the polyhouse can be a boon to the farmers. With advancing technologies, proper information delivery system must be there to make farmers get updated with the progress in agriculture. As Information and Communication Technology (ICT) tools are acquiring its foothold even among the rural communities, proper utilisation of suitable tools can help farmers to get more insight of the advances and in turn aid in efficient decision making.

The technology of polyhouse cultivation was introduced in Kerala in the year 2005-2006 through the centrally sponsored scheme for promoting hi-tech farming and taken forward by State Horticultural Mission, Kerala. The scheme was started with 1,115 polyhouse units all over the state and gained appreciation from farmers over time. But now the trend of polyhouse cultivation is declining as the farmers are facing constraints and stopping the cultivation under the structure. The skill and knowledge might be the biggest problem as far as farmers in the state are concerned. Proper information delivery mechanisms can lift up the courage of farmers to adopt advanced technology like polyhouse farming. As Information Communication Technologies (ICTs) are ruling the world in recent decades, proper utilization of popular and accessible tools can help the farmers through proper knowledge upgradation.

Mobile phones are one such promising technology which is capable of transforming the agricultural sector. In recent decades, we have witnessed the surge of mobile based user-friendly tools for various purposes in our day to day life from simple communication to huge financial transactions. The best use of mobile phones can make information dissemination efficient, timely, and accurate.

While designing a tool, especially for the purpose of knowledge upscaling, it should be able to address various pedagogical problems concerning the end users. Once suitably developed, it must serve as an efficient technology transfer mechanism. Hence, in the present study, a mobile application was designed and developed to serve as a ready to use digest pertinent to crop production details for farmers involved in vegetable cultivation under polyhouse in Kerala.

The study, 'User-centred design, development and end-user assessment of an m-tool for vegetable cultivation in polyhouse' was undertaken with the aim to develop an m-tool for polyhouse cultivation and to conduct an end user assessment of the developed m-tool. The study also analysed the present ICT utilisation, m-readiness and factors affecting the m- readiness of the polyhouse farmers. Addition to these, the research assessed the information needs and training needs of the polyhouse farmers, the constraints faced by farmers regarding cultivation of vegetables in polyhouse.

The study was conducted in six districts from three zones of Kerala. The selected districts were Kozhikode and Malappuram from north zone, Thrissur and Ernakulam from central zone and Alappuzha and Thiruvananthapuram from south zone. A total of 240 farmers constituted the sample. Four commonly cultivated vegetable crops in polyhouse viz, yard long bean, salad cucumber, chilli and amaranthus were identified. Through random sampling method, from every selected district, 10 farmers each cultivating/who had already cultivated each of the above vegetable crops in the previous years were included in the study.

The study is ex-post facto in nature. The variables selection was based on the objectives of the study through extensive literature review. The data was collected using structured questionnaire through direct interviews. The collected data was subjected to statistical analyses using tools such as frequency, percentage, mean, Spearman's correlation analysis, linear and binary logistic regression, Kruskal Wallis test, factor analysis, and Kendall's coefficient of concordance. The salient findings of the study, the implications drawn from the work, conclusion along with future line of research are given below.

5.1. Salient findings of the study

- Analysis of the profile characteristics of the farmers revealed that 76.67 per cent of the farmers belonged to middle aged category and 88.33 per cent were males. All the farmers were literate with at least secondary level of education. Majority of the farmers (46.66%) completed graduation. Most of the farmers were highly innovative (75.00%) and showed less resistance to change (50.00 %). Social participation, mass media exposure and achievement motivation were found to be high for majority of the farmers with 43.33 per cent, 51.66 per cent and 38.33 per cent farmers respectively

- Mobile phones were the most popular ICT gadgets among polyhouse farmers with a score of 204 out of 240. Mobile-based apps were the next most used information-gathering tool by farmers followed by social media with scores of 189 and 188 respectively. The fourth position was taken over by websites and portals with a score of 159 out of 240.

- The information collected through ICTs for agricultural purposes was mainly about plant protection followed by particulars on production practices with scores of 151 and 138 out of 200, respectively.

- More than a third of polyhouse farmers (36.67%) were utilising ICTs to a higher extent. Less than a fourth (23.33%) of the respondents were found to have low ICT utilisation.

- The Kruskal Wallis test showed that there was significant difference in ICT utilisation among farmers of the selected districts. Farmers in Thiruvananthapuram district showed highest value followed by Thrissur and Malappuram in second and third positions respectively.

- Spearman's correlation analysis pointed out that education, annual income, innovativeness, social participation, mass media exposure, and achievement motivation showed a positive correlation with ICT utilisation and variables such as age, experience, and resistance to change exhibited a negative correlation with ICT utilisation.

- Results from binary logistic regression indicated that the variables age, family size, experience, social participation, mass media exposure and change resistance showed significant regression coefficient. Odds ratio showed that, there was 4.961 and 4.222 times chance that the farmer would fall in the category of above average ICT utilisation if a unit increase in social participation and mass media exposure occurs, respectively.

- Factor analysis using principal component method reduced the dimensionality of variables affecting ICT utilisation to four factors namely information dynamics, innovation orientation, proficiency enhancement, demographics based on eigen value. Percentage of variance explained by these factors were 26.59, 16.79, 14.65, and 9.68, respectively.

- Linear regression analysis revealed that information dynamics, innovation orientation and proficiency enhancement factors showed significant effects on ICT utilisation, in which a unit increase of these factors cause 7.37, 11.01 and 8.33 times increase in ICT utilisation

- The constraints in ICT utilisation were analysed and found that lack of locally relevant information, non-availability of information in the vernacular and lack of needed contents online were the main problems faced by farmers. Other issues include lack of awareness, adequate skills and technophobia.

- Analysing the data of subdomains of m-readiness indicated that higher score was obtained for physical readiness (score = 50.95) followed by psychological readiness (score = 47.95). Technological and economic readiness scored 44.33 and 44.17 respectively. The total m-readiness scores worked out revealed that 48.33 percent farmers showed high level of m-readiness

- The results of the Kruskal Wallis test showed that there was no significant difference in m-readiness among districts.

- The results of the Spearman's correlation analysis showed that education, annual income, innovativeness, social participation, achievement motivation, trainings attended and ICT utilisation had a positive correlation with m-readiness and variables such as age, family size, experience, and resistance to change exhibited a negative correlation with m-readiness.

- Results from binary logistic regression indicated that the variables innovativeness, mass media exposure, and ICT utilisation were significant. Odds ratio shows that there is 151.28 times chance that the farmer will fall in the category of above average m-readiness when a unit increase in innovativeness occurs and 1.33 times chance that the farmer will fall in above average category if a unit increase in ICT utilisation occurs.

- Factor analysis using principal component method reduced the dimensionality of the variables affecting m-readiness to four factors namely innovation orientation, information dynamics, proficiency enhancement, demographics based on eigen value. Percentage of variance explained by these factors were 21.83, 20.01, 14.67, and 11.15, respectively.

- Linear regression analysis points out that innovation orientation, information dynamics, and proficiency enhancement factors showed significant effect on m-readiness, in which a unit increase of these factors cause 33.24, 9.73, and 18.79 times increase in m-readiness.

- The variables related to polyhouse cultivation were also found out, which shows 98.33 per cent of farmers had naturally ventilated polyhouses. The average construction cost incurred was Rs. 1226 per m^2 and 56.67 per cent of respondents spent more than average rate for construction. Majority of the farmers (40.00%) spent at least Rs. 45 per square metre of area per season as variable cost. The income from polyhouse vegetable cultivation was in the range of Rs. 300-500 per square metre per season for more than half of the farmers (56.67%). Almost all the farmers (95.00%) attended trainings on polyhouse cultivation.

- Constraints faced by farmers while cultivating under polyhouse were assessed and ranked according to mean value. Lack of availability of skilled laborers was the main physical constraint followed by unavailability of quality inputs. High occurrence of pests and diseases and difficulty in maintaining polyhouse were major issues related to management of polyhouse. Among economic constraints, high cost of repair and high wage of skilled workers were the problems. Farmers faced problems of price fluctuations and they lacked proper awareness on marketing and export of the produce.

- The findings after assessing vegetable wise information needs of farmers specifies that farmers needed information mainly on construction of polyhouse, disinfection and pest and disease control in polyhouse, micro irrigation and drip irrigation, the methods to repair, maintain and control climatic factors under polyhouse for all the crops.

- Training needs of the polyhouse farmers were assessed as part of the study. Trainings on disinfection, micro irrigation, fertigation, maintenance and repair, pest and disease management, training and pruning were the most essential needs.

- The vegetable-wise information needs on four crops were prioritised according to the responses made by the farmers. Accordingly, the content was created and the prototype of the mobile app for vegetable cultivation under polyhouse was made. The app consists information on the vegetable crops viz., salad cucumber, yard long bean, chilli and amaranthus. The app is bilingual with information given in English as well as in the vernacular; Malayalam.

- The end user assessment of mobile app was conducted which received decent feedback from the farmers. The elements such as navigation, comprehension, and user friendliness got better mean scores.

5.2. Implications of the study

- As polyhouse cultivation provides higher and frequent yield, proper infrastructure is required by the farmers to keep the perishable products. Referring the constraints faced by the farmers on polyhouse cultivation, it can be noted that proper storage or effective supply chain or cold chain facilities are not available as per the need of the farmers. Thus, the study implies the need of efficient and affordable storage facilities for supporting the farmers.

- It was observed during the survey that despite the financial support from the government agencies, hi-tech farmers are struggling to keep their polyhouses functional. The reason for the increasing number of dysfunctional polyhouses must be properly analysed and necessary action be taken to overcome this.

- On analysing the information needs of farmers, it was clearly understood that there is a need of proper communication of required knowledge to polyhouse farmers. So, transfer of technology in respect of polyhouse farming must be made effective using the most popular tools among the farmers.

- Successful application of ICTs depends upon digital literacy of the people. It has to be seriously noted in the study that the number of need-based e-literacy trainings provided for farming communities are very less. If one traces the training provided for farmers by the line departments, there have been only a few e-literacy training programmes organised in Kerala state. This trend needs serious rethinking. The concerned authorities should give emphasis on the digital literacy of the farmers besides agriculture.

- Assessment of ICT utilisation of polyhouse farmers, pointed out that mobile phones are the most commonly used ICT tool. Proper mobile based technologies can have a positive effect in knowledge and skill development of farmers. As mobile app usage is high among farmers, the study implies to make use of mobile and related technologies for proper information dissemination.

- The constraint analysis regarding ICT usage among farmers done in the study has highlighted the lack of availability of ICT tools providing location specific information in the vernacular, which implies the need for such ICT tools, which in turn would help the farmers to use the tools efficiently and effectively.

- Constraint analysis points out that lack of proper knowledge in polyhouse cultivation affected the efficiency of production. The income of farmers from the polyhouse can be increased by providing timely polyhouse specific information and trainings. Besides the agronomic practices inside a polyhouse, basic trainings are required on the hardware part of polyhouse construction.

- Gender inclusiveness in hi-tech agriculture is still low even though the number of females outnumber the male population in Kerala state. Polyhouse cultivation being in a limited area, female farmers can easily undertake it. By developing solutions that are more inclusive, farmers could tap into a much larger market, consequently improving their income.

- The m-readiness scale developed for the study can be used for future studies to measure the m-readiness of farmers as the scale was one of the pioneering attempts in this area.

5.3. Conclusion

The study closely analysed the ICT utilisation and m-readiness of polyhouse farmers along with their personal, psychological, and socio-economic profile. Most of the farmers were tech-savvy and highly innovative. Furthermore, they were utilising mobile phones and other ICT tools regularly. This creates a scope to develop various digital platforms for effective delivery of agricultural information. If properly utilised, ICTs can create huge and positive impact on the farming sector. Especially mobile phones can fill the digital divide as it is the most popular, handy and affordable device. Based on the information needs of farmers on four crops, a mobile app was developed as part of the study to assist farmers in polyhouse cultivation. The end user assessment indicated that the app was user friendly and content given was sufficient. Apart from this the constraints of polyhouse farmers were also assessed. It can be observed from the results that maintenance of polyhouse, pest and disease control in the polyhouse, unaffordability of the expenses and lack of proper guidance are the major problems faced by them. The responses from the farmers indicates the need for training regarding polyhouse cultivation. These issues must be addressed properly for effective promotion of polyhouse vegetable cultivation

5.4. Future line of work

- The mobile app developed covered only four crops due to time and resource limitations. The developed app can be upgraded by adding more crops and information.

- A study can be conducted to analyse the utilisation of the developed mobile app and the effect of the developed mobile app on polyhouse vegetable cultivation.

- More ICT tools can be developed on a User Centred Design Mode, as done in the present study to cater to the needs of hi-tech farmers.

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Appendices

APPENDIX I

Respondent no:

KERALA AGRICULTURAL UNIVERSITY
COLLEGE OF AGRICULTURE, VELLANIKKARA
DEPARTMENT OF AGRICULTURAL EXTENSION

User centered design, development and end user assessment of an m-tool for vegetable cultivation in polyhouse

Interview Schedule

(For Academic purpose only)

1. **Name :**
2. **Contact No.:**
3. **Address:**

   Panchayath:

   Block:

   District:
4. **Age: _________** years
5. **Gender:** M / F
6. **Family details:**

Sl. No.	Education	Occupation	Income (in Rupees)
		Total	

7. **Land holding: _________** cents
8. **Experience in farming: ____________** years

9. Have you attended any e-Literacy / m-Literacy/ ICT based trainings: Yes / No

If yes, please provide details:

Sl. No	Name of the training programme	Content of programme	Institution organized the training	Duration of training

10. Mass media exposure

Sl. No.	Medium	Always	Often	Sometimes	Rarely	Never
1	Newspapers					
2	Magazines					
3	Agricultural publications					
4	Leaflets/ folders					
5	Radio					
6	Television					

11. Social participation

Indicate your involvement in any social organisation

Sl. No.	Membership - categories	Frequency of contact		
		Regularly	Occasionally	Never
1	No membership			
2	Membership in one organisation			
3	Membership in more than one organisation			
4	Office bearer in one organisation			
5	Office bearer in more than one organisation			

12. Innovativeness:

When would you like to adopt a new / improved practice/ technology?

Sl. no.	Statement	Put a tick (✓) against the statement
1	As soon as it is brought to my knowledge	

2	After I had seen other people tried successfully	
3	I prefer to wait and take my own time	
4	I am not interested to adopt new technologies	

13. Achievement motivation

Sl. No.	Statements	Strongly agree	Agree	Un-decided	Disagree	Strongly disagree
1	One should work hard till the results are achieved					
2	One should work like a slave until the person is satisfied with the result					
3	One should succeed in his occupation even if he/she is neglectful of his family					
4	Work comes first even if one cannot rest					
5	One should enjoy work as much as a play					
6	One should set difficult goals or oneself and try to reach them					

14. Change resistance

Sl. No.	Statements	Strongly agree	Agree	Un decided	Disagree	Strongly disagree
1	I am hesitant to adjust with a new situation					
2	I would like to continue the present situation and change is not needed					
3	Change is needed in life according to changing world					
4	Changes of situation always make me uncomfortable					
5	Continuing the present way will not help in					

	progress of life					
6	I am ready to welcome a new technology					

15. Details of polyhouse

1. Type of polyhouse (put a tick (✓) against the relevant one)
   a. Naturally ventilated
   b. Climate controlled
2. Area of the polyhouse (m^2): __________
3. Crops cultivated (area-wise):
   1. ________________________, ________________m^2
   2. ________________________, ________________m^2
   3. ________________________, ________________m^2
   4. ________________________, ________________m^2
   5. ________________________, ________________m^2
   6. ________________________, ________________m^2

4. Material of construction:
5. Source of construction material:
6. Subsidy availed (in Rupees):
7. Cost of construction of polyhouse:
8. Equipment / additional facilities used in polyhouse (put a tick (✓) against the relevant ones) and their cost:

Particulars	Yes/ no	Cost (in Rupees)
a. Cooling system		
b. Drip irrigation		
c. Fogging system		
d. Fertigation system		
e. Training structures		
f. Staking/supporting system		
g. Mulching		
h. Insect traps		

i. Cold storage		
j. Packing house		
k. Others (specify):		

9. Variable cost involved in polyhouse cultivation of vegetables (in Rupees)

Particulars	Last cultivated year	Cost (inactive polyhouse)	Cost (active polyhouse)
a. Land preparation:			
b. Bed preparation:			
c. Planting material:			
d. Labour charges:			
e. Family labour:			
f. Plant protection:			
g. Fertilizers			
h. Plant growth regulators:			
i. Training and pruning:			
j. Staking/ support system:			
k. Harvesting:			
l. Grading			
m. Packing			
n. Storage			
o. Transportation			
p. Others (specify):			

Total: ₹ ____________

10. Income from polyhouse:

a. Crop wise yield (kg)

i.

ii.

iii.

iv.

v.

vi.

b. Average price per kilogram (crop wise; in Rupees)

i.

ii.

iii.

iv.

v.

vi.

Total income: ₹ ______________________

11. Trainings attended related to polyhouse:

16. Vegetable wise information needs

Sl. No	Particulars	Not needed	Slightly needed	Needed	Essential	Highly essential
I	**Design and construction of polyhouse**					
a.	Selection of site for polyhouse construction					
b.	Orientation of polyhouse					
c.	Selection of materials for construction of polyhouse					
d.	Ridge height					
e.	Gutter height					
f.	Covering material					
II	**Hi-tech seedling procurement and production**					
a.	Source of seeds					
b.	Seedling production					
c.	Grafted seedling production					
d.	Crop varieties suitable for hi-tech vegetable cultivation					
f	Transplantation of seedlings					

III	**Crop layout and design**					
a.	Soil analysis					
b.	Bed preparation					
c.	Planting in growbags and potting mixture					
d.	Spacing of the seedlings					
e.	Training of the crops					
IV	**Disinfection**					
a.	Disinfection of polyhouse					
b.	Soil sterilization					
c.	Fumigation					
V	**Micro irrigation**					
a.	Drip irrigation					
b.	Installation of irrigation system					
c.	Operation of the irrigation system					
d.	Maintenance and repair of the irrigation system					
VI	**Fertigation**					
a.	Fertilizers suitable for fertigation					
b.	Operation of fertigation unit					
c.	Maintenance and repair of fertigation system					
d.	Calculation of fertilizer doses					
e.	Maintenance of pH, EC and other soil parameters					
VII	**Cooling system**					
a.	Installation of fogger					
b.	Operation of fogger					
c.	Maintenance and repair of fogger					
VIII	**Maintenance and repair of polyhouse**					
a.	Cleaning of covering material of polyhouse					
b.	Changing the covering material of polyhouse					

c.	Maintaining weather parameters inside polyhouse					
IX	**Pest and disease management**					
a.	Symptoms of diseases and pest infestation					
b.	Biocontrol agents against pest and diseases					
c.	Method of application of biocontrol agents					
d.	Traps used for pest control					
e.	Plant protection chemicals					
f.	Dosage of the chemicals					
g.	Soil application of chemicals					
h.	Foliar spray of the plant protection chemicals					
X	**Nutrient management**					
a.	Deficiency symptoms (macro and micro nutrients)					
b.	Toxicity symptoms (macro and micro nutrients)					
c.	Bio fertilizers to be applied					
d.	Composting					
e.	Chemical fertilizers to be applied					
f.	Rate of application of fertilizers					
g.	Stage and time of application of fertilizers					
h.	Soil application of fertilizers					
i.	Foliar application of chemicals					
XI	**Weed management**					
a.	Weed flora found in polyhouses					
b.	Mechanical weeding					
c.	Chemical weeding					
d.	Stage of weeding					

XII	**Pollination in crops**					
a.	Beekeeping					
b.	Knowledge about assisted pollination					
c.	Stage of keeping hives					
d.	Maintenance of bee hives					
XIII	**Training of crop**					
a.	Training methods					
b.	Pruning methods					
c.	Time of training / pruning					
d.	Stage of training / pruning					
XIV	**Harvesting**					
a.	Stage of harvesting					
b.	Method of harvesting					
c.	Harvesting time					
XV	**Marketing**					
a.	Grading					
b.	Packing					
c.	Storage					
d.	Market rates of vegetables					
XVI	Govt. schemes and subsidies for cultivation of polyhouse					
XVII	Others (specify)					

17. Training needs

Sl. No	Particulars	Not needed	Slightly needed	Needed	Essential	Highly essential
II	**Hi-tech seedling procurement and production**					
a.	Seedling production					
b.	Grafted seedling production					

c.	Transplantation of seedlings					
III	**Crop layout and design**					
a.	Seedbed preparation					
b.	Planting in growbags and potting mixture					
IV	**Disinfection**					
a.	Disinfection of polyhouse					
b.	Soil sterilization					
c.	Fumigation					
V	**Micro irrigation**					
a.	Installation of irrigation system					
b.	Operation of the irrigation system					
c.	Maintenance and repair of the irrigation system					
VI	**Fertigation**					
a.	Operation of fertigation unit					
b.	Maintenance and repair of fertigation system					
VII	**Cooling system**					
a.	Installation of fogger					
b.	Operation of fogger					
c.	Maintenance and repair of fogger					
VIII	**Maintenance and repair of polyhouse**					
a.	Cleaning of covering					

	material of polyhouse					
b.	Changing the covering material of polyhouse					
IX	**Pest and disease management**					
a.	Method of application of biocontrol agents					
b.	Soil application of chemicals					
c.	Foliar spray of the plant protection chemicals					
X	**Nutrient management**					
a.	Composting					
b.	Soil application of fertilizers					
c.	Foliar application of chemicals					
XI	**Weed management**					
a.	Mechanical weeding					
b.	Chemical weeding					
XII	**Pollination in crops**					
a.	Beekeeping					
b.	Assisted pollination					
c.	Maintenance of bee hives					
XIII	**Training and pruning**					
a.	Training methods					
b.	Pruning methods					
XIV	**Harvesting methods**					
XV	**Marketing**					
a.	Grading					

b.	Packing					
c.	Storage					
XVI	Others (specify)					

18. m-Readiness

I. Physical Readiness

Rate the availability/ accessibility of the following facilities required for the use of mobile phones

Sl. no	Particulars	Excellent	Good	Average	Poor	Very poor
1	Availability of power supply					
2	Accessibility of mobile phones					
3	Accessibility of smart phones					
4	Accessibility to smart-phone service centers					
5	Customer care services					
6	Network coverage					
7	Internet connectivity					
8	Availability of guidance/ technical support, when needed					
9	Availability of spare parts					
10	Availability of sim cards					
11	Availability of phones with long battery life					
12	Recharging facilities					
13	Accessibility of smart phones with enough storage facility					
14	Availability of wi-fi facility					
15	Free from health issues that prevents mobile phone usage					

II. **Technological readiness**

Rate your competency in doing the following operations/ activities using mobile phones

Sl no	Particulars	Highly competent	Competent	Moderately competent	Not competent	Not at all competent
1	Make calls in smart phones/ touch screen phones					
2	Send SMS / text messages					
3	Browse internet in mobile phones					
4	Use of mobile apps					
5	Install an application (m-app)					
6	Update an application (m-app)					
7	Uninstall an application (m-app)					
8	Use of e-mail in mobile phones					
9	Use of virtual groups using social media in mobile phones					
10	Watch videos in mobile phones					
11	Send information in different formats					
12	Use of technical terms associated with the use of mobile phones. *Eg*: install, texting, sending, saving, deleting, pdf, jpg *etc*.					
13	Texting messages in English					

14	Texting messages in the vernacular					
15	Use of smart phones without the help of others					

III. <u>Psychological readiness</u>

Sl no	Particulars	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
1	I don't like to use mobile phones for purposes other than making and receiving calls					
2	Wherever I go I carry my mobile phone with me					
3	I use/am ready to use mobile phones for all my communication					
4	I am not ready to use mobile phones as many features are uncomfortable for me					
5	I don't use smartphones as old model phones are sufficient					
6	I like to use mobile phones for the possible services					
7	I am ready to use mobile phone as a good learning tool					
8	I want to learn/ already know to use mobile phone without the help of others					
9	I am afraid to use mobile phones					

10	I find it difficult to remember the operations in mobile phones					
11	I need a mobile phone even if I can access the mobile phones of my family members					
12	I can/ want to use mobile phones as used by a competent user					
13	Smart phones are necessary for my daily life					
14	I prefer mobile phones to printed sources for gathering information					
15	I am eager to learn about various applications of mobile phones					

IV. Psychological readiness

Sl. No	Particulars	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
1	I can afford an ordinary mobile phone					
2	I cannot afford a smart phone					
3	I am ready to buy a high-end smart phone					
4	I can afford the use of internet facility (net connectivity)					
5	Call rates are affordable					
6	Repairing charges of mobile phones are very high					
7	I prefer to change my mobile phones rather					

	than repairing it					
8	I have more than one phone in my house					
9	Accessories are affordable					
10	Unavailability of mobile phones through installment payment causes difficulty in buying					
11	Tariff plans are affordable to me					
12	External storage facilities are available at affordable rates					
13	SMS charges are high					
14	Paid apps are unaffordable to me					
15	I like to change my mobile phones when new models with updated features arrives in market					

19. Present ICT utilization

I. Frequency of utilization of ICT

Sl. No.	Particulars	Always	Often	Sometimes	Rarely	Never	1.Agricultural/ 2.Non agricultural/ 3.Both
a)	**Gadgets**						
1	Mobile phones (smart phones)						
2	Computer/ laptop						
3	Tablets						
4	Others (specify)						

b)	Services						
1	Mobile apps						
2	Websites and portals						
3	DSS/ Specialised software						
4	SMS Services						
5	Call centres						
6	e-mail						
7	Social media						
8	Others (specify)						

II. Purpose of using ICT in agriculture

Sl no	Purpose	Always	Often	Sometimes	Rarely	Never
1	Procurement of quality inputs					
2	Production practices					
3	Weather related information					
4	Plant protection					
5	Credit and insurance					
6	Post-harvest handling of produce					
7	Value addition					
8	Market related information					
9	Agricultural schemes and subsidies					
10	Others (specify)					

III. Constraints in using ICT

Sl no.	Particulars	Very important	Fairly important	Important	Slightly important	Not at all important
1	Lack of adequate skill					
2	Lack of proper infrastructure					
3	Lack of adequate services in the					

	locality					
4	Lack of awareness about various ICT tools					
5	Non availability of information in the vernacular					
6	Lack of locally relevant information					
7	Lack of needed contents online					
8	High cost of the gadgets and associated accessories					
9	Lack of enough time to spent on technologies					
10	Technophobia					
11	No relative advantage over conventional information gathering methods					
12	Better alternatives					
13	Lack of confidence and motivation to use ICT tools					
14	If others, please specify					

20. Constraints in polyhouse cultivation

Sl. No.	Constraints	Very important	Fairly important	Important	Slightly important	Not important
Physical constraints						
1	Limited/ irregular electric power supply					
2	Water scarcity					
3	Unavailability of quality inputs					

4	Lack of availability of skilled laborers					
Management related constraints						
1	Lack of knowledge on vegetable cultivation under polyhouse					
2	Difficulty in maintaining polyhouse					
3	High occurrence of pest, diseases and physiological disorders under polyhouse					
4	Difficulties in following package of practices for vegetable cultivation under polyhouse					
5	Inadequate guidance from the part of concerned officials					
Economic constraints						
1	High wage of skilled workers in polyhouse					
2	Low income/profit from polyhouse					
3	High cost for repair and maintenance					
4	Poor yield and low quality of produce					
5	Non availability of credit in time					
Marketing related constraints						
1	Price fluctuations					

2	Lack of awareness regarding marketing and export of the produce					
3	Inadequate storage facilities					
4	Inadequate post-harvest handling facilities					
Policy related constraints						
1	High subsidy					
2	Unavailability of insurance in case of damage					
VI	**Others (specify)**					

21. Suggestions

1.

2.

3.

4.

5.

KERALA AGRICULTURAL UNIVERSITY
COLLEGE OF AGRICULTURE, VELLANIKKARA
DEPARTMENT OF AGRICULTURAL EXTENSION

User centered design, development, and end user assessment of an m-tool for vegetable cultivation in polyhouse

Questionnaire for evaluation of m-tool

(For Academic purpose only)

Particulars	Very poor	Poor	Fair	Good	Outstanding
Design and layout					
Overall appearance					
Colour combination					
Home screen appeal					
Positioning of icons					
Content grouping					
Alignment					
Readability					
Font size					
Font style					
Contrast between font and background					
Line spacing					
Line length					
Consistency of fonts					
Contents					
Subject matter coverage					
Adequacy of information					
Authenticity of information					
Relevance of information					
Quality of pictures					

Appropriateness of pictures					
Usefulness of hyperlink to external websites					
Comprehension					
Easiness in understanding					
Brevity of information					
Usefulness of information					
Logical arrangement of content					
Clarity of information					
Simple language					
Navigation					
Easiness in identifying of clickable items and thumbnails					
Touch screen functionality for navigation					
Speed of navigation from page to page					
Easiness to navigate backwards					
User friendliness					
User friendliness of interface					
Easy to locate needed information					
Labels of the groups and subgroups					
Contents per page					
Easiness of use					
Predictability of next screen					
General app features					
Compatibility with device					
Size of app					
Free from errors while operating app					
Offline availability of required					

information					
Time taken to open the app					
Time taken to load a page					

Constraints

-
-
-
-

Suggestions

-
-
-
-

USER CENTERED DESIGN, DEVELOPMENT, AND END-USER ASSESSMENT OF AN M-TOOL FOR VEGETABLE CULTIVATION IN POLYHOUSE

by

POORNIMA C P

(2017 - 21 - 001)

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirement for the degree of

Doctor of Philosophy in Agriculture

Faculty of Agriculture
Kerala Agricultural University

DEPARTMENT OF AGRICULTURAL EXTENSION

COLLEGE OF AGRICULTURE

VELLANIKKARA, THRISSUR - 680 656

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ABSTRACT

Hi-tech farming is gaining grip in Indian farming system. Polyhouse farming which is a subset of hi-tech farming is an alternate new system of crop production which reduces dependency on climatic factors along with economic use of water, fertilisers and other inputs necessarily needed for farming. In a state like Kerala where per capita availability of land is less and density of population is increasing, the polyhouse can be a boon to the farmers. With advancing technologies, proper information delivery system must be there to make farmers get updated with the progress in agriculture. As Information and Communication Technology (ICT) tools are acquiring its foothold even among the rural communities, proper utilisation of suitable tools can help farmers to get more insight of the advances and in turn aid in efficient decision making.

With this background, the present study was aimed to design and develop a user centred m-tool for vegetable cultivation in polyhouse. The study also intended to analyse the m-readiness of farmers, ICT utilisation, training needs for polyhouse cultivation along with constraints faced in the cultivation. The results of the study would help the authorities, policymakers and extension workers for formulating and implementing necessary plans for promoting polyhouse cultivation. The mobile app developed will guide the farmers to scientifically cultivate vegetables under polyhouse.

This exploratory study was conducted in six districts from three zones of Kerala. Four commonly cultivated vegetable crops in polyhouse *viz.*, yard long bean, salad cucumber, chilli and amaranthus were identified. From every selected district, through random sampling, 10 farmers each cultivating or who had already cultivated each of the above vegetable crops in the previous years were selected for the study. Thus, a total of 240 farmers constituted the sample.

Analysis of the profile characteristics of the farmers revealed that 76.67 per cent of the farmers belonged to middle aged category and 88.33 per cent were males. All the farmers were literate with at least secondary level of education. Majority of the farmers (46.66%) completed graduation. Most of the farmers were highly innovative (75.00%) and showed less resistance to change (50.00 %). Social participation, mass media exposure and achievement motivation were found to be high for majority of the farmers with 43.33 per cent, 51.66 per cent and 38.33 per cent farmers respectively

The analysis of the ICT utilisation indicated that the polyhouse farmers of Thiruvananthapuram, Thrissur and Malappuram districts utilised ICT tools to a greater

extent. The binary logistic regression analysis indicates that variables such as age, family size, experience, social participation, mass media exposure and change resistance showed a significant relation with ICT utilisation. Factor analysis using principal component method reduced the variables to four factors namely information dynamics, innovation orientation, proficiency enhancement and demographics. The farmers reported that lack of locally relevant information, non-availability of information in the vernacular and lack of needed content online were the main constraints regarding ICT utilisation.

The study revealed that majority of the polyhouse farmers were m-ready. Odds ratio of binary logistic regression says that there is 151.28 times chance that m-readiness falls in above average category if a unit increase in innovativeness occurs. Similarly, there is 0.40 times chance that m-readiness falls in below average category if a unit increase in mass media exposure occurs. Factor analysis using principal component method reduced the variables to four factors namely information dynamics, innovation orientation, proficiency enhancement and demographics.

Most of the farmers cultivated under naturally ventilated polyhouses (98.33 %) and in an area less than 500 m^2 (83.33 %). Nearly half of the farmers received subsidy of more than 60 per cent. Maintenance of polyhouse, pest and disease control in the polyhouse, and unaffordability of the expenses were the major constraints faced by polyhouse farmers. Farmers needed information mainly on disease control in polyhouse, micro irrigation and drip irrigation, the methods to repair, maintain and control climatic factors under polyhouse for all the crops. Regarding the training needs, skill development was needed mainly in the areas of disinfection, micro irrigation, fertigation, maintenance and repair of polyhouse.

Prototype of a bilingual (English and Malayalam) mobile app for vegetable cultivation in polyhouse was made based on the information needs of the farmers on crops *viz.,* salad cucumber, yard long bean, chilli and amaranthus. The end-user assessment of the developed m-app done with the help of 30 polyhouse farmers showed that the elements such as navigation, comprehension and user friendliness scored high. Based on the assessment, improvements in design and layout as well as readability was made to improve the quality of the developed m-app.