# Innovations in e-Agricultural Extension Technology (e-AET): Diffusion and Adoption of Agri-Expert Systems among Extension Professionals in Kerala.

*by*


**MODEM RAVIKISHORE**

**(2012-11-161)**


**THESIS**

**Submitted in partial fulfillment of the requirements for the degree of**

## MASTER OF SCIENCE IN AGRICULTURE


**Faculty of Agriculture**
**Kerala Agricultural Univer**

**DEPARTMENT OF AGRICULTURAL EXTENSION**
**COLLEGE OF AGRICULTURE**
**VELLAYANI, THIRUVANANTHAPURAM-695 522**
**KERALA, INDIA**


**2014**

# DECLARATION

I, hereby declare that this thesis entitled "**Innovations in e-Agricultural Extension Technology (e-AET): Diffusion And Adoption of Agri-Expert Systems among Extension Professionals in Kerala**" 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, fellowship or other similar title, of any other University or Society.

Vellayani,
05 -08-2014

**MODEM RAVIKISHORE**
(2012-11-161)

# CERTIFICATE

Certified that this thesis entitled **"Innovations in e-Agricultural Extension Technology (e-AET): Diffusion And Adoption of Agri-Expert Systems among Extension Professionals in Kerala"** is a record of research work done independently by **Mr. Modem Ravikishore (2011-12-161)** 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 him.

Vellayani,
Date: 05-08-14

**Dr. Allan Thomas**
(Major Advisor, Advisory Committee)
Assistant Professor (Sr scale)
Department of Agricultural Extension
College of Agriculture
Vellayani.

# CERTIFICATE

We the undersigned members of the advisory committee of **Mr. Modem Ravikishore (2012-11-161)**, a candidate for the degree of **Master of Science in Agriculture** with major in Agricultural Extension, agree that the thesis entitled **"Innovations in e-Agricultural Extension Technology (e-AET): Diffusion And Adoption of Agri-Expert Systems among Extension Professionals in Kerala"** may be submitted by **Mr. Modem Ravikishore (2012-11-161)**, in partial fulfilment of the requirement for the degree.


**Dr. Allan Thomas**
Chairman, Advisory Committee
Assistant Professor (Sr scale),
Department of Agricultural Extension,
College of Agriculture, Vellayani,
Thiruvananthapuram-695 522

9/8/14
**Dr. R. Prakash**
Professor and Head,
Department of Agricultural Extension,
College of Agriculture, Vellayani,
Thiruvananthapuram-695 522
(Member)

9/8/14
**Dr. B. Seema**
Professor,
Department of Agricultural Extension,
College of Agriculture, Vellayani,
Thiruvananthapuram-695 522
(Member)

9.8.14
**Dr. Vijayaraghava Kumar**
Professor,
Department of Agricultural Statistics,
College of Agriculture, Vellayani,
Thiruvananthapuram-695 522
(Member)

External Examiner
9/8/14
डॉ. एस. कलावती
Dr. S. KALAVATHI
प्रधान वैज्ञानिक
Principal Scientist
केन्द्रीय रोपण फ़सल अनुसंधान प्रादेशिक केन्द्र
Central Plantation Crops Research Institute, Regional Station (I.C.A.R)
कृष्णापुरम डाक, कायंकुलम, केरल - ६९० ५३३
Krishnapuram.P.O, Kayamkulam, Kerala - 690 533

## ACKNOWLEDGEMENTS

*I bow to the infinity, the Unknown and the Unknowable, who is the only one behind each and every impulse of the universe. It will be a foolery to thank that cosmic consciousness with the triviality of human languages.*

*With respectable regards and immense pleasure, I take it as a privilege to place on record my profound sense of gratitude, indebtedness and thanks to Dr. Allan Thomas, Assistant Professor, Department of Agricultural Extension and Chairman of the Advisory Committee for his worthy counsel, constant attention, splendid and stimulating guidance, kind treatment, abundant encouragement, I received at every stage of planning and execution of research work and the preparation of my thesis which would not have been possible without his help and support.*

*I am pleased to place my profound etiquette to Dr. R.Prakash, Professor and Head, Department of Agricultural Extension and esteemed member of my Advisory Committee for his learned counsel, unstinted attention, arduous and meticulous guidance, kind treatment during the course of investigation and constructive criticism have installed in me the spirit of confidence and deep sense of respect and gratitude.*

*I feel dearth of words to express my deep sense of gratitude, respect and sincere thanks to Dr. B. Seema, Professor, Department of Agricultural Extension and esteemed member of my Advisory Committee for her worthy counsel, insightful and inspiring guidance, keen interest in planning and valuable suggestions during the course work.*

*I extend my profound gratitude to Dr. Vijayaraghava Kumar, Professor, Department of Agricultural Statistics for his wholehearted effort in statistical analysis and interpretation of the results rendered throughout the course of this research endeavor.*

*I express my sincere thanks to Dr. N. Kishorekumar, Professor and PG in-charge , Department of Agricultural Extension for his keen interest, timely support and co-operation,* *erudite suggestions, astute remarks, wondrous guidance during the course of work and at the time of investigation.*

*My heartful thanks to Agricultural Extension teaching staffs, Dr. C. Bhaskaran Dr.S.Shilaja, Dr. G. Sobhana, Dr.S.Mothilal Nehru, Dr. V.B. Padmanabhan,Dr. A.Anilkumar and Dr.G. Sreedaya for their friendly approach, creative suggestions and constant encouragement rendered to me during the course of my study and research work.*

*I also extend my acknowledgements to Kamarudeen Sir, Farm Manager, Radhakrisnan AG and to all non-teaching staffs of the Department of Agricultural extension for the help rendered to me during the course of study.*

*I humbly thank the authorities of Kerala Agricultural University for the financial help in the form of stipend during my study period.*

*My loving and wholehearted thanks to my classmates Priya peter, Hinduja.N.A., Anupama.S, Haseena beevi.A and Rubeena for their help, good company, positive criticism and moral support throughout my P.G. programme without whose help it would have been impossible to complete my research work.*

*My grateful thanks are due to my seniors Shoba, Sadam, Rahul, Chinchu, Sangeetha and Shely for their blissful presence and assistance and also my juniors Akshay, Sachana, Reeba, Revathi, Ibi, Sujitha for their wishes and valuable suggestions at each and every stage of my work.*

*I express my heartfelt gratitude and thanks to my hostel seniors, Sreenivas, Rajagopal, Chandrashekhar and Sudhakar for their valuable guidance and encouragement.*

*I joyfully recollect the friendly help and contributions which I got from my heart-bound batch-mates friends Sreelakshmi, Pavan, Raja shekhar, Jayanth, lokesh, Darshan, Jayasheela, Hemanth, Jacob, Henry, Prasanth, Dipin, Nikhil, Anees, Safeer and Sreejith and also my juniors Sreenu, Murali and Murali Nagaraju and thank them for their companionship during my P.G. study for their wishes and valuable suggestions at each and every stage of my work.*

*With boundless affection and love, I would hearty acknowledge the timely help for my goal setting, spiritual upliftment and encouragement of my beloved friend Supriya in whose cheerful company and special care I have never felt my work as burden during my studies and worries.*

*No words are enough to express the fondness to my best friends Sri Vidya, Yuva and Sankar for their help, guidance, constant encouragement, companionship, love and affection showered in my personal and professional life throughout the period of this study.*

*Diction is not at all enough to express my feelings towards my most venerable ever loved parents, Sri. M. R. NAGA BHUSHANAM and Smt. M.PADMAVATHI and my brother SURESH who have given me life and taught the concepts of life and their dedicated efforts to educate me to this level and without whom, I wouldn't have been here on this Elysium. Their boundless affection, meticulous care, admonishing remarks, consistent support and inimitable love acted as impetus on my fortitude during the whole course of my research without whose valuable moral support, the thesis would not have seen the light of the day.*

*Finally, I wish my humble thanks to one and all who have directly or indirectly contributed to conduct of the study.*

*Modem Ravikishore*

# CONTENTS

## LIST OF TABLES

# LIST OF FIGURES

## LIST OF PLATES

# LIST OF ABBREVIATIONS

| | |
|---|---|
| % | per cent |
| & | and |
| ICT's | Information Communication Technologies |
| E-AET | Electronic Agricultural Extension Technology |
| E-AE | Electronic Agricultural Extension |
| ES | Expert System |
| AES | Agricultural expert system |
| DSS | Decision Support Systems |
| EW's | Extension Workers |
| KW's | Knowledge Workers |
| AA's | Agricultural Assistants |
| FA's | Field Assistants |
| EP | Extension professionals |
| FLEP | Front line extension personnels |
| ICAR | Indian Council of Agricultural Research |
| KVK's | Krishi Vigyan Kendras |
| NGO's | Non-Governmental Organisations |
| KAU | Kerala Agricultural University |
| *et al.* | and co-workers/co-authors |
| Fig. | Figure |
| *i.e.* | that is |
| r | Correlation coefficient |
| *viz.* | namely |
| *per se* | mean |
| IRRI | International Rice Research Institute |
| APRTC | Asia Pacific Regional Technology Centre |
| SDLEARN | Sustainable Development e-Learning Network |
| MANAGE | National Institute of Agricultural Extension Management |

# *Introduction*

# 1. INTRODUCTION

Perceiving the needs and demands of technologies, the extension network has been launched countrywide to disseminate the newer technologies. Yet, it was an imbroglio, that whether the available services could meet these needs with the existing scarce financial and human resources. Rolling (1980) mentioned, that "unfortunately many extension professionals have been trained too narrowly and focus on technology and its introduction. Thus they miss many opportunities for helping their clients as well as missing out a lot of exciting aspects of rural extension and intervention through communication". Schultz (1981) also reported that, for developing a highly productive economy the natural resources, physical capital and raw labour would not alone be sufficient.

Dynamics of socio-economic development and effective transfer of technology requires a wide array of human skill. As agricultural technology is constantly subjected to metamorphosis over years today farmers are swamped with many new cultivars, pesticides, farm machines and farming techniques. Coping with this ever-growing complexity is overwhelming. To meet new challenges and opportunities, the knowledge and information has become one of the most critical inputs to agriculture in addition to soil, seed, water, fertilizer, pesticides, farm implements etc. Access to knowledge and information about agricultural prices, weather forecast, inputs, right farm practices, reliable research recommendations etc. have become essential for improving agricultural productivity and farm profitability while protecting fragile natural resources. Hence, in order to make prudential and accurate decisions, farm managers / extension workers / farmers need speedy access to advice on agricultural problems which could be timely, reliable and consistent.

Owing to complexity of problems faced in agricultural management, the precise decision is very much a mandate. While so, the affordability and availability of scientists' wisdom becomes the question. Though, they extend a willful service, the affordability of ideas in time availability, accessibility and all that matters a lot. It is in this juncture the hall mark in the development of telecommunications and computer-based information technology in the era of globalization probably would be the best alternative and rather means for sea change in extension.

Development in ICT (Information Communication Technology) may reduce the dependence on other actors in the extension stream. Our extension strategy should not be depending on conventional extension methods like, demonstrations, trainings, Radio and TV broadcasts. It should make a radical drift into computer-based information technology in agricultural extension (FAO, 1993; Zijp, 1994). This will bring new information services to the farming community and would bring about a significant change in agriculture in terms of reduced costs, increased storage, easy usage, rapidity etc. Computer technology in its recent advancement focusses on software programmes that are available to assist in filling the knowledge of experts for analysis and design of complex problems. Knowledge based computer programmes or expert System containing "expert knowledge" would help access to these problems. It would further improve the access to scarce expertise. It would be also a promising means of providing information.

An Expert System (ES) is a computer programme that is designed to emulate the logic and reasoning processes that an expert would use to solve a problem in his/her field of expertise, using artificial intelligence technology (Waterman, 1986). It performs many functions as an expert does, such as posing relevant questions and explaining its reasoning process. The other features of an expert system, as described by Nebandahl (1988), are: it's rules, heuristics and other techniques to represent knowledge in a symbolic manner; and has ability to integrate procedural, judgmental or preferential and uncertain information. It further interacts with human sees that the content matches with the comprehension and good understanding. It contains a knowledge-base about a specific decision domain or situation that is in a large measure distinct from the inference mechanism. It consists of an inference engine, or inferential reasoning capability that is in a large measure distinct from the knowledge-base.

An expert system tends to behave as human experts in decision-making and is highly interactive. It has the ability to capture human decision-making expertise, interactive and represent this expertise as a series of rules and facts. Minimizing or avoiding errors in complex tasks, protecting the perishable knowledge of experts, and make it available when and where required, looking into all possible alternatives, displaying unbiased judgments, readily available for use unlike human experts and less expensive to consult than human experts. One of the most exciting features of expert system development is the availability of this very sophisticated computer technology for immediate practical use by the entire agricultural community.

Expert system started to gain popularity in the early 1980s. Expert systems of today support many problem-solving activities such as decision making, knowledge fusing, designing, and planning, forecasting, regulating, controlling, monitoring, identifying, diagnosing, prescribing, interpreting, explaining, training etc. using different techniques and it was expected that future expert systems would support even more activities (Prasad and Sinha, 2003).

## 1.1. NEED FOR AGRICULTURAL EXPERT SYSTEMS *VIS A VIS* THEIR DIFFUSION AMONG THE EXTENSION PROFESSIONALS

As far as the need of expert system in technology transfer in agricultural sector is concerned,

- The advantage of capturing the yeomen experience and applying it to a broader range of problems and situations in agriculture might be the primary reason for building an expert system.

- The conventional systems were generalistic advocacy role would be summarized by substituting and supplementing with expert system, as because it is a blend of information catering to the diverse needs of farmers facilitating for all possible questions and relevant answers in an inbuilt mechanism. Hence, expert system would help in a big way to solve the problem reposed by the farming community as a holistic service device.
- In the changing agricultural scenario, agricultural field has not been computerized so far in a way it is demanded. However, in the last decade, artificial intelligence based computer programmes called expert system received a great deal of attention throughout the world, due to its impressive problem solving capability in a variety of fields. To mention a few, it has greater potential in research, ability to solve complex problems by its dynamic and heuristic strategies.
- The other primary goal of expert system research is to make expertise available to farmers and agricultural advisors who need immediate answers. For that purpose portable computers loaded with in-depth knowledge of specific subjects would do.
- The application of areas of expert system will be plenty. It has enormous scope to help the farming community by enabling the capability of extension professionals in utilizing agricultural expert systems for sharp decision making in various aspects of agriculture.
- Information gap could be possibly subsided or nullified by expert systems which can emulate the problem-solving logic of human experts are potential tools to aid in training, particularly in diagnosis, systematic and pest management decision-making (Heong *et al.*, 1989).
- Tapping all these advantages and plusses in a convergent way, it was felt apt that inventorisation and content coverage of prevailing agri-expert systems and their diffusion among the extension professionals would be making a significant impact and a ready reckoner for farming community.

Hence, the present study was taken up with the following objective.

- To suggest measures to enhance the capability of extension professionals in utilizing agricultural expert systems for the benefit of farming community for decision making in various aspects of agriculture. For this a systematic appraisal of existing expert systems in agriculture *vis a vis* their diffusion among the extension professionals will be studied. This study also will attempt to reveal the potential impact in the field of Kerala agriculture with policy suggestions to scale up its use.

## 1.2. SCOPE AND IMPORTANCE OF THE STUDY

A major technology invading the clientele of extension professionals today is the personal computer, internet and specific software based programmes like 'expert systems'. Major shifts are underway in the way information being accessed by agricultural extension professionals, including a diversification of channels through which information is received. The Government of Kerala (State Planning Board) in the recent years have given tremendous support for ICT initiatives in agriculture and allied enterprises. The State Plan document (2012-2013) has earmarked a lump-sum amount for ICT initiatives in agricultural information and support services. Over the last few years many promising innovations in e-Agricultural Extension Technology has been realized and many expert systems were developed along with other innovations intended for agro advisory services to farmers through extension professionals/ personnels in-order to provide precise, specific, useful and need based recommendations.

A communication technology like expert systems achieves its full potential when enough of those in user's communication network also adopt the technology. The value to a business of having expert system, for instance, is limited if none of its customers and suppliers themselves use these expert systems.

If expert system is intended for benefit of the farming community through the guidance and support of extension personnel, the first to be aware and to use the same should be the extension personnel. The extent of use of the expert system will have a direct bearing on the adoption of intended technologies among the farming community. Hence, a systematic appraisal of existing expert systems in agriculture *vis a vis* their diffusion among the extension personnels will be of great significance in terms of its practical utility.

The creation and diffusion of innovation in a social system results in positive externalities and is a *conditio sine qua non* for economic development. Knowledge about the trajectory of the stage of absorbing innovation by potential adopters has significant cognitive benefits for its producers, who are the sources of innovations, in terms of assessing their effectiveness, as well as for the institutions establishing the legal and institutional framework for an innovative system aimed at boosting the diffusion of knowledge in the economy (Cosmin, 2011). Various expert systems released for the support of extension personnels for effective advisory services is an innovation in ICT enabled extension. No scientific studies into diffusion and adoption of 'agri-expert systems' among extension professionals in the field of agriculture in Kerala has been conducted till date. Hence, it becomes imperative to study the diffusion and adoption of innovations in e-Agricultural Extension Technology (expert systems) among extension professionals in Kerala which throws light into the scientific utility of the proposed study.

A decision support programme imitates an expert by involving a client in a problem-solving situation, often providing a recommendation in response to a client's request that is highly interactive. Hence an expert system intends to help the farmers to make better decisions and provide useful advice, thus fills the knowledge gap between the expert and the user.

## 1.3. LIMITATIONS OF THE STUDY

As the study is part of Masters Research the area of study was confined to only one district namely Thiruvananthapuram. As it was a maiden attempt, selection of respondents who were already using agri-expert systems was found to be difficult. Sufficient reviews were not available to support the findings of the study. Hence generalization of the results may not be appropriate. All the data were collected by personal interview with the respondents. Most of the responses were from the respondents' recall memory and not based on written records. However, due care was taken to ensure high reliability of the data and every effort was putforth to conduct this study as objectively and systematically as possible in a real field situation.

## 1.4. PRESENTATION OF THE THESIS

The entire Master's thesis is presented as five chapters:
The first chapter 'introduction' explains the importance of the topic, objectives, scope and limitation of the study. Second chapter, 'theoretical orientation' deals with review of relevant literature in line with the objectives of the study. Third chapter 'research methodology' describes the sampling design, the study area, measurement of independent and other variables, method of data collection and statistical tools used. Fourth chapter 'results and discussion' discusses the results of the study to draw specific inferences and the final chapter 'summary' briefly summarizes the work done and salient findings, explains the implications based on the results of the study and also suggests future areas of research.

# Review of Literature

## 2. REVIEW OF LITERATURE

A proper conceptual framework for the study based on the ideas and concepts gathered from review of existing literature of both theoretical and empirical nature will facilitate the researcher for planning the study in a comprehensive way. As the studies on the agricultural expert systems in Kerala are less, the works on expert systems reported from other countries were reviewed to identify and internalise different variables that are relevant to the different areas of present research and to presume probable relationship among them. Hence, the available studies that are directly or indirectly related to the topic of research from various sources are exhaustively reviewed. The literatures based on the objectives of the present study are elucidated in this chapter under the following sub headings.

2.1. e-Agriculture extension technology

2.2. Concepts on agricultural expert system

2.3. History and evolution of expert systems

2.4. Personal and social characteristics of the respondents of study.

2.5. Inventorisation and Content coverage of expert systems

2.6. Level of awareness on expert system

2.7. Attitude of extension professionals towards expert system.

2.8. Frequency and nature of agri-expert system use by the respondents.

2.9. Diffusion-Adoption stages in terms of extent of use of expert system technology *vis a vis* extension professionals.

2.10. Constraints experienced by extension professionals in using agri-expert systems.

## 2.1 E-AGRICULTURE EXTENSION TECHNOLOGY

The application of communications and information technology, (computer and Internet) in agricultural extension programs, and delivery of agricultural information for users, and on the Internet network has led to the emergence of the Electronic Agricultural Extension (E-Agricultural extension). e-agricultural extension is an extension system that depends on new communications information technology represented in computer technology and the internet for diffusion of agricultural information and knowledge, and available to all users without attached to the place, time, and flexibly and easily. (Thomas and Daney, 2002).

e-agricultural extension is an extension system that allows the use and application of information technology and communications technologies (ICT's) to access and obtain information related to agricultural production, agricultural marketing, distribution, agricultural prices, the results of agricultural research and agricultural innovations. (Engalhard, 2003). It is these definitions of observing that electronic agricultural extension depends on the computer and internet technology, which requires training of agricultural extension agents on this technology and their application in agricultural extension (Elbert and Antonie, 2012).

Meera *et al.* (2004) noted that ICT can bring new information services to the rural areas where the farmer (end user) will have much control, than ever before, over the current information channels. Access to such information sources is a crucial requirement for the sustainable development of the farming systems. They also added that ICT can be of immense help by enabling Extension Worker's (EW) into Knowledge Worker's (KW). The emergence of such knowledge workers will result in the realization of the much talked about bottom-up, demand-driven technology generation, assessment, refinement and transfer. ICT would enable extension workers to gather, store, retrieve and disseminate a broad range of information needed by small producers such as information on best practices, new technology, better prices of inputs and outputs, better storage facilities, improved transportation links, collective negotiations with buyers, information on weather.

It was found that ICT allows efficient and transparent storage, processing and communication of information and that entrepreneurial innovation in this field may affect economic and social change (Kaushik and Singh, 2004). In some green houses, the temperature, humidity, light control, fertilization and phyto-sanitary treatments are automatically operated using programmed computers. For some crops there are commercially available fully automated artificial intelligence software's robotics dealing with the whole cultivation process, from planting to packaging in a greenhouse (Nokker. 2004).

Now a days, majority of Asians in developing countries emphasis the need to build massive ICT infrastructures to take advantage of agricultural information (Woods *et al.*, 2002). By using ICT, particularly the internet, agricultural information is accessed more easily and the scope for communication also enlarges. There are experiences gained from the involvement of ICT within organisations in Asia such as the International Rice Research Institute (IRRI) and Asia Pacific Regional Technology Centre (APRTC) and Sustainable Development e-Learning Network (SDLEARN). They found that application of ICT on e-learning in particular, is an effective alternative in addressing the continuing educational needs of agricultural knowledge especially in the areas of sustainable agriculture and natural resource management (Abdon *et al.,* 2006).

Jensen (2007) demonstrated that ICT helped fishers along the coastline in Kerala, India to learn about prices at different locations and decide where to sell their products profitably. As a result, price volatility and variation dropped; producer prices rose and at the same time consumer prices dropped.

Application of expert system in the area of agriculture would take the form of integrated crop management decision aids and would encompass water management, fertilizer management, crop protection systems and identification of implements. In order to remain competitive, the modern farmer often relies on agricultural specialists and advisors to provide information for decision-making. An expert system is normally composed of a knowledge base (information, heuristics, etc.), inference engine (analyze knowledge base), and end user interface (accepting inputs, generating outputs). Software named 'CROP-9-DSS' incorporating all modern features like, graphics, photos, video clippings etc. has been developed. This package will aid as a decision support system for identification of pest and diseases with control measures, fertilizer recommendation system, water management system and identification of farm implements for leading crops of Kerala (India) namely coconut. rice. cashew. pepper, banana, four vegetables like amaranthus, bhindi, brinjal and cucurbits. 'CROP-9-DSS' will act as an expert system to agricultural officers, scientists in the field of agriculture and extension workers for decision-making and help them in suggesting suitable recommendations (Ganesan. 2007).

The ICT projects like e-choupal, Akshaya, Bhoomi, Drishtee, N-logue and Krishi Vigyan Kendras of Indian Council of Agricultural Research (ICAR) have shown some promise towards scaling up of ICT application in agriculture. Among ICT's for agricultural extension, Kissan Call Centre initiative of Government of India, e-sagu (www.esagu.in), e-arik (www.earik.in), India development gateway (www.indg.in) and e-aAqua (www.aaqua.org) are notable examples (Saravanan, 2010).

ENS, 2012 quotes the words of Dr. T. R. Gopalakrishnan (Director of Research, KAU and Dr. Ahamed, P. (Director, CeL of KAU) about the online portal that offers a plethora of agricultural advisory-cum-decision support systems like the KAU Fertulator, e- Crop Doctor and e-Karshaka Jalakam for the benefit of farming community. It was opined that the ICT enabled tools in the portal provides the stakeholders with all the information on major crops of Kerala from sowing to harvesting in an interactive manner and the same being bi-lingual (both in English and Malayalam) will serve every farmer, researcher and extension agent personally. Another view was that 'KAU Fertulator' simplifies the time consuming calculation of the rate of fertilizer for field application while the bilingual e-Crop Doctor is a user friendly and time saving decision support system which helps to find out accurately the quantity and dilution ratio of insecticides, fungicides, antibiotics and weedicides required for a unit crop area, for all the crops of Kerala. The data is based on the recommendations of agricultural research centres in Kerala.

## 2.2 CONCEPTS ON AGRICULTURAL EXPERT SYSTEM

Knowledge-based expert system technology has been applied to a variety of agricultural problems. Since the early eighties the following paragraphs present how expert systems were considered in agriculture.

Bundy (1984) stated that the application of expert system generally falls under three classes, namely, expert system proper, intelligent front-ends, and hybrid systems. An expert system proper is a purely rule based system, relying on a sizable knowledge base. It is based on a qualitative, causal understanding of how things work. Such a system is more suitable under situation wherein qualitative data are used. It is essentially conceptual and heuristic rule-based system. An intelligent front-end is a user-friendly interface to a software package, enables the user to interact with the computer using his/her terminology. It minimizes or avoids misuse of complex models by less experienced users. A hybrid system represents the integration of algorithmic techniques with expert system concepts.

An expert system is a computer programme that is designed to emulate the logic and reasoning processes that an expert would use to solve a problem in his / her field of expertise, using artificial intelligence technology. (Waterman, 1986)

An expert system is a system that employs human knowledge captured in a computer to solve problems that ordinarily require human expertise. Well-designed systems imitate the reasoning process experts use to solve specific problems. Such systems can be used by non-experts to improve their problem solving capabilities. (Turban, 1993)

Durkin (1994) defined an expert system as a computer program designed to model the problem solving ability of a human expert.

Turban and Aronson (2001) conceptualized agricultural expert system as a system that used human knowledge captured in a computer to solve the problems that ordinarily require human expertise.

Rao (2003) defined that the expert systems were based on the concept of artificial intelligence in which the experience and knowledge of human experts were captured in the form of 'IF-THEN' rules and facts, to solve the field problems.

An expert system is a software that manipulates encoded knowledge to solve problems in a specialized domain that normally requires human expertise. The knowledge of an expert system must be obtained from subject specialists or other sources of expertise, like books and journal publications. (Patterson, 2004)

Rajotte *et al.* (2005) commented that agricultural expert systems were tools for agricultural management since they could provide the site specific, integrated and interpreted advice that farmers and consultants need to more efficiently manage agricultural concerns.

The Expert System in agriculture is a simple expert system based on agriculture related problem solving models, include diagnostics model, prediction model and farm management model. This expert system will allow farmer to interact with their regional language with the system and can get the solution over the defined problem. (Nitin *et al.*, 2013)

It may be generalized from the above review of literature that agricultural expert system is computer-aided software designed to solve field problems in agriculture based on the concept of artificial intelligence. The experience and expertise of human experts are captured and stored in computer which can be retrieved and utilized in the problem situation. For convenience and user friendliness of the software, various developments in the programmes were noticed.

## 2.3 HISTORY AND EVOLUTION OF EXPERT SYSTEMS

In 1986, a new expert system generator for PCs appeared on the market, derived from the French academic research: Intelligence service, sold by GSI-TECSI Software Company. This software had a radical innovation: it used propositional logic ("Zeroth order logic") to execute expert systems, reasoning on a knowledge base written with everyday language rules, producing explanations and detecting logic contradictions between the facts. (Bertrand Savatier, 1987). There is no general standard for the structure or architecture of expert systems, most include at least four components: a knowledge base, an inference engine, a user interface, and an explanation facility (Doluschitz and Schmisseur, 1988).

Kurata *et al.* (1989) described expert systems for farm machinery troubleshooting and farm work scheduling. The farm machinery program collected information about problems in machinery operation and provided a scheduling system for sending a technician to the farm, depending on the diagnosis. The work scheduling expert System consisted of long, middle and short term scheduling programs for field operations. The number of working days for each farm, progress of operations, materials to use and requirements for a specific day's operation were some of the questions answered. Morgan *et al.* (1989) described expert system for crop variety selection for winter wheat in Scotland. The system considered the soil characteristics, water availability and prevalence of diseases. By using the system, agricultural extension officers were able to recommend varieties with confidence thereby reducing the demand for advice from specialist crop advisors.

Travis (1992) developed an expert system known as the Penn State Apple Orchard Consultant (PSAOC) to help apple growers make better decisions about production and pest management. The system integrated various facets of apple production. It gave the apple grower the information necessary to reduce some purchased inputs by substituting high quality, integrated, information derived from three sources (state-of-the-art apple production and IPM knowledge; site specific, farm level data; and weather records). Raman *et al.* (1992) described an expert system used for drought management. The system used linear programming model to generate optimal cropping patterns based on data from past drought experiences as also from synthetic drought occurrences. Using this, one can identify the degree of drought in the current situations and its similarity to the identified drought events and be able to get the corresponding management strategy.

Rafea (1996) introduced LIMEX (Lime Expert System) an integrated expert system with multimedia that had been developed to assist lime growers and extension agents in the cultivation of lime for the purpose of improving their yield. The scope of LIMEX expert system included the assessment of requirement of inputs for irrigation, fertilization, and pest control.

Christov (1997) indicated that Information Technology for Crop Irrigation Scheduling and fertilizing (ITCISF) software was developed and tested on large scale to improve water and fertilizer use efficiency at no current sampling, multi-variant management. It was found to provide new opportunities for both the investigators and farmers. Murthy and Srinivasacharyulu (1998) reported that the Synapse expert system developed by IRDC, Canada captured the expertise necessary in low technology industries that depended on experience. This was tested in tea factories in SriLanka. The system could be used in industries where maintaining quality control was necessary, for overseeing instruments and monitoring agricultural activities. Warren (1999) designed the Virginia Integrated Pest Management Expert (VIPMEW) for Wheat to combine the best available information regarding wheat pest management of disease pathogens, weeds, and insects into a decision support system that would provide potential outbreak risk and pest control information to the Comprehensive Resource Planning System (CRPS). This system was an educational tool for farmers and extension personnel.

Lukeeram *et al.* (2000) reported that the Potato Extension and Training Information System (PETIS) were developed principally for the small-scale potato growers. The system was equipped with audio files that provided information in English. Illiterate users had an option that read the summary of the content in Creole and Bhojpuri. Icons and pictures were included to enable rural users to navigate easily at the basic levels of the site. Rafea *et al.* (2000) reported that the Egyptian Regional Wheat Management System was an integrated expert system with a crop simulation model aimed at addressing all aspects of irrigated wheat management in Egypt. In order to achieve this goal, the system was designed to perform the functions such as select the appropriate variety for a specific field, advise the farmer on field preparation, design schedules for irrigation and fertilization, control pests and weeds, manage harvests, prevent malnutrition, diagnose disorders and suggest treatments. Main subsystems of the Neper wheat were: wheat planning system, pest identification system and weeds identification system.

Bell *et al.* (2001) reported that 'TropRice' was a knowledge driven support system that delivers expert information to help technology transfer agents make more informed practical decision related to rice production in the tropics. It was developed in response to the recognition that many researchers, extension agents, and farmers did not have access to the most up-to-date information on how to improve their rice growing practices. Edrees *et al.* (2002) presented an expert system for paddy production management, gave advice to paddy growers in Egypt to improve paddy productivity, the system contained two main parts namely, a strategic part and tactic part. The strategic part gave strategic advice (*i.e.* list of agricultural operations) before cultivating paddy crop. The strategic part contained four sub-systems namely; variety selection, land preparation, planting, irrigation and fertilization. The tactic part diagnosed the problems that occurred during paddy growing season and gave advice about how to control these problems. The tactic part contained two sub-systems *viz;* disorders diagnosis and treatment.

Ghosh and Samanta (2003) presented a rule- based, object-oriented expert system for insect pest management in tea named 'TEAPEST.' The system identified major insect pests of tea and suggested appropriate control measures.

'TEAPEST' showed good performance. Shen (2003) mentioned the following expert systems: PestDiag was a multimedia expert system to identify common vegetable insects of more than 80 species in north China. Designed with the technology of SASD (Structural Analysis and Structural Design) and OOP (Object Oriented Programming), the system had been encoded by Microsoft Visual BASIC. PESTD1AG proved useful in assisting vegetable insect pest management for agricultural administrative agencies, plant protectionists and farmers. It helped users to identify vegetable insect pests in the field and then provided them with knowledge of integrated management of the pests. In addition. the system actualized a new way to professional education and training either at agricultural university level or peasant level. Multimedia technique made this system user-friendly, more vivid and vigorous.

Rao (2003) and Prasad and Babu (2006) reported that the National Institute of Agriculture Extension Management (MANAGE) developed. an expert system-Rice Crop Doctor in collaboration with National Institute of Information Technology, to diagnose rice pests and diseases and to suggest curative and preventive measures. The rice crop doctor diagnosed the pest or diseases depending on the symptoms identified by the user with the help of photographs and textual information.

Information technology support systems are rapidly evolving over the past decade. Traditional information systems are categorised into 5 systems: transaction processing systems (TPS), management information systems (MIS), decision support systems (DSS), group support systems (GSS), expert systems (ES), and executive support systems (EES). However, the usefulness of this classification is quickly losing its value as most current information systems incorporate more than one system. In this classification, expert systems are regarded as an extension to decision support systems (Thomson and Baril, 2003).

**Main types of IT support systems.**

| System | Employees supported | Description |
|---|---|---|
| Transaction processing system(TPS) | All employees | Processes an organization's basic business transaction (e.g., Purchasing, billing, and payroll). |
| Management information system(MIS) | All employees | Provides routine information for planning, organising, and controlling operations in functional areas. |
| Decision support system(DSS) | Decision makers, Managers | Combines models and data to solve semi-structured problems with extensive user involvement. |
| Group support system (GSS) | People working in groups | Supports working processes of groups of people (including those in different locations). |
| Expert system (ES) | Knowledge workers, non-experts | Provides stored knowledge of experts to non-experts and decision recommendations based on built-in expertise. |
| Executive support system(ESS) | Executives, senior managers | Supports decisions of top managers |

Cheng-gang *et al.* (2004) stated that the agricultural expert system contained fertilizer inquiry system, cultivating inquiry system, plant protection system and climate inquiry system. By those systems agriculture production was instructed. With the development of Internet, Intelligence expert system was developed from single version to net version such as 'grape cultivating management expert system' was issued by Academy of Chinese Agricultural Sciences. "Intelligence Rice Cultivating Management Expert System' and "Intelligence Corn Cultivating Management Expert System' were issued by Changchun Academy of Agricultural Sciences. In Jilin province, the peasants could use the expert system to solve the entire problem they met during the agricultural production. Balasubramani (2004) developed computer based expert system on plant protection aspects of rubber, based on the judges opinion, collected from scientists and extension officers of Rubber Board and rubber growers. He named the system as RUBEXS-04 using Visual Basic 6.0 software.

Abeyrathne *et al.* (2005) designed an expert system using wxCLIPS shell. which worked under windows environment. The SSSDPS (Simple Sprinkler System Designing Expert Systems) Expert was designed with an interactive GUI where the non-experts and non-technical users could browse through the expert system with much ease through interaction with the computer. Almost all the technical data needed for a preliminary designing of a simple system was embedded to the expect system, so that the user only needed to provide field specific information. The developed SSSDPS expert gave very accurate outputs for given conditions. The system output was useful in proper designing of a simple irrigation system. This system could help non-technical users and sprinkler irrigation system installers in Sri Lanka to come up with better system layouts for productivity maximization with the available resources. Hogan *et al.* (2005) reported that late-season insecticide sprays could be reduced by using the Bollman program. Cotman was a computer-based expert system developed by the University Of Arkansas Division Of Agriculture and contained Bollman as one of its components. EXNUT (Expert system for peanuts), a knowledge automation system to help manage irrigated peanut production, compiled data from individual peanut fields throughout the growing season and made recommendations for irrigation, the application of fungicides, and if favourable pest conditions might exist. Many other knowledge automation systems had been developed at the NPRL (National Peanut Research Laboratory) that made decisions on variety selection, land preparation and harvest scheduling, as well a whole farm-planning modules, which used a linear programming interface for optimization. Each of these knowledge automation systems functioned as stand-alone systems or as modules in farm operations management. (USDA, 2005)

Islam *et al.* (2006) presented 'expert system on wheat crop management, an integrated system that addressed all aspects of wheat management in India. This system designed to cover the agriculture operations, variety selection, fertilizer application, and insecticide/pesticide application on one hand and economic benefits on the other. This system would help in diagnosing a pathological disorder in the plant and would suggest its control measures. It would also help in identifying insects, pests, weeds and would suggest defence mechanism measure. Hadi (2006) reported that a new ICT-KM project developed a series of expert systems that would provide farmers with the latest information on the pest management of chickpeas, barley and wheat. The utilization of intelligent systems in plant protection (UISPP) project included knowledge acquisition tools and pest management knowledge database. UISPP team members represented the Central Laboratory for Agricultural Expert Systems (CLAES), International Centre for Research in the Dry Areas (ICARDA), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and International Rice Research Institute (IRRI). They were working directly with farmers and through extension agents. Prasad *et al.* (2006) described the development of a rule-based expert system, using expert system shell ESTA (Expert System Shell for Text Animation), for the diagnosis of the most common diseases occurring in the Indian mango. The objective was to provide computer-based support for the agricultural specialists or farmers. The proposed expert system would make diagnosis on the basis of responses of the user made against queries related to particular disease symptoms. The knowledge base of the system would contain knowledge about symptoms and remedies of 14 diseases of Indian mango tree appearing during fruiting and non-fruiting season. The picture base of the system contained pictures related to disease symptoms and was displayed along with the query of the system. The result given by the system had been found to be sound and consistent.

Vinod Kumar *et al.* (2008) reported that a computerised expert tool image based rapeseed mustard disease expert system was developed to help extension personnels, researchers and farmers in identification and management of these diseases. The expert system uses a hierarchical classification and a mix of the text description, photographs and artistic pictures. The system involves two main sub-tasks, namely, diagnosis and management. The system designed and developed using Visual Basic as front-end and Microsoft Access-2000 as back-end software. Khan *et al.* (2008) reported that Dr. Wheat: a web-based expert system for diagnosis of diseases and pests in Pakistani wheat is a web-based expert system for wheat crop in Pakistan. The rule-based expert system covers two main classes of problems namely diseases and pests, normally encountered in wheat crop. Jiajia Hou *et al.* (2013) reported that an expert system of diagnosis for orchard pests and diseases based on expert system, production rule reasoning and web technology. This system combines knowledge framework of pests and diseases diagnosis with expert system technology, making the users diagnose the diseases and obtain related information and prevention strategy. Expert systems are such tools that will develop the management of crops and agri-components scientifically with advanced information technology improving the overall management of agricultural production centres and contributing the economic, ecological and sociological benefit and thus making contributions to the development of excellent, effective and sustainable modernization of agriculture for better future.

## 2.4 PERSONAL AND SOCIAL CHARACTERISTICS OF RESPONDENTS OF STUDY

### 2.4.1. Age

Age was operationally defined as the chronological completed years of the extension personnel at the time of investigation.

Frempong *et al.* (2006) in their research study on challenges of infusing information and communication technologies in extension for agricultural and rural development in Ghana revealed that most (36.4%) of respondents were aged 40 and above.

Adesope *et al.* (2007) in their study on extension and research proficiency requirement in information and communication technologies in South eastern Nigeria concluded that 58.5 percent of the researchers are between the 35-40 years old, while 100 percent of the extensionists are between 29-34 years.

Adesope *et al.* (2007) in their study on effect of personal characteristics of extension managers and supervisors on information technology needs in the Niger Delta area of Nigeria concluded that the age of majority of the respondents were between 40 and 45 years.

Nagalaksmi (2008) in her study on integrating ICT with multiple functions for agriculture development concluded that majority of extension personnel (52.94 %) were under old age category, 26.47 per cent of extension personnel were under middle age and 20.59 per cent of extension personnel were under young age category.

Salau and Saingbe (2008) in their study on access and utilization of information and communication technologies (ICT) among agricultural researchers and extension workers revealed that mean age for the researchers and extension workers were 44.83 and 41.06 years respectively implying that agricultural researchers and extension workers were in the middle ages.

Ahmadpour *et al.* (2010) in their study on a factor influencing the design of electronic learning system in agricultural extension found that the average age of extension agents were 39.66 years.

**2.4.2. Education**

Education refers to the number of years of formal schooling obtained by the extension personnel.

Rao (2000) in his study on communication techniques used by Agricultural Assistants (AA's) of Karnataka State Department of Agriculture reported that majority of AA's (40%) were educated up to SSLC followed by 33.33 per cent who were educated up to pre-university course level only, whereas 23.33 per cent of the AA's had education up to graduation level and only 3.33 per cent AA's had agricultural diploma.

Hedjazi *et al.* (2006) in their study on factors affecting the use of ICT's by Iranian agriculture extension specialists reported that only 3.8% of the specialists had a Ph. D. degree, 34.6% of them had Master's degree and more than half of them (61.5%) had Bachelor's degree.

Frempong *et al* (2006) in their research study on challenges of infusing information and communication technologies in extension for agricultural and rural development in Ghana revealed that more than half of the extension agents (50.9%) have received education up to tertiary or university level.

Adesope *et al.* (2007) in their study on extension and research proficiency requirement in information and communication technologies in Southeastern Nigeria concluded that 89.6 percent of the female researchers had M.Sc. as highest academic qualification.

Kiran (2007) in his study on perception of organizational climate by Scientists of University of Agricultural Sciences, Dharwad concluded that majority of the scientists (86.25%) possessed Doctorate or other equivalent and the rest of them (13.75%) possessed Master degree.

Agwu *et al.* (2008) in their study on use of Information Communication Technologies (ICT's) among Researchers, Extension Workers and Farmers in Abia and Enugu States: Implications for a National Agricultural Extension Policy on ICTs reported that 37.5% of the researchers had master's degree, 27.5% and 22.5% had PhD and B.Sc. degrees respectively.

Salau and Saingbe (2008) in their study on access and utilization of information and communication technologies (ICT) among agricultural researchers and extension workers revealed that 85 per cent and 64.44 percent of researchers and agricultural workers had computer literacy respectively.

Meera *et al.* (2010) conducted study on critical analysis of e-learning opportunities and e-readiness in the public extension system: empirical evidence from Tamil Nadu. opined that 63 percent respondents were having Master's Degree in agriculture as the educational qualifications. It was also learnt that these post graduate extension officers have been exposed to basics of computers and ICTs during their studies.

**2.4.3. Training**

Training was operationally defined as the number of trainings undergone by the respondents so far in the subject matter related to Information and Communication Technology (ICT).

Lakshminarayan (1992) in his study on extension teaching methods used by Agricultural Assistants (AA's) found that 80.00 per cent of the Agricultural Assistants had under gone refresher training and 20.00 per cent of them did not under go any refresher training.

Rao *et al.* (1999) reported that majority of the farmers and agricultural officials were willing to undergo training for using expert system in transfer of technology as it directly concerned them. The potential for designing short training session for using expert system for transfer of technology and related activities needed to be exploited on a priority basis. Interactive video type expert system had been preferred by all for effective training.

Rao (2000) in his study on the communication techniques used by the agricultural assistants of Karnataka state department of agriculture in Dharwad district opined that all the AAs received training on communication techniques and on subject matter areas.

Balasubrainani (2004) reported that cent per cent of the subjects requested to conduct training on the operation of the expert system. A majority (88.33 %) of the subjects felt one day training was enough to familiarize with operation of expert system.

Frempong *et al.* (2006) in their research study on challenges of infusing information and communication technologies in extension for agricultural and rural development in Ghana revealed that 23.7 percent who were extension professionals have attended professional courses on ICT , while 29.2 percent of the respondents have received ICT trainings on their own at business centers such as community learning centers.

Adesope *et al.* (2007) in their study on extension and research proficiency requirement in information and communication technologies in Southeastern Nigeria revealed that 68.9 per cent and 70.4 per cent of researchers and extensionist respectively have been exposed to training for between 2 and 5 years with the mean years of exposure of 4.5 years.

**2.4.4. Innovativeness**

Innovativeness was the degree to which an individual is relatively earlier in adopting new ideas than other members of the social system. In this study it refers to the behavioral pattern of an individual who has interest and desire to seek changes in ICT tools and ready to introduce such changes which are practical and feasible. (Rogers and Shoemaker, 1971)

Senthilkumar (2000) found that majority (67.74%) of the extension professionals were having medium level of innovativeness followed by high

(31.66%) of innovativeness and only 5 percent having low level of innovativeness.

Frempong *et al.* (2006) in their research study on challenges of infusing information and communication technologies in extension for agricultural and rural development in Ghana revealed that (96.2%) of the extension workers could create opportunities to introduce new teaching approaches for training of extension agents.

Murali and Venkataramaiah (2008) in their research study on relationship between profile characteristics of students with their exposure to agricultural websites concluded that higher the innovativeness, the higher would be the exposure to agricultural websites.

**2.4.5. Availability**

Availability was operationalized as expert system offered with reasonable proximity and appropriate hardware and software.

Nair (2004) found that 65 percent of the Agricultural Assistants (AA's) stated that computers are available in their institution.

Hedjazi *et al.* (2006) revealed that among ICTs, computer and internet availability was perceived as easily available for the rendering service to the farmers.

**2.4.6. Accessibility**

Accessibility refers to the ability to access the expert system by the respondent.

Brenda (1998) in his study on computer anxiety levels of Virginia cooperative extension field personnel revealed that over 33% of them used computer and only 8% had a computer in their office.

Frempong *et al.* (2006) in their research study on challenges of infusing information and communication technologies in extension for agricultural and rural development in Ghana revealed that less than a quarter (23.4%) of the extension workers personally owned and used computer at home.

Adesope *et al.* (2007) in their study on extension and research proficiency requirement in information and communication technologies in Southeastern Nigeria concluded that 82 percent of the female researchers indicated that they know how to access Internet on their own while 74.1 percent of female extensionists indicated that they do not have adequate access to ICT.

Wims (2007) in his study on analysis of adoption and use of ICTs among Irish farm families found that 56% of farmers owned a home PC and 48% had home internet connectivity.

Agwu *et al.* (2008) in their study on use of Information Communication Technologies (ICTs) among researchers, extension workers and farmers in Abia and Enugu States reported that 65% of the researchers, 56% of the extension workers and 33% of the farmers asserted that they had access to ICT facilities. The fact that majority (67%) of the farmers do not have access shows that most rural areas in Enugu and Abia states don't have access to major ICT facilities and so are not likely to be aware of major agricultural findings.

Salau and Saingbe (2008) in their study on access and utilization of information and communication technologies (ICT) among agricultural researchers and extension workers revealed that researchers have 87.00 per cent access to ICT facilities while the extension worker had (66%) access. On the level of utilization of ICT in agriculture communication the researchers scored as high as 85 percent while extension workers scored 70.30 percent. Further, computer literacy was 68.88 percent and 64.44 percent for researchers and agricultural workers respectively.

**2.4.7. Retrievability**

Retrievability was operationalised as the extent to which the information provided in the system can be easily located and received by any user. The received information should be easily understood by the user and could be printed as hand out for future references.

Rao *et al.* (1999) reported that majority of the researchers felt that expert systems were relatively easy to handle and use.

Helen (2008) reported that researchers in transfer of technology did not have any difficulty in locating and retrieving information from agricultural expert system.

**2.4.8. Relevancy**

Relevancy was defined as the opinion of the respondents about the suitability of the information provided in agricultural expert system to the users' situation

Helen (2008) reported that majority of the farmer respondents complained that few chemicals recommended for farming actions given in the Diagnose-4.0 were not available locally eg: Edifenphos. Diagnose-4, hence should be improved by providing more information on preventive measures, biological control measures and cultural practices considering chemical control methods as the last option.

**2.4.9. Format clarity**

Format clarity refers to the extent to which the information given is in clear format which help the receiver to arrive at a decision.

Eastmond (1995) suggested that it is effective for the trainers to post messages to the learner to stimulate discussion, and encourage interaction, if the format is of clarity.

One of the most important design principles, which is supported both by web-designer published experiences, and by research on hypertext learning environments, is that the learner should be provided with guidance (Jacobson, Maouri, Mishra, Kolar, 1995).

DeBra (1996) suggests that the designer use multiple columns on the screen, and/or break up the text with graphics to make the line length more manageable.

Cotrell and Eisenberg (1997) noted that developers are in agreement that graphics, and multimedia in general, should be used only when they directly support the materials.

Everhart (1997) suggests that the site should be "sensible, clear, and clutter free".

Jones and Farquhar (1997) noted that the most consistent principal on web site instructional design is that the text presented on a given page should be limited and clear.

Nielson (1997) suggests that instructional text on the computer should be about 50 percent as long as would be the case if the same text was presented as hard copy.

Nair (2004) reports that the management information system in Public sector enterprises as a whole produced many reports that had format clarity.

Helen (2008) reported in her study that extension workers perceived that instructions given in tutorial page had to be improved for more clarity. 'Diagnos 4.0' should be included with more real photographs wherever needed, especially the symptoms with more clarity and zooming effect.

**2.4.10. Information Content**

Information content was operationalised as the extent to which the information on the subject matter was covered in the agricultural expert system.

Rao *et al.* (1999) reported that expert systems which were highly crop specific or technology specific were preferred over general packages.

Helen (2008) in her study quoted that extension workers were in need of biological control measures in detail and that was found lacking in the Diagnose-4.0 system.

### 2.4.11. Timeliness

Timeliness was operationally defined as the quality of information as far as time factor is concerned.

Hicks and Gullett (1981) stated that the more pertinent and timely the information better would be the resulting decision

Nair (2004) reported that most of the information or reports produced by the Kerala public sector were timely.

### 2.4.12. Accuracy

Accuracy is defined as the quality of information being near to the true value.

Batchelor *et al.* (1991) reported that pest management recommendation from extension bulletins and expert system were compared with the expert's recommendations and the results indicated the potential improvement in the decision making process with accurate results.

Rafea (1996) reported that Lime expert system (LIMEX) was able to correctly assess 16 out of 20 cases. The results also suggested LIMEX as a significant and useful tool for lime cultivation.

Nair (2004) reported that the management information system in Public sector enterprises as a whole produced many reports that were accurate.

## 2.5 INVENTORISATION AND CONTENT COVERAGE OF AGRI-EXPERT SYSTEMS

Vecino (1989) concluded that creation of an expert system on any theme had the indirect positive effect of forcing the decision making center to clarify its reasoning processes. In this way a large amount of knowledge about the real processes of decision making by experts was obtained.

Huber (1990) informed that the branch of science known as artificial intelligence covers a number of different fields of application. Expert system is one such field, which has attracted significant attention in recent years. However, agricultural research has been devoting too little attention to the other fields such as robotics or image comprehension, despite the interesting applications they promise. Basic discussion and research are lacking in these fields. There is great potential for research in the field of artificial intelligence and this should not be completely ignored by those engaged in agricultural research.

Gilmore (1993) commented that expert systems were becoming widely used in all areas of the community and provided a way of accessing knowledge bases especially the distilled knowledge of experts in a wide variety of disciplines. Expert systems would feature and should feature as means of providing simple access to complex information.

Knight and Mumford (1994) identified that decision support systems were able to help farmers make difficult decisions by providing information in an easily understandable and quickly accessible form. The scarcity of expert advice, increasingly complex decisions and reduced economic margins increased the importance of making the right pest management decision at the right time. It was against this background that decision support systems had an important role to play in the fight against losses caused by pests and diseases.

Expert systems for crop management of cucumber, tomatoes, orange, lime, and wheat developed for Egypt can be used as tools for decision making, for training, and for technology transfer in developing countries. (Rafea, 1994)

Arumugam (1995) supported that all the three classes of the developed expert systems were found to be effective when compared to the actual field practice. It was concluded that the expert system technique was a viable and efficient tool for intelligent decision making for these irrigation management domains.

Rafea *et al.* (1995) studied the various natural resources conservation systems. Such types of expert systems are used to conserve the natural resources. There are two problems facing decision makers to conserve water resources namely: efficient utilization of water resources, and the pollution resulting from the usage of chemical fertilizers and pesticides. Regarding soil conservation, there are two main problems namely: the urban expansion, and the soil degradation resulting from excessive use of fertilizers and other bad agricultural practices.

Robinson (1996) reported that, expert systems are being used in a wide range of areas in agriculture. Its main usage areas are: crop management advisors, livestock management advisors, planning systems, pest management systems, diagnostic Systems, conservation/engineering systems, process control systems, and marketing advisory systems.

As expert systems have been using in different fields of life like medicine, process controlling etc. so agriculture field has also not been left affected by these knowledge based systems. These systems are being used by agricultural decision makers at different levels: "operation level and planning level. On the operation level, the extension workers in the village, district, and/or governorate can use the system to support him in making his decision in giving the appropriate advice to the growers. On the planning level, the decision makers can use the expert system to predict the needs of water, fertilizers, and pesticides". (Rafea, 1996)

Sadagopan (1998) mentioned that expert systems could capture the human expertise and multiply it, provide affordable expertise to all, use the 'distilled' expertise of human expert to train others and could document the expertise for prosperity.

Wai *et al.* (2000) reported that the agriculture expert system were to help the farmers to do single point decisions, to have a well planning before starting to do anything on their land. Secondly, it was to design an irrigation system for their plantation. Third was to select the most suitable crop variety or market outlet. Fourth was Diagnosis or identification of the livestock disorder. Fifth was to interpret the set of financial accounts. Sixth was to predict the extreme events such as thunderstorms and frost. And lastly was to suggest a sequence of tactical decisions throughout a production cycle such as plant protection and nutrition decisions, livestock feeding and the like.

Balasubramani *et al.* (2003) pointed out that the expert system was intended to help farmers to make better decisions and provide useful advice, filling the knowledge gap between the expert and the user.

Liping (2003) commented that agricultural expert system had rich agricultural knowledge and deductive procedure of imitating mankind that could provide the users with all kinds of consultation services and the measures of making a strategic decision to solve the different agricultural problems. Agricultural expert system possessed the superiority of wide adaptability, rapid response, low cost and less dangerous.

Sarma (2003) mentioned that inputs distribution, marketing information systems, land-water management, cropping pattern, management of natural resources and extension services etc. could be solved through various techniques of modeling and expert systems.

Wagner *et al.* (2003) indicated that in the past several decades, many expert system applications have been developed and reported in the literature. Case studies of these applications typically include a detailed description of the problem domain, knowledge acquisition techniques used and also some indication of the relative success of the application. The results of an extensive content analysis of more than 90 expert system applications in the field of production and operations management focuses on describing the knowledge acquisition techniques used and also on the problem domain that the applications address. For years developers have speculated that certain types of problems such as planning, are more difficult, but may yield a higher-impact system. Likewise, developers and empirical Knowledge acquisition researchers have tried to determine the conditions under which certain Knowledge acquisition techniques will work better than others. Researchers have also speculated for years about which techniques might work best for different problem domains. By carefully analyzing this large body of case studies and operationalizing the notion of the 'impact' of the Expert System application, they began to make normative conclusions about which techniques and which problem domains seem to yield applications that have the highest impact on the respective organization. This will offer more tangible evidence regarding the possible linkages between problem domains and knowledge acquisition techniques in a more pragmatic manner than has been done previously.

According to Senthilkumar (2004), expert systems were important development in information technology. These advised the farmers which alternative to choose from a wide range of possible alternatives by processing data from a large number of variables according to certain decision rules. These systems applied the decision rules more consistently and processed the relevant data more effectively than the farmer could himself.

Adhiguru and Birthal (2006) stated that expert system had the merits in terms of more subject matter coverage, decision support, direct access to information, minimize time, distance barriers and empower rural intermediary organizations. It had the potential to facilitate cost-effective production, vertical integration, value-added marketing, minimize transaction costs, improved communication efficiency, encourage competitiveness and accelerate growth.

Ganesan (2007) opined that expert system would play a major role in the dissemination and application of useful knowledge leading to economic growth and higher standards of living. They were not only the vehicles to apply expert's knowledge to particular problems, but were potentially powerful learning resources to help users to develop their own expertise. For both developed and developing countries this could bring more productivity and employment in agriculture through wider and more diverse applications of new scientific results. More over this provided wider scope for individual managerial initiative of farmers, reinforcing local abilities to solve local problems.

Prasad and Babu (2006) studied the various agricultural expert systems developed in the last three decades and outlined their salient features. Expert systems for pest control and crop protection constitute a very significant class of agricultural expert systems. Pest management and crop protection includes a large number of techniques using varied knowledge in entomology, plant pathology, nematology, weeds and vertebrate pests.

Sunil (2006) found that the most important utility of the system as perceived by the farmers was as a tool to diagnose various plants protection problems. The next important utility of the system was as a calculator to estimate chemicals and also as a management tool in identifying various concerns. The most important use of the formation and decision support system for the extension personnel was as a tool in estimating quantity of chemicals and fertilizers. This was followed by such uses like reference materials and diagnostic tool assumed top priority.

Agriculture expert system is widely used in the various fields of agriculture and greatly promoted the modernization of the agricultural production process and for high quality and high efficiency agriculture in China (Li Quan, 2008)

Expert systems are used to solve problems by answering questions typed at a keyboard attached to a computer on such diversified topics, for example, in pest control, the need to spray, selection of a chemical to spray, mixing and application, optimal machinery management practices, weather damage recovery such as freeze, frost or drought, etc. Now-a-days expert system in agriculture is employed more for diagnosis and management of economically significant pest problems like diseases and insects of crop plants. (Mercy Nesa Rani *et al.*, 2011)

Expert system is now being using into agriculture sector. Expert system is most powerful approach that simulates human knowledge from an expert in certain domain for assist human to make decision at a level of or greater than human expert. Expert system helps to growers in making economically viable and environmentally strong decision related to crop management. After considering success of expert system various expert systems were developed in agriculture. (Yelapure and Kulkarni, 2012)

Nitin *et al.* (2013) reported that benefits to the farmer using expert system such as diagnosis of crop disease, irrigation schedule, selecting proper pest control, selecting fertilizer and their quantity.

## 2.6 LEVEL OF AWARENESS ON EXPERT SYSTEM

Level of awareness on agricultural expert system was operationalized as the level of awareness of respondents about the functions of agricultural expert system. Awareness model has two fold natures, which are they involve a representation of one's current state or behaviour matched to some standards or criterion. This implies that awareness consists of both an object of attention and an evaluate context in which that object is framed. This is proposed by Wegner and Guliano (1982), who suggested that awareness have both a "focal" and a "trait" dimension. The focus (target) of awareness is what it is explicitly about, whereas the trait aspect of awareness concerns the implicit perspective from which the target appears.

Pandey and Mehta (2002) pointed out the awareness of educational technologies in open learning system by target group. It was found that cent-percent extension agents were completely aware about print material and contact session, whereas awareness regarding rest of the technologies was completely low. Awareness index of more than half of the respondents was medium level.

Senthilkumar (2003) in his study reported that less than half (44.44%) of the extension agents had a medium level of awareness on electronic databases, followed by low level of awareness (33.33%) and only 22.22 per cent had a high level of awareness on electronic databases.

Adesope *et al.* (2007) who noted that in the Niger Delta area of Nigeria, about 98 percent of the extension agents indicated they were aware of information communication technologies, while 2.3 percent were not.

Thambiratti (2008) explored that the teacher must create awareness among students about proper use of technology. Teachers can make use of technology to create an appetite for learning among the students.

Thangaraja *et al.* (2008) attempted a study on the utilization behavior of online journals by the students of Tamil Nadu Agricultural University (TNAU). The results showed that majority (95.00%) of the students were aware about the availability of online journals in their respective subjects.

Umarani and Saimaheswari (2010) in their study on awareness and adoption of technologies by women headed households reported that around 50.00 per cent of the sample women were not aware of the technologies.

Mabe and Oladele (2012) revealed that extension officers were more aware of the nine ICT tools out of the listed 37 ICT tools. Prominent information communication technologies among extension officers were mobile phones (1.79). computer (1.68). internet (1.77). overhead projector (1.62), fax machines (1.60). organization e mail (1.58). fixed telephone (1.52). personal email (1.52) and organization website (1.50).

## 2.7 ATTITUDE OF EXTENSION PROFESSIONALS TOWARDS EXPERT SYSTEM

Al-Rani (1990) made an attempt to identify and examine the students' attitude towards learning about computers, using computers. The results revealed that the students' attitude towards computer were positive.

Shashaani (1994) states that, "recent empirical studies have shown that computer experience is positively related to computer attitudes".

Attitude towards e-learning model will be positively influenced by its perceived system's usefulness and ease of use. Learner attitudes and responses are interconnected and a positive correlation exists between the two (Paris, 2004)

Ndubisi (2004) reported that attitude towards e-learning model will be positively influenced by its perceived system's usefulness and ease of use.

Chetsumon (2005) reported that extension agent's attitude towards the use of POSOP expert system and its determinants, their belief with regard to using POSOP expert system, and their evaluation of expected outcomes from using POSOP expert system, were all positive or favorable, with means of 3.63, 3.40 and 3.65 respectively.

Omidi *et al.* (2008) found that negative attitude of organizations towards virtual education is a barrier to the development of e-learning programmes.

Yaghoubi (2009) assessed agricultural extension and education graduate students' perceptions of e-learning in Iran. The results indicated that students with positive attitudes to new technologies were all more positive in favor to e-learning than other students.

Yaghoubi *et al.* (2011) studied the agricultural insurance agents' attitude towards e-learning. Results showed that attitude to e-learning are relatively positive.

In many developing countries, e-learning is still regarded as an innovative mode of learning. Experience shows that transferring technologies can provoke the adoption of e-learning, only if people are willing and their attitude is positive for adoption. In fact, adoption of e-learning is related to the learners' attitude and prior experience of e-learning. Results of the study showed that the extension workers' attitude to e-learning is generally positive and in most aspects relevant to the learners' prior experience (Amir, 2012).

## 2.8 FREQUENCY AND NATURE OF AGRI-EXPERT SYSTEM USE BY THE RESPONDENTS

Agwu *et al.* (2008) in their study on use of Information Communication Technologies (ICTs) among researchers, Extension Workers and Farmers in Abia and Enugu States: Implications for a National Agricultural Extension Policy on ICTs reported that out of 24 ICT facilities listed, 14 facilities were frequently used by the researchers and these facilities include internet, television set, voltage stabilizer, radio set, printer, flash drive, diskette, computers, UPS, mobile phone and e-mail.

Aboh (2008) in his study on assessment of the frequency of ICT tools usage by Agricultural Extension agents in IMO state, Nigeria revealed that only mobile phone and computer were frequently used by respondents. The overall mean of 0.89 suggests that ICT tools were not frequently used for extension services.

Ndag *et al.* (2008) in their study comparative analysis of information and communication technology (ICT) use by agricultural extension workers in South-West and North-Central Nigeria concluded that majority (51.43%) of the respondents had low level ICT use in South-West Nigeria, majority had moderate (43.86%) to high level (48.57%) ICT use in North-Central Nigeria.

Singh *et al.* (2009) elucidated the use of Internet based e- resources at Manipur University. It was noticed that 30.7% of students use Internet to little extent, 28.8% to some extents and 13.1% of students use Internet to full extent. However 27.4% of respondents are non-users of Internet.

Meera *et al.* (2010) conducted study on Critical analysis of e-learning opportunities and e-readiness in the public extension system: Empirical Evidence from Tamil Nadu and opined that majority of the extension workers (55%) are willing to spend thirty minutes to one hour per week for updating their knowledge.

## 2.9 DIFFUSION-ADOPTION STAGES IN TERMS OF USE OF EXPERT SYSTEM TECHNOLOGY *VIS A VIS* EXTENSION PROFESSIONALS

Expert systems are used mainly as extension tools in contrast to research activity. Their extension role presents several fundamental obstacles to their successful adoption in agriculture. A simulation model can be considered a success if it adequately performs its simulation functions. However, expert systems must be judged by higher standards. They cannot be considered successful just because of correct mimicking as they must also be employed by at least some of the potential users (Plant and Stone, 1991).

As mentioned earlier most technology innovations have two components - hardware and software. As expert systems require a computer it is important to note, as would be expected, there is clear evidence that the use of management information systems appears to be positively correlated with computer adoption (Lippke and Rister, 1992).

Appropriate participation of the agricultural Extension Service in the adoption-diffusion process for the Computer and Internet by Agricultural extensional agents is a debated issue (Risdon, 1994).

According to Sathiyaseelan (1998) TNAU model had the highest symbolic adoption score and was significantly superior to that of MANAGE-model. but it was on par with the MANAGE-model with respect to its effectiveness in terms of symbolic adoption.

Lynch *et al.* (2000) developed a model of the adoption of intelligent support systems (decision support systems and Expert Systems) by farmers. The model relies on Rogers' diffusion theory. the developer-based versus adopter-based approaches to technology, user involvement in the development of the innovation, and the importance of the usefulness and ease of using software. Evidence concerning the adoption of intelligent systems in Australian agriculture is presented to show that this model offers a reasonable explanation of the low rate of adoption of these systems in agriculture. The authors have pointed out that there are certain issues that are critical for wider adoption and successful use of intelligent support systems in agriculture which include participatory approaches, and use of 'softer' systems methodologies that acknowledge the importance of involving the user early in the development process and pay attention to the decision-making styles and social context of potential users.

Today a growing number of agricultural operators are adopting the Computer for its extensional business applications, as well as for researching product markets and obtaining marketing services. The Computer Age has lowered the cost of obtaining, producing, and delivering information while increasing the quantity and rate at which information flows (Paarlberg and Paarlberg, 2000).

Chetsumon (2005) reported that adoption of expert systems appears to depend on the system attributes, the support of the systems, and user characteristics. Clearly, the usefulness of the systems as perceived by the users and specific system attributes such as utility, accuracy, reliability, efficiency, ease of use, and user interface play an import role in an expert system's acceptance.

Michailidis (2007) detailed about the adoption of Internet in agriculture. It was found that landholders in rural areas were increasing their use of computers and internet. This was because of the increased availability of hardware, software and communication infrastructure at reasonable cost. Therefore it is clear that the time spent on computer use has increased for all respondents. (67%) of respondents indicating that their time spent had increased significantly.

Early adopters are the more progressive extension workers who use the Internet for accessing agricultural information to aid in managing their extensional business. These operators represented 30% of these extension agents and the largest segment in the diffusion-adoption chain. Because the study focused on extension workers, this proportion seems consistent with the progressive but cautious demeanors typical of early adopters. Innovators, who act more independently of their peers in their agricultural activities, account for only 11.5% of extension workers. (Ahmed, 2012)

## 2.10. CONSTRAINTS EXPERIENCED BY EXTENSION PROFESSIONALS IN USING AGRI-EXPERT SYSTEMS

The poor knowledge of facilitator about subject matter and inadequate infrastructure facility like power supply and internet facility in rural area were perceived constraints by respondent farmers to make best use of ICT services. Similar constraint in utilization of ICT in agriculture and rural development by farmers were also reported by Adhiguru *et al.*, (2003).

The technologies depend on computers, internet and land line connections. The problems also include slow and disruptive internet connectivity, poorly maintained land lines, the unreliability of electricity supply and power backup systems and operational constraints from the inadequate maintenance and support of the equipment (Annamalai and Rao, 2003).

Senthilkumar (2003) revealed that the modern information and communication techniques require more skill to operate.

Balasubramani (2004) in his study reported that cent per cent of the subjects expressed that, computer and other accessories are required to utilize expert System. It was followed by 98.33 per cent of the subjects felt as it required regular update. whenever situation changes. Because the expert System was designed considering the present situation further it calls for updating to meet the changing situations.

The organisational barriers include lack of time available for training: cost versus value: lack of appropriate content related to specific needs: language barrier (as most of the content is delivered in English); difficulties in measuring e-Learning effectiveness; lack of strategic planning and direction, lack of e-Learning awareness; lack of incentives; and finally, lack of management support (Baldwin-Evans, 2004).

The United States Development Agency (USDA, 2005) declared that lack of effective training remains a major ICT adoption constraint. Major constraints affecting utilization of ICT by extension officers in the Niger Delta were revealed to be poor ICT infrastructure development; high cost of broadcast equipment; high charges for radio/TV presentation; high cost of access/interconnectivity and electricity power problem: It was also revealed that private agencies extension officials recorded more constraints (14 to 54%) than public sector extension officials (11 to 42%) with regard to 26 constraint items under focus. This may be because they had more access to the utilization of ICT provided by their institutions and therefore apprised of the problems inherent in their use. This is unlike public sector extension agents who utilize mainly interpersonal communication in their extension activities, due to paucity of funds to invest in ICT. It is obvious that despite abundant experiences with ICT initiatives and programmes, ICT adoption remains a major issue and current critical concern (USDA, 2005).

Soekartawi (2005) identifies some problems in developing countries as being related to infrastructure and Internet connection, human resources, policy support from government and pedagogy. He emphasises that human resources is one of crucial factors to diffuse utilizing ICT to learners.

Muilenburg and Berge (2005) determine eight barriers factors to online learning including administrative/instructor issues. social interactions. academic skills. technical skills. learner motivation. time and support for studies cost and access to the Internet and technical problems.

Alemna and Sam (2006) have alluded to the problems of poor ICT infrastructure development, electricity. illiteracy and overbearing costs. as deterrents to ICT utilization in developing countries.

Ali and Magalhaes (2008) divided the barriers in the adoption of e-Learning into two factors: organisational and technical issues. As for the technical barriers, the most commonly cited are system crashes, bandwidth and infrastructure upgrading, accessibility, usability, technical support and perceived difficulties in using such a system.

Sing *et al.* (2009) found the difficulties in browsing the Internet based information resources. It was found that low speed Internet access, erratic power supply and lack of required full text journals are problems with regards to the use of Internet based e-resource.

Sudaryanto (2011) stated that even though it is found that there was a growing interest of computer for agriculture development; inconsistency of IT deployment across regions also creates constraints within an increasingly integrated global industry. As responsiveness and speed of business were critical to the success of e-agriculture, any technical constraints were impediments to the growth of the industry. At the same time, farmers have been somewhat slower to adopt computer and Internet technology than the average American. Some of this was related to place. Some was related to age (older individuals adopt computing more slowly) and personality traits that resist spending additional time inside doing record keeping.

# Materials and Methods

# 3. MATERIALS AND METHODS

This chapter deals with the brief description of methods and procedures that were used for meeting the objectives set forth in this study. The methodology followed in the study is presented under the following subheadings:

3.1. Research design

3.2. Locale of the study

3.3. Selection of the respondents

3.4. Operationalisation and measurement of the variables

3.4.1. Measurement of dependent variables

3.4.2. Measurement of independent variables

3.4.3. Effectiveness index of expert system application in agriculture

3.4.4. Constraints experienced by agri- expert system respondents

3.5. Data collection procedure

3.6. Statistical tools

3.7. Conceptual framework of the study

## 3.1. RESEARCH DESIGN

'Ex-post-facto' and 'explorative' research designs were used for conducting this study. 'Ex-post-facto' research design is a systematic inquiry in which the scientist does not have direct control over the independent variables because their manifestations have already occurred or because they are inherently not manipulable (Kerlinger, 1983). This research design was resorted to in this study, as there was no scope for manipulation of any variables under study. Since the researcher had to probe for expert system components, explorative design too was used for the study.

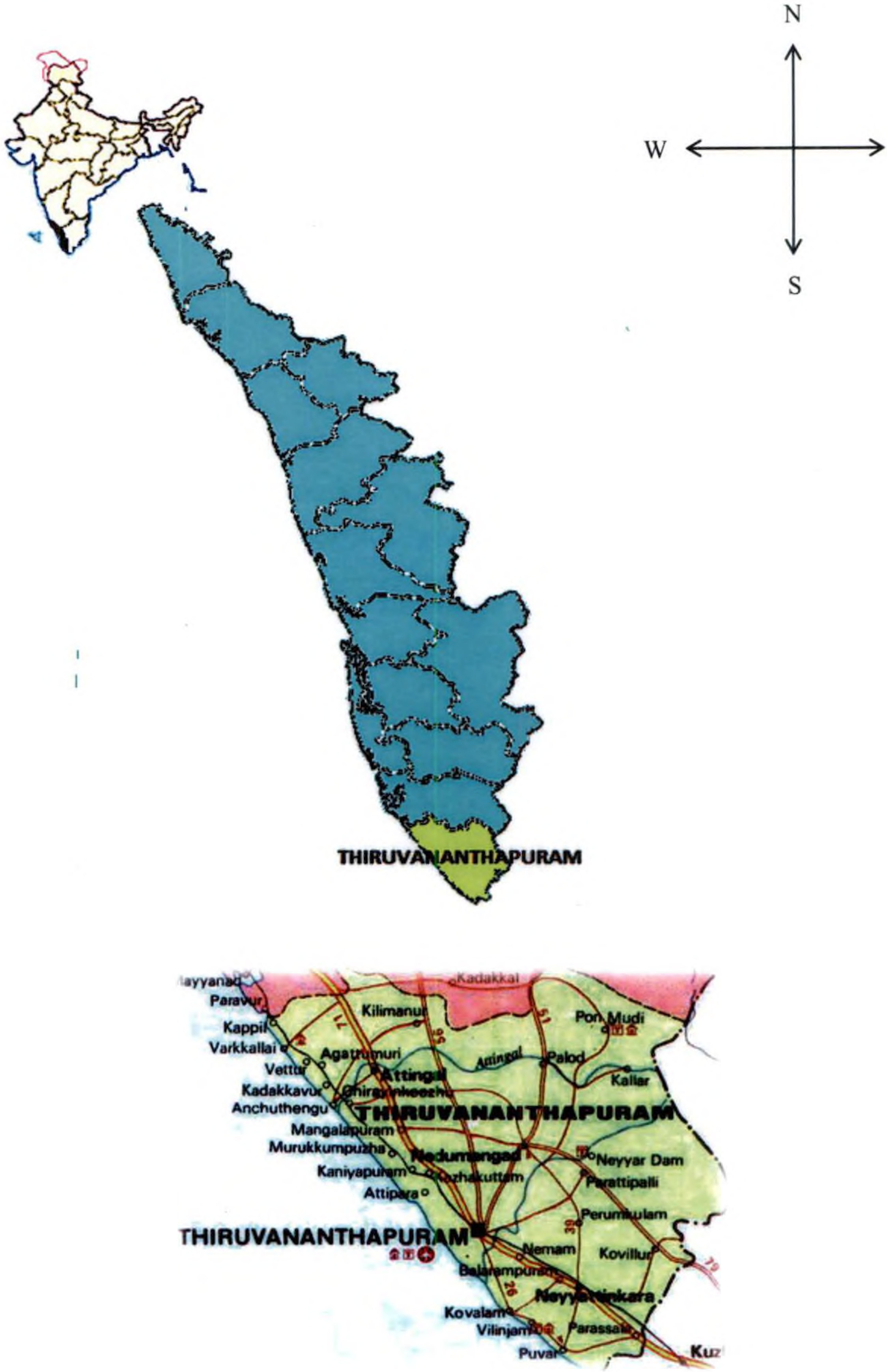



Fig.1. Map of Kerala with district of study

## 3.2. LOCALE OF STUDY

The study was conducted in the Thiruvananthapuram district and it was purposively selected for the study because it is the capital city for governing policy initiatives and the headquarters for IT ventures *viz.*, IIITMK, C-DIT, IT Mission, Information Kerala Mission, e-Governance, FRIENDS, ICT initiatives of State Department of Agriculture etc. Moreover, application of IT in agriculture is heralded and monitored by the 'IT Cell' of Directorate of Agriculture located at Thiruvananthapuram.

## 3.3. SELECTION OF THE RESPONDENTS

The respondent groups of the study comprises of Officers from State Department of Agriculture, Front line extension professionals of KVK's and NGO's actively involved in the field of agriculture and scientists involved with extension programmes of Kerala Agricultural University, ICAR Institutes and Commodity Boards. A total of 100 respondents would be selected for the study.

### 3.3.1. Officers of State Department of Agriculture:

There are about 300 extension professionals working in Thiruvananthapuram district in different offices under the State Department of Agriculture, *viz.,* Principal Agriculture Office, Assistant Director Office, Krishibhavans and Farms. Forty (n=40) extension professionals primarily consisting of Agricultural Officers working in the Krishibahavans will be randomly selected for the study.

### 3.3.2. Front Line Extension personnel's:

Thirty front-line extension professionals (n=30) of KVK's and NGO's actively involved in the field of agriculture will be the respondents of the study.

### 3.3.3. Scientists

Thirty (n=30) Scientists involved with extension programmes of Kerala Agricultural University, ICAR Institutes and Commodity Boards will be selected as the respondents for the study.

## 3.4. OPERATIONALISATION AND MEASUREMENT OF THE VARIABLES

### 3.4.1 Measurement of dependent variables

**1) Diffusion and adoption of agri-expert systems - with special reference to adoption stages.**

Diffusion and adoption was operationalized as an individual decides that the expert system is good enough for full scale and continued use.

The procedure followed by Ahmed (2012) with slight modification was adopted for the study. The test constituted 5 questions which were provided with Yes or No answers. The adoption stage was administered to the respondents and was asked to tick mark the correct answer. Based on the stage, respondents were classified into five stages accordingly.

| Stages | Weightages | Cumulative scores |
|---|---|---|
| Awareness | 1 | 1 |
| Interest | 2 | 3 |
| Evaluation | 3 | 6 |
| Trial | 4 | 10 |
| Adoption | 5 | 15 |

Based on the stage of adoption respondents were categorized into innovators, early adopters, early majority, late majority and laggards for adopter categorization using percentiles, as measure of check. Cumulative scores were worked out to classify the respondents into adopter categories.

| Adopter categories | Percentile classification |
|---|---|
| Innovators | ($>P_{80}$) |
| Early adopters | ($P_{80}$-$P_{60}$) |
| Early majority | ($<P_{60}$-$P_{40}$) |
| Late majority | ($<P_{40}$-$P_{20}$) |
| Laggards | ($<P_{20}$) |

**2) Attitude towards expert systems**

It was operationalized as type of attitude possessed by the respondents towards expert systems.

The procedure followed by Chetsumon (2005) with slight modification was used. This scale has 14 statements, among these 7 were positive statements and 7 statements were negative. The scoring pattern was followed as given below.

| Category | For positive statements | For negative statements |
|---|---|---|
| Strongly disagree | 1 | 5 |
| Disagree | 2 | 4 |
| Undecided | 3 | 3 |
| Agree | 4 | 2 |
| Strongly agree | 5 | 1 |

Based on the total scores the respondents were classified into 3 categories using quartiles, as measure of check.

| Category | Quartile classification |
|---|---|
| Low | Less than (Quartile deviation 1) |
| Medium | Between ($Q_1$-$Q_3$) |
| High | More than (Quartile deviation 3) |

### 3.4.2 Measurement of independent variables

In order to assess the influence of the profile characteristics of the respondents for meeting the objectives of the study, the characteristics of the respondents and attributes of expert systems were identified as detailed below:

A list of 42 independent variables related to the personal characteristics of the expert system respondents which are important for meeting the objectives of the study were collected after detailed review of literature and discussion with subject matter specialists. The lists of variables were then sent to 30 judges (Appendix-I). They were asked to examine the variables critically and to rate the relevancy of each variable on a three-point continuum ranging from most relevant, relevant and least relevant with weightages of three, two and one, respectively. Out of 30 judges only 21 responded.

The final variables were selected based on the criterion of mean relevancy score, which was obtained by summing up the weightages, obtained by variable and dividing it by the number of judges, responded. Those variables got score more than the mean score were selected for the study. The variables with the mean relevancy scores are presented in Appendix II.

The personal characteristics of the expert system respondents which constituted the independent variables thus selected for the study were age, education, training and innovativeness of expert system respondent in relation to sustainability of the expert systems.

The perceived attributes of the expert system which constituted the independent variables thus selected for the study were accessibility, availability, timeliness, retrievability, relevancy, accuracy, format clarity and information content of expert system in relation to sustainability of the expert systems.

The selected 12 independent variables and their measurement for study are presented in Table 1.

**Table 1. Independent variables and measurement scales / scores used**

| Sl. No. | Independent variables | Measurement and scoring procedures developed or adopted by |
|---|---|---|
| 1 | Age | Hinge (2009) |
| 2 | Education | Kiran (2007) |
| 3 | Training | Hailemicheal (2002). |
| 4 | Innovativeness | Kikon (2010) |
| 5 | Availability | Hassan (2008) |
| 6 | Accessibility | Hassan (2008) |
| 7 | Retrievability | Helen (2008) |
| 8 | Relevancy | Helen (2008) |
| 9 | Format clarity | Hassan (2008) |
| 10 | Information content | Helen (2008) |
| 11 | Timeliness | Hassan (2008) |
| 12 | Accuracy | Hassan (2008) |

**1) Age**

Age was operationalized by considering the chronological age of the extension personnel in completed years at the time of investigation.

The respondents were categorized into three groups based on the procedure as followed by Hinge (2009).

| Age category | Years |
|---|---|
| Young | < 31 years |
| Middle aged | 31-50 years |
| Aged | > 50 years |

**2) Education**

In this study education is operationalized as the number of years of formal schooling obtained by the extension personnel.

The scoring procedure quantified by using the items and weights used by Kiran (2007) with slight modification.

| Category | Score |
|---|---|
| Graduation (Ag.) | 1 |
| M.Sc (Ag.) / M.Sc (H. Sc) | 2 |
| Ph. D (Ag.) / Ph. D (H. Sc) | 3 |

**3) Training**

Training refers to the training received by the respondents on ICT tools. Each training was given a score of one.

| Have you attended any training on ICT- Y/N | If Yes No. of Training | Its Duration |
|---|---|---|
| | | |

Then based on duration of training undergone by the respondents, it was classified into three categories as given below; this is with slight modification of the procedure as followed by Hailemicheal (2002). Percentage was used for interpretation of data.

| Category | No. of personnel | Percent |
|---|---|---|
| 1-3 days | | |
| 4-6 days | | |
| >7 days | | |

**4) Innovativeness**

It refers to the behavioral pattern of an individual who has interest and desire to seek changes in ICT tools and ready to introduce such changes which are practical and feasible.

For quantifying this variable, the scale used by Kikon (2010) was made use of. The scale consists of 4 statements. After obtaining the response as 'high, medium and 'low', a score of 3 was given to 'high', score of 2 was given to 'medium' and score 1 for 'low' response was assigned. The final scoring was arrived by summing up the scores of statements and the scores ranged from 4 to 12.

Then, based on the total score, the respondents were categorized into 'low', 'medium' and 'high' by considering the mean ($\overline{X}$) and standard deviation (SD) as measure of check.

| Category | Score |
|---|---|
| Low | Less than (mean - S.D) |
| Medium | Between (mean ± S.D) |
| High | More than (mean + S.D) |

**5) Availability**

Availability was operationalized as ICT offered with reasonable proximity and appropriate hardware and software.

The scoring procedure followed by Hassan (2008) with slight modification was used in this study. The degree of the availability was measured using a three point continuum and the scoring was done as,

| | |
|---|---|
| Always | 3 |
| Some times | 2 |
| Rarely available | 1 |

**6) Accessibility**

It refers to the ability to access the expert system.

The scoring procedure followed by Hassan (2008) with slight modification was used in this study. The degree of the accessibility was measured using a three point continuum and the scoring was done as,

| | |
|---|---|
| High | 3 |
| Medium | 2 |
| Low | 1 |

**7) Retrievability**

It was operationalized as the extent to which the information provided in the system can be easily located and received by any user.

The procedure followed by Helen (2008) with slight modification was used in this study. The scale consists of 4 statements. After obtaining the response as 'high, medium and 'low', a score of 3 was given to 'high', score of 2 was given to 'medium' and score 1 for 'low' response was assigned. The final scoring was arrived by summing up the scores of statements and the scores ranged from 4 to 12.

Then, based on the total score, the respondents were categorized into 'low', 'medium' and 'high' by considering the mean ($\bar{X}$) and standard deviation (SD) as measure of check.

| | |
|---|---|
| High | 3 |
| Medium | 2 |
| Low | 1 |

**8) Relevancy**

It was operationalized as the opinion of the respondents about the suitability of the information provided in the agricultural expert system to the users' situation. It was assessed whether the system was able to provide information suitable to the users' and appropriate to the users' needs.

The procedure followed by Helen (2008) with slight modification was used in this study. The scale consists of 4 statements. After obtaining the response as 'high, medium and 'low', a score of 3 was given to 'high', score of 2 was given to 'medium' and score 1 for 'low' response was assigned. The final scoring was arrived by summing up the scores of statements and the scores ranged from 4 to 12.

Then, based on the total score, the respondents were categorized into 'low', 'medium' and 'high' by considering the mean ($\bar{X}$) and standard deviation (SD) as measure of check.

| | |
|---|---|
| High | 3 |
| Medium | 2 |
| Low | 1 |

**9) Format clarity**

It was operationalised as the extent to which the information given is in clear format which help the receiver to arrive at a decision.

The procedure followed by Hassan (2008) with slight modification was used in this study. The scale consists of 4 statements. After obtaining the response as 'high, medium and 'low', a score of 3 was given to 'high', score of 2 was given to 'medium' and score 1 for 'low' response was assigned. The final scoring was arrived by summing up the scores of statements and the scores ranged from 4 to 12.

Then, based on the total score, the respondents were categorized into 'low', 'medium' and 'high' by considering the mean ($\bar{X}$) and standard deviation (SD) as measure of check.

| | |
|---|---|
| High | 3 |
| Medium | 2 |
| Low | 1 |

**10) Information content**

Information content was measured as the extent to which the information on the subject matter was covered in the expert system. It was assessed whether the provided information was complete to the users.

The procedure followed by Helen (2008) with slight modification was used in this study. The scale consists of 4 statements. After obtaining the response as 'high, medium and 'low', a score of 3 was given to 'high', score of 2 was given to 'medium' and score 1 for 'low' response was assigned. The final scoring was arrived by summing up the scores of statements and the scores ranged from 4 to 12.

Then, based on the total score, the respondents were categorized into 'low', 'medium' and 'high' by considering the mean ($\bar{X}$) and standard deviation (SD) as measure of check.

| | |
|---|---|
| Adequate | 3 |
| Somewhat adequate | 2 |
| Not adequate | 1 |

**11) Timeliness**

This was operationalized as the information provided when it is needed. According to Kamath (2003) it means the quality of information as far as time factor is concerned. For effective decision making timely information is essential.

The procedure followed by Hassan with slight modification (2008) was used in this study. The scale consists of 4 statements. After obtaining the response as 'high, medium and 'low', a score of 3 was given to 'high', score of 2 was given to 'medium' and score 1 for 'low' response was assigned. The final scoring was arrived by summing up the scores of statements and the scores ranged from 4 to 12.

Then, based on the total score, the respondents were categorized into 'low', 'medium' and 'high' by considering the mean ($\bar{X}$) and standard deviation (SD) as measure of check.

| | |
|---|---|
| High | 3 |
| Medium | 2 |
| Low | 1 |

**12) Accuracy**

It was operationalized as the quality of information being near to the true value. According to Kamath (2003) any inaccurate information leads to faulty decisions, so accurate information is needed for successful decision making.

The procedure followed by Hassan (2008) with slight modification was used in this study. The scale consists of 4 statements. After obtaining the response as 'high, medium and 'low', a score of 3 was given to 'high', score of 2 was given to 'medium' and score 1 for 'low' response was assigned. The final scoring was arrived by summing up the scores of statements and the scores ranged from 4 to 12.

Then, based on the total score, the respondents were categorized into 'low', 'medium' and 'high' by considering the mean ($\bar{X}$) and standard deviation (SD) as measure of check.

| | |
|---|---|
| High | 3 |
| Medium | 2 |
| Low | 1 |

### 3.4.3. Effectiveness index of expert system application in agriculture

Based on the relevant review of literature and discussion with experts of Department of Agriculture and Kerala Agricultural University, items related to expert system applications in agriculture were identified and effectiveness index of expert system developed. The statements were ranked based on their mean scores in decreasing order of importance.

| S. No | Items | Based on the importance | | | | |
|---|---|---|---|---|---|---|
| | | 5 | 4 | 3 | 2 | 1 |
| 1 | Quick availability and opportunity of the expert system to programme itself. | | | | | |
| 2 | Expert systems ability to exploit a considerable amount of knowledge. | | | | | |
| 3 | Reliability of the expert system. | | | | | |
| 4 | Scalability of the expert system. | | | | | |
| 5 | Pedagogy (As a means to effective learning through expert system) | | | | | |
| 6 | Expert systems ability on preservation and improvement of knowledge. | | | | | |
| 7 | Expert systems ability to address the new areas neglected by conventional computing. | | | | | |

Effectiveness index was calculated by using this formula and distributed the respondents based on effectiveness index of each respondent into high, medium and low using quartiles as measure of check.

$$\text{Effectiveness index} = \frac{\text{Total actual score obtained} - \text{Total minimum possible score.}}{\text{Total maximum possible score} - \text{Total minimum possible score}} \times 100$$

Total minimum possible score (7)

Total maximum possible score (35)

Plate.1. Conducting training to the respondents on agri-expert systems and collecting data from the respondents

### 3.4.4. Constraints experienced by agri- expert system respondents

Based on discussion with scientists, experts in agriculture and also through relevant review of literature, some of the constraints faced by expert system respondents were identified. A list containing fifteen such constraints were included in the final questionnaire (Appendix 2). The list was open ended so that the additional constraints expressed by the expert system respondents at the time of interview could also be included.

The response to each constraint was obtained on a five-point continuum from most important to least important, with the score 'five', 'four', 'three', 'two' and 'one' respectively. After which each of the constraint statement was enumerated based on the maximum score (which was 5). Therefore, statements with maximum responses having the highest score of 5 could be counted and frequency/percentage was worked out. Hence the statement with maximum frequency was designated as the most important constraint followed by the others in the decreasing order of importance.

## 3.5. DATA COLLECTION PROCEDURE

The data were collected using a well-structured interview schedule prepared for the purpose (Appendix III). A draft interview schedule was prepared which was pre-tested by conducting a pilot study in non sample area and suitable modifications were made in the final interview schedule which was then directly administered to the expert system respondents by the investigator and responses recorded at the time of interview. Agricultural Officers, front-line extension professionals and Agricultural Scientists were included as respondent categories in the study.

## 3.6 STATISTICAL TOOLS USED IN THE STUDY

The collected data were scored, tabulated and analysed using statistical methods as described below.

### 3.6.1 Mean

The respondents were grouped into categories with reference to the means of the independent variables. After grouping the respondents into categories, their percentages were worked out.

### 3.6.2 Percentage Analysis

After grouping the respondents into various categories based on the score on utilization or extent of adoption of agricultural expert systems, simple percentage was worked out to find out percentage distribution of the respondents. It was also used to interpret the results of independent variables selected for the study.

### 3.6.3 Correlation Analysis

Simple correlation analysis was taken into consideration for analysing the influence of independent variables on the attitude of respondents towards expert system and extent of adoption of agri-expert system.

### 3.6.4 Quartile Deviation

The quartile deviation is half the difference between the upper and lower quartiles in a distribution. It is a measure of the spread through the middle half of a distribution. It is useful to classify the data into different quartiles which can lead to categorisation of respondents into different categories.

### 3.6.5 Percentile Analysis

Percentile finds the value under which X percent of the numbers lie. The $n^{th}$ percentile of a set of data is the point where n per cent of the data is below it. It is useful to classify the data into different percentiles which can lead to categorisation of respondents into different categories.

### 3.6.6 Kendall's Co-efficient of Concordance

Kendall's co-efficient of concordance was used to verify whether there was agreement among the respondents in providing their responses to the study. It was calculated by the formula:

$$W = \frac{S}{(1/12)\, K^2 (N^3 - N)}$$

S = Sum of squares of the observed deviation from the mean of $R_j$

$$S = \Sigma R_j^2 - \frac{(\Sigma R_j)^2}{N}$$

K= Number of sets of ranking

N= Number of individuals or object ranked

$(1/12)\, K^2 (N^3 - N)$ = Maximum possible sum of the squared deviations the sum S which would occur with perfect agreement among K rankings.

The computed value of 'W' was tested for its significance by using $X^2 = K (n-1) w$ with N-l degrees of freedom.

3.7. CONCEPTUAL FRAMEWORK OF THE STUDY

A conceptual model of the study has been framed based on the objectives set forth for the study, the concepts theoretically designed from the review of literature and factors influencing the attitude and adoption of agri-expert systems. The frame work explains the relationship between the profile characteristic of respondents (independent variables) and the dependent variables namely attitude of respondents towards agri-expert systems and adoption of agri-expert systems among extension professionals. The conceptual frame work is given in Fig.2.

The findings of this study have been reported in the succeeding chapter with results and discussion.

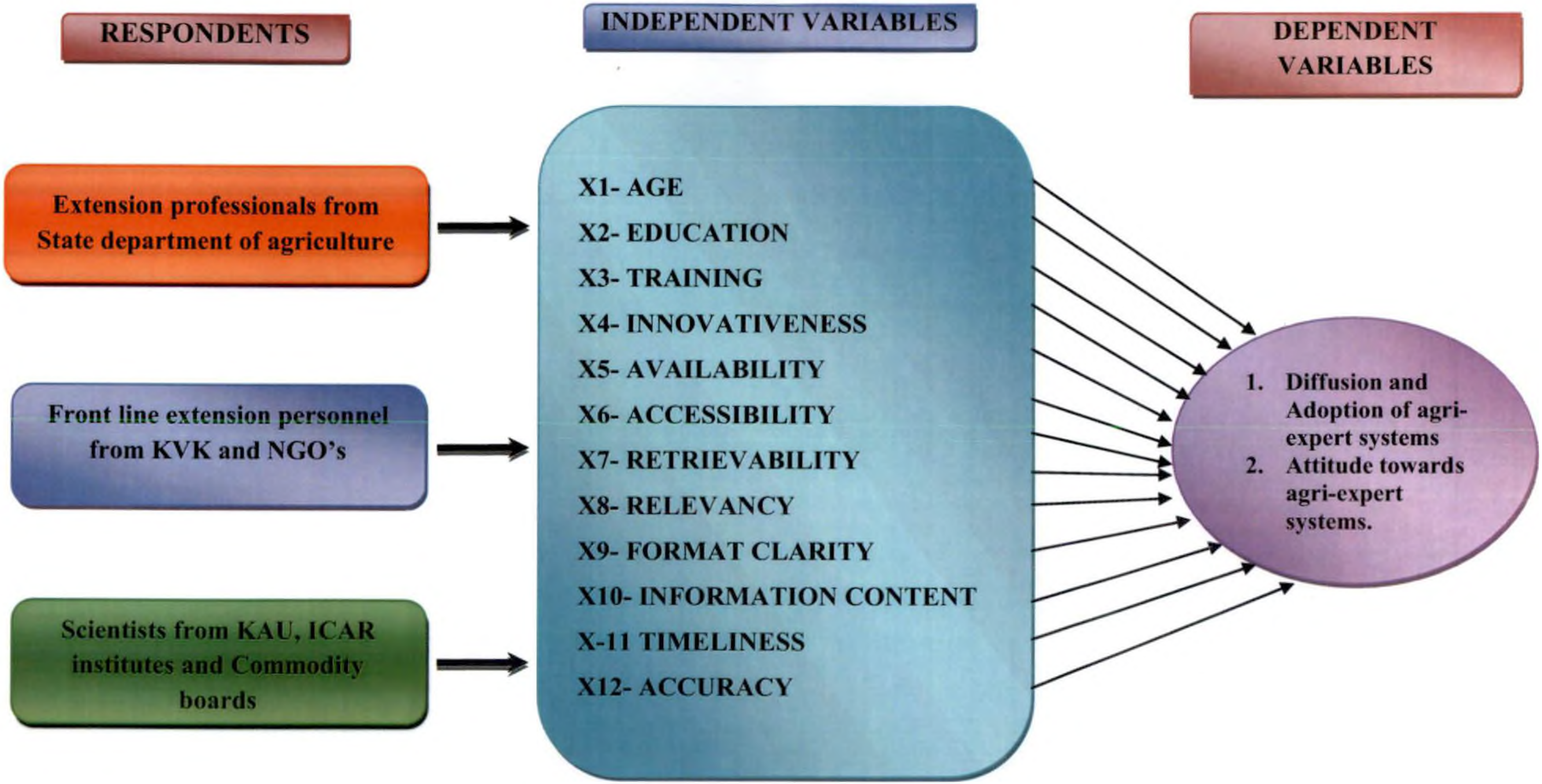



**Fig.2.CONCEPTUAL MODEL OF THE STUDY**

# Results and Discussion

# 4. RESULTS AND DISCUSSIONS

The main body of research report is 'Results and Discussions' whose purpose is to provide sufficient information so as to arrive at valid conclusion and recommendations. Discussion helps to interpret the results of the study in proper perspective and to relate them with other relevant studies. For the purpose of clarity and brevity, with reference to the objectives, the data collected during the study were coded, analysed, interpreted and the results and discussions are presented under the following headings:

4.1. Distribution of the respondents based on their personal and socio-cultural factors using agri-expert systems.
4.2. Inventorisation and Content coverage of expert systems
4.3. Level of awareness on expert system specific for Kerala agriculture
4.4. Attitude of extension professionals towards expert system.
4.5. Frequency and nature of agri-expert system use by the respondents.
4.6. Diffusion-Adoption stages in terms of extent of use of expert system technology *vis a vis* extension professionals.
4.7. Effectiveness Index of expert system application in agriculture.
4.8. Constraints experienced by extension professionals in using agri-expert systems.
4.9. Empirical model of the study

## 4.1 DISTRIBUTION OF THE RESPONDENTS BASED ON THEIR PERSONAL AND SOCIO CULTURAL FACTORS

A clear understanding of the personal characteristics of the respondents enables the investigator to interpret the data in an appropriate way. The results on distribution of the respondents based on their personal and socio cultural factors are presented below.

### 4.1.1 Age

Age was operationalized as the number of completed years of respondents at the time of investigation and the chronological age was taken as a measure. All the categories of respondents were classified into three categories, viz; young, middle and old age category. The distribution of respondents according to their age is furnished in Table 1.

**Table 1. Distribution of the respondents based on their age**

N=100

| Category (Years) | Extension professionals n=40 | | Front line extension personnel. n=30 | | Scientists n=30 | | Total | |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % |
| <31 | 3 | 7.5 | 6 | 20 | 0 | 0 | 9 | 9 |
| 31-50 | 33 | 82.5 | 17 | 56.66 | 20 | 66.66 | 70 | 70 |
| >50 | 4 | 10 | 7 | 23.33 | 10 | 33.33 | 21 | 21 |

It was evident from the Table 1 that more than half of the sampled respondents were in middle aged category whereas, old and young age category were less *i.e.* 21 and 9 per cent respectively.

In case of the 'extension professionals' distribution, majority of the respondents belonged to the middle age category i.e. 82.5 per cent. 10 per cent belonged to the old age category and only 7.5 per cent was found to be belonging to the young age category. Whereas with respect to front line extension personnel's more than half of the respondents belonged to the middle age category *i.e.* 56.66 per cent. 23.33 per cent belonged to the old age category and 20 per cent belonged to the young age category. In case of scientists more than half of the respondents were from the middle age category and the other from the old age category.

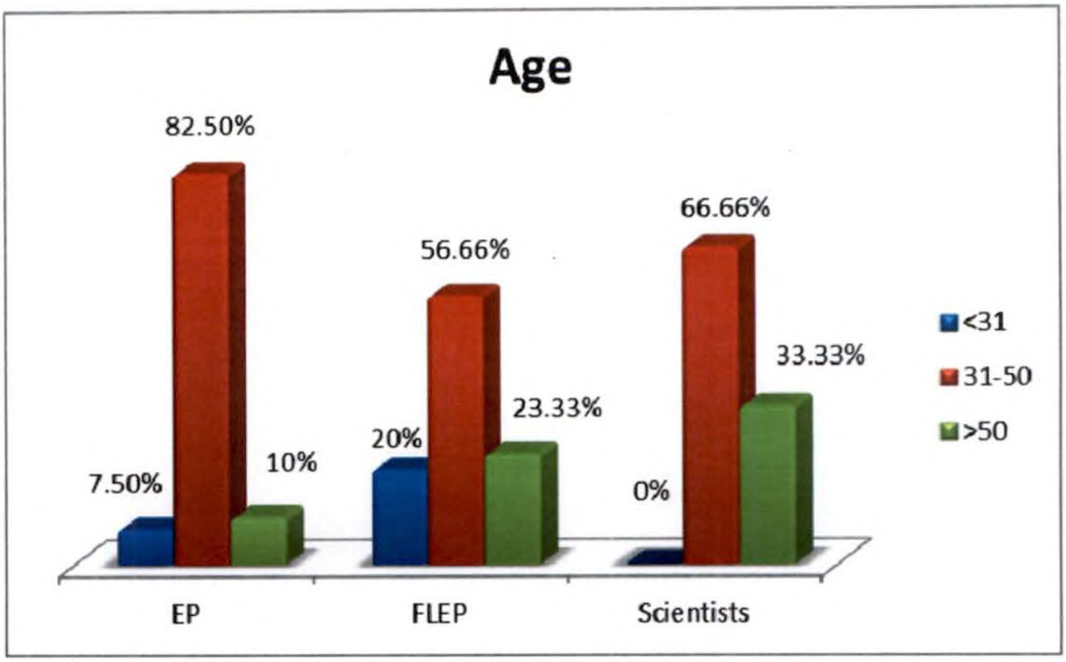



Fig.3. Age

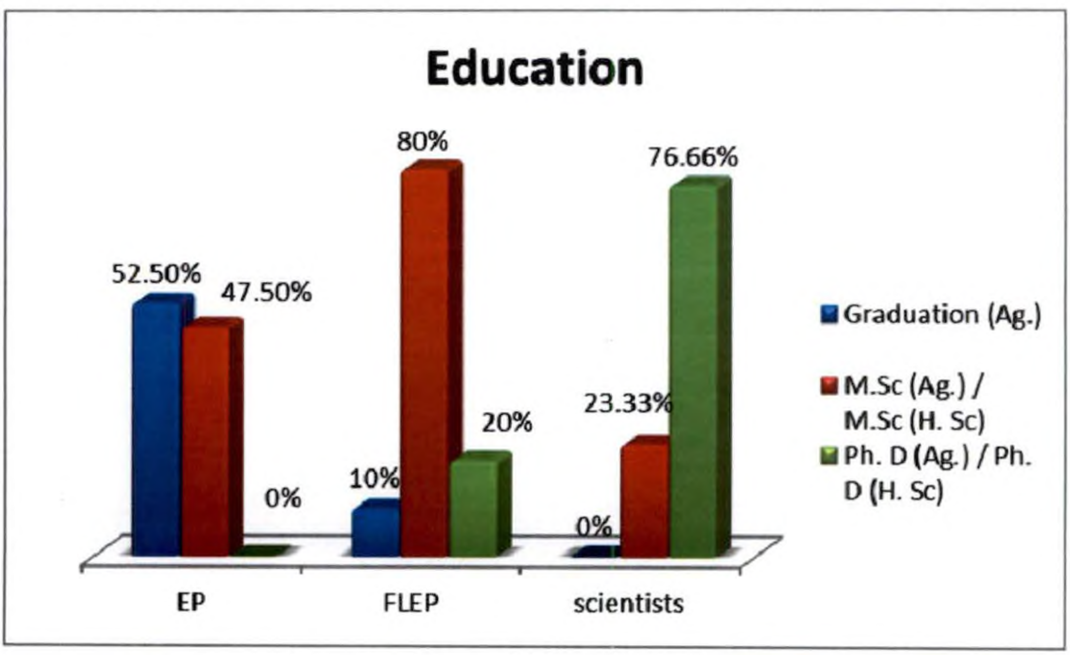



Fig.4. Education

Hence it was inferred that majority (70%) of the respondents were middle to old age category and only 9% belonged to young age category. This was because majority of the respondents from the department were new recruits and recently being inducted into the department. The lower percentage of young age category could be attributed to the fact that the pace of recruitment in agriculture department is at a slower rate. The finding that many of the respondents were in the middle to old age category is in concordance with the results of Helen *et al.* (2008).

### 4.1.2 Education

In this study education refers to the completion of important stages of formal education system undergone by the different categories of respondents at the time of enquiry. The distribution of respondents based on their education is furnished in Table 2.

**Table 2. Distribution of the respondents based on their education**

N=100

| Category | Extension professionals. n=40 | | Front line extension personnel. n=30 | | Scientists n=30 | | Total | |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % |
| Graduation (Ag.) | 21 | 52.5 | 3 | 10 | 0 | 0 | 24 | 24 |
| M.Sc (Ag.) | 19 | 47.5 | 24 | 80 | 7 | 23.33 | 50 | 50 |
| Ph. D (Ag.) | 0 | 0 | 3 | 20 | 23 | 76.66 | 26 | 26 |

A perusal of the Table 2 reveals the distribution of the respondents according to their educational qualification. It could be observed from the table that half of the sampled respondents were holding master's degree whereas remaining half of the sampled respondents were graduates and doctoral degree holders with 24 per cent and 26 per cent respectively.

Observing the 'extension professionals' distribution of the State Department of Agriculture, more than half of the respondents were graduates with 52.5 per cent. 47.5 per cent were holding master degrees with no doctoral degree respondents. With respect to 'front line extension personnel' distribution, majority of the respondents were holding master degrees. About 20 per cent were holding doctoral degrees and 10 per cent respondents were graduates. In case of scientists all the respondents were having either master degree (23.33%) or doctoral degree (76.66%).

Hence it was inferred that 50 per cent of the extension professionals of SDA (State Department of Agriculture) were holding master degrees and about 25 per cent each category *i.e.* front line extension personnel and scientists were possessing graduation and doctoral degrees. Higher percentage of extension professionals possess higher educational qualification minimum B.Sc.(Ag) at the time of entry into service and any additional qualification may help them to attain further better positions. This could be the reason that half of the total respondents fell in the category of higher qualification. Majority of the respondents' *viz.,* front line extension personnel and scientists had M.Sc. or higher degrees of qualification as it was a minimum mandate for them to attain a position in their relevant fields. The findings are in line with the findings of Adesope *et al.* (2007).

**4.1.3 Training**

Modern farming practice has undergone several changes due to the increased application of science and technology; hence technology users to be efficient needs be trained. Education and training broadens the outlook and skill development which may reduce frustration on the part of users in retrieving required information. Tables 3 and 4 highlight some aspects of trainings attended by the respondents.

**Table 3. Distribution of respondents according to the trainings undergone related to ICT**

N=100

| Category | Extension professionals. n=40 | | Front line extension personnel. n=30 | | Scientists. n=30 | | Total | |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % |
| Undergone training | 27 | 67.5 | 16 | 53.33 | 12 | 40 | 55 | 55 |
| Not-undergone training | 13 | 32.5 | 14 | 46.66 | 18 | 60 | 45 | 45 |

It was evident from the Table 3 that more than half of the respondents had undergone training with less than half of the respondents having not undergone any training programme on ICT related aspects.

Examining the 'extension professionals' distribution, majority of the respondents had undergone training on ICT i.e. 67.5 per cent. 32.5 per cent were yet to undergo training. In case of front line extension personnel's distribution, more than half of the respondents had undergone training on ICT *i.e.* 53.33 per cent while 46.66 per cent have not undergone training. However, in case of scientists the results were contrary to the results of extension professionals of State Department of Agriculture and NGO's involved in field level extension wherein 60 per cent of respondents have not attended any training programme and the rest having attended the training on ICT.

This result could be from the fact that the extension professionals who are into direct service for the farming community had to be trained with the advent of recent applications of ICT in agriculture that is largely at use. The government policy for quicker and efficient delivery mechanisms of extension services to the

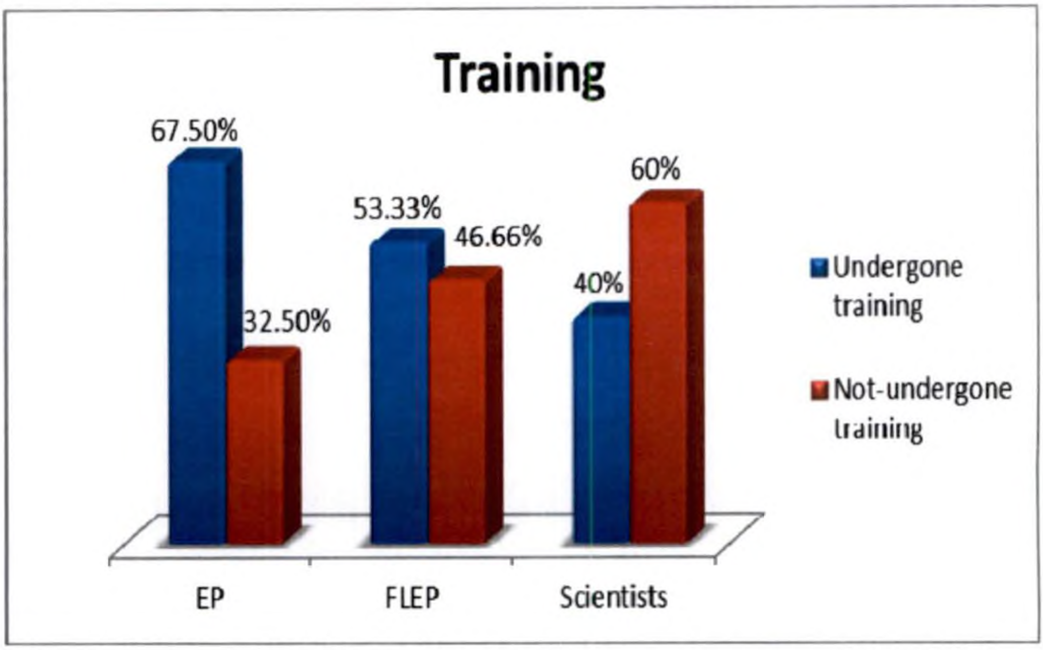



Fig.5. Training

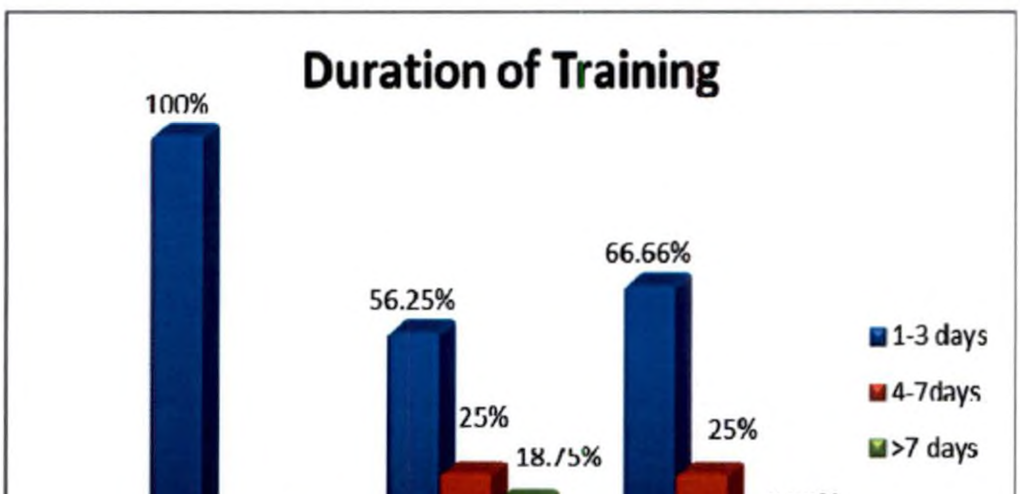



Fig.6. Duration of Training

farming community also facilitated more opportunities to the respondents to undergo training and remain updated on ICT services. However, the result that 60 per cent respondent under scientist category having not undergone training on the current level of ICT tools available for extension delivery could be attributed to the fact that they are not involved with direct field level extension or just get involved with limited field level extension. Also, many of the tools are developed by them for use by the extension professionals which have been accrued through professional expertise/specialization and hence training on ICT application at field level service was not a concern for them. The findings are in line with the findings of Adesope *et al.* (2007).

**Table 4. Distribution of respondents based on duration of the training programmes**

N=55

| Category | Extension professionals. n=27 | | Front Line Extension personnel's. n=16 | | Scientists. n=12 | | Total | |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % |
| 1-3 days | 27 | 100 | 9 | 56.25 | 8 | 66.66 | 44 | 80 |
| 4-7days | 0 | 0 | 4 | 25 | 3 | 25 | 7 | 12.72 |
| >7 days | 0 | 0 | 3 | 18.75 | 1 | 8.33 | 4 | 7.27 |

Analysis of the data in Table 4 proved that majority of trainees i.e. 80 per cent had undergone 1-3 days training programme with a very few per cent having undergone training for more than 3 days.

Observing the 'extension professionals' distribution, cent per cent respondents had undergone 1-3 days training programme. In case of 'front line extension personnel's distribution, more than half the respondents had undergone 1-3 days training programme followed by 4-7 days (25%) and more than 7 days (18.75%) respectively. In case of scientists, 66.66 per cent trainees had undergone 1-3 days training and the rest either 4-7 days (25%) or more than 7 days (8.33%) respectively.

Hence it was inferred that more than half of the extension personnel had undergone training and 80 per cent of the respondents had undergone 1-3 days training programme. This was because implementation of ICT driven approaches might have prompted the different institutional mechanism to impart their employees with training, which in turn might have created opportunity for them to attend training programmes related to ICT aspects.

### 4.1.4 Innovativeness

Innovativeness is an important attribute of the respondents being disposed to do something by virtue of introducing new ideas. The distribution of respondents based on their innovativeness is furnished in Table 5.

**Table 5. Distribution of respondents based on their innovativeness**

N=100

| Category | Extension professionals n=40 | | Front line extension personnel's. n=30 | | Scientists. n=30 | | Total | |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No | % |
| Low (<Mean-S.D) | 10 | 27.5 | 5 | 16.66 | 4 | 13.33 | 19 | 19 |
| Medium (Mean ±S.D) | 14 | 35 | 12 | 40 | 11 | 36.66 | 37 | 37 |
| High (>Mean + S.D) | 16 | 37.5 | 13 | 43.33 | 15 | 50 | 44 | 44 |
| | Mean-9.1 S.D-1.87 | | Mean-9.26 S.D-1.70 | | Mean-9.36 S.D-1.58 | | | |

It could be perceived from the table 5 that 44 per cent of the respondents were under high innovativeness category followed by medium (37%) and low (19%) respectively.

Witnessing the extension professionals' distribution, majority of the respondents were under high and medium innovativeness (37.5%, 35%) followed by low (27.5%) respectively. In case of 'front line extension personnel's' distribution, majority of the respondents were under high and medium innovativeness (43.33%, 40%) followed by low (16.6%) respectively. In case of scientists, half of the respondents were under high innovativeness followed by medium (36.66%) and low (13.33%) respectively.

Hence it was inferred that 44 per cent of the respondents were under high innovativeness category followed by medium (37%) and low (19%) respectively. This might be because most of the people always have urge to do new things and attain acclaim through achievements or accomplishments in their respective career fields. Further, now-a-days new and more and more innovative ICT tools are accessible to them and hence these kind of results. However, in case of scientists half of the respondents were under high innovativeness because scientists are keener to know about new ICT aspects and make it available for the benefit of farming community. Hence, they directly get involved in developing new ICT tools. The finding is not in conformity with findings of Senthilkumar (2000) and Frempong *et al.* (2006).

**4.1.5 Availability**

Availability of hardware and software will augment the respondent to adopt the expert system and solve the problems through expert system. The distribution of respondents based on availability of agri-expert systems is furnished in Table 6.

It could be evident from the table 6 that majority of the respondents perceived that KAU expert systems were always and sometimes available (41 and 41 per cent respectively). Only 18 per cent opined that KAU expert systems were rarely available.

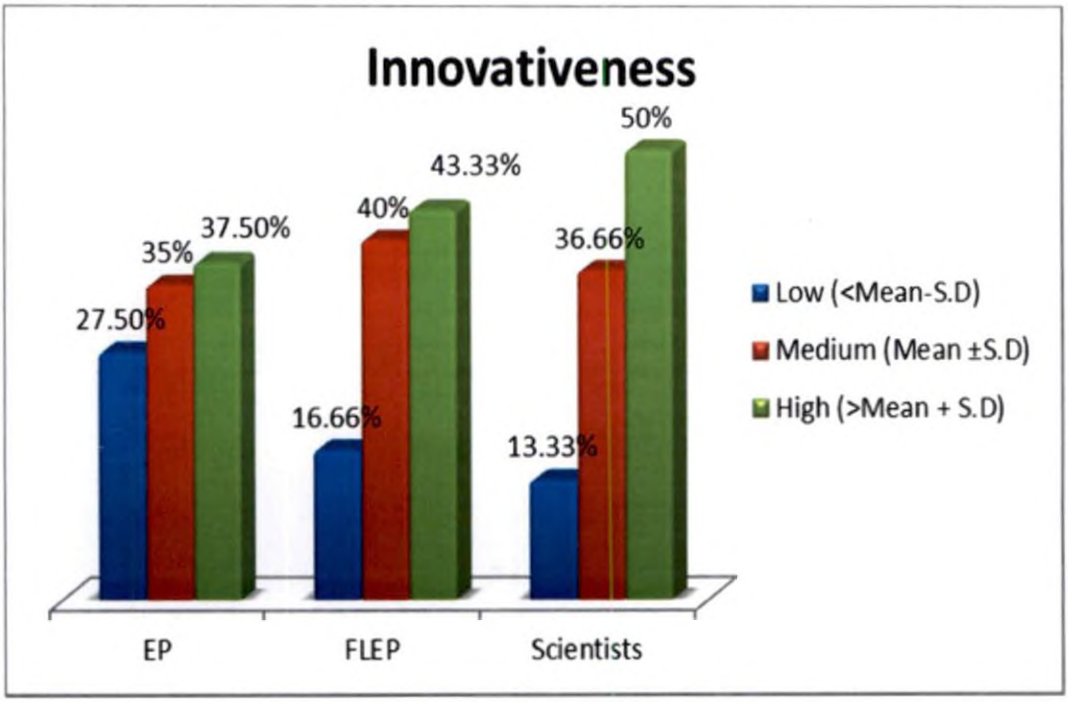



Fig.7. Innovativeness

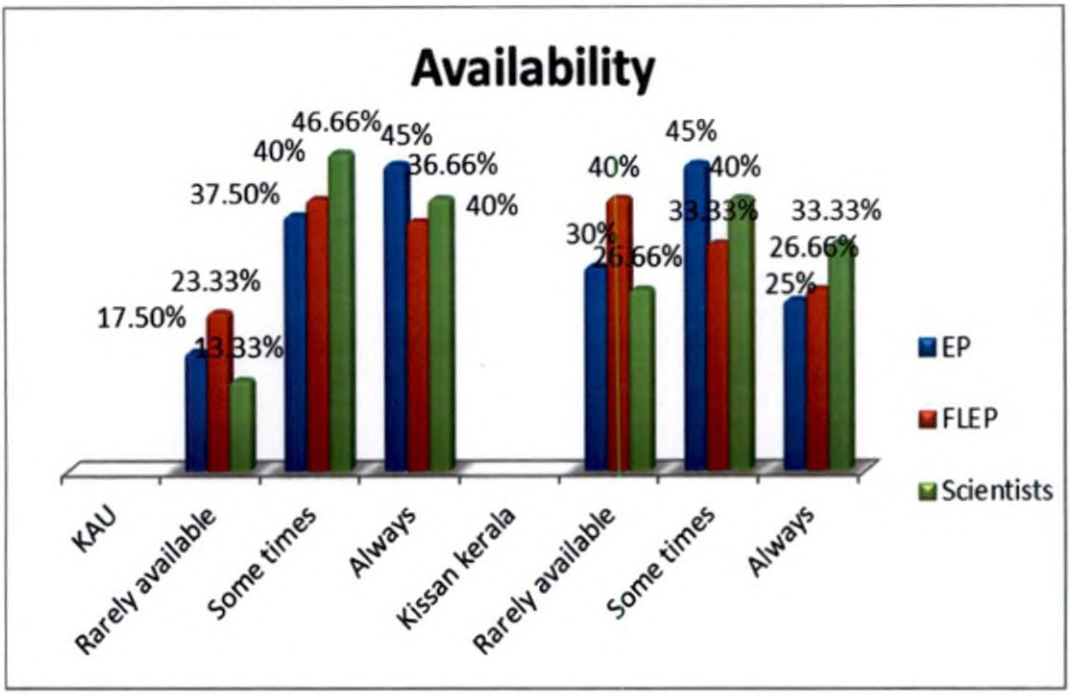



Fig.8. Availability

**Table 6. Distribution of respondents based on availability of agri-expert systems.**

N=100

| Category | Extension professionals . n=40 | | Front line extension personnel's. n=30 | | Scientists. n=30 | | Total | |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % |
| **KAU expert systems** | | | | | | | | |
| Rarely available | 7 | 17.5 | 7 | 23.33 | 4 | 13.33 | 18 | 18 |
| Some times | 15 | 37.5 | 12 | 40 | 14 | 46.67 | 41 | 41 |
| Always | 18 | 45 | 11 | 36.67 | 12 | 40 | 41 | 41 |
| **Kissan Kerala expert system** | | | | | | | | |
| Rarely available | 12 | 30 | 12 | 40 | 8 | 26.66 | 32 | 32 |
| Some times | 18 | 45 | 10 | 33.33 | 12 | 40 | 41 | 40 |
| Always | 10 | 25 | 8 | 26.67 | 10 | 33.33 | 28 | 28 |

In case of Kissan Kerala expert system, 40 per cent of the respondents perceived that Kissan Kerala expert system was 'sometimes available' followed by rarely available (32%) and always available (28%) respectively.

Observing the extension professionals' distribution, 45 per cent of the respondents felt that KAU expert systems was always available followed by sometimes available (37.5%) and rarely available (17.5%) respectively. About front line extension personnel distribution, 40 per cent of the respondents opined that KAU expert systems are sometimes available followed by always available (36.67%) and rarely available (23.33%) respectively. In case of scientists 46.67 per cent opined that KAU expert systems sometimes available followed by always available (40%) and rarely available (13.33%) respectively.

In case of Kissan Kerala expert system, 45 per cent of the extension professionals' perceived that Kissan Kerala expert systems was sometimes available followed by rarely available (30%) and always available (25%) respectively. With respect to front line extension personnel, 40 per cent of the respondents perceived it as rarely available followed by sometimes available (33.33%) and always available (26.66%) respectively. In case of scientists 40 per cent of the respondents perceived that the same was sometimes available followed by always available (33.33%) and rarely available (26.66%) respectively.

Hence it was inferred that majority of the respondents perceived KAU expert systems as always and sometimes available (82% together) which was higher than the availability of Kissan Kerala expert system (69% together) as perceived by the different categories of respondents together. This might be because most of the respondents were having desktop or laptop in their home or office. Also, the fact that KAU expert systems could be available in off-line forever once it is downloaded from the site, could be the reason for perceiving it as more frequently available when compared to Kissan Kerala.

**4.1.6 Accessibility**

Accessibility of an expert system is an important attribute of any delivery system. In this study accessibility is referred to as the degree to which the expert system can be frequently used by the extension professionals for problem solutions and decision making for the benefit of farming community. The distribution of respondents based on accessibility of agri-expert systems is furnished in Table 7.

It could be evident from the table 7 that majority of the respondents felt that KAU expert systems accessibility was high (43%) followed by medium (40%) and low (17%) respectively. Where as in case of accessibility of Kissan Kerala expert systems; 30 per cent of respondent felt its accessibility was high and 26 per cent perceived it was low. 44 percent of the respondents perceived it to have medium level of accessibility.

**Table 7. Distribution of respondents based on accessibility of agri-expert systems.**

N=100

| Category | Extension professionals. n=40 | | Front Line Extension personnel's. n=30 | | Scientists. n=30 | | Total | |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % |
| KAU expert systems | | | | | | | | |
| Low | 9 | 22.5 | 5 | 16.66 | 3 | 10 | 17 | 17 |
| Medium | 15 | 37.5 | 13 | 43.33 | 12 | 40 | 40 | 40 |
| High | 16 | 40 | 12 | 40 | 15 | 50 | 43 | 43 |
| Kissan Kerala expert system | | | | | | | | |
| Low | 13 | 32.5 | 8 | 26.66 | 5 | 16.66 | 26 | 26 |
| Medium | 18 | 45 | 12 | 40 | 14 | 46.66 | 44 | 44 |
| High | 9 | 22.5 | 10 | 33.33 | 11 | 36.66 | 30 | 30 |

Spotting the extension professionals' distribution, 40 per cent of the respondents professed that KAU expert systems were having high accessibility followed by medium accessibility (37.5%) and low accessibility (22.5%) respectively. With respect to front line extension personnel distribution, 43.33 per cent of the respondents perceived that KAU expert systems were having medium accessibility followed by high accessibility (40%) and low accessibility (16.66%) respectively. In case of scientists half of the respondents i.e. 50 per cent opined that KAU expert systems were having high accessibility followed by medium accessibility (40%) and low accessibility (10%) respectively.

In case of Kissan Kerala expert system 45 per cent of the extension professionals' perceived that Kissan Kerala expert system was having medium accessibility followed by low accessibility (32.5%) and high accessibility (22.5%) respectively. With respect to front line extension personnel, 40 per cent of the respondents perceived that Kissan Kerala expert system was having medium accessibility followed by high accessibility (33.33%) and low accessibility (26.66%)

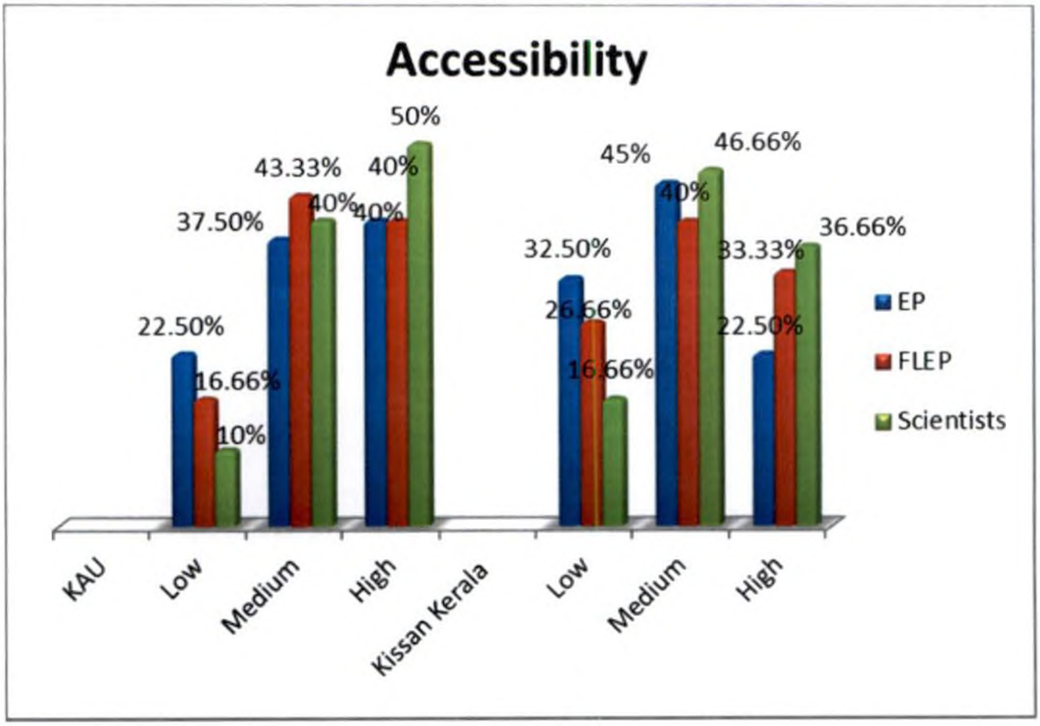



Fig.9. Accessibility

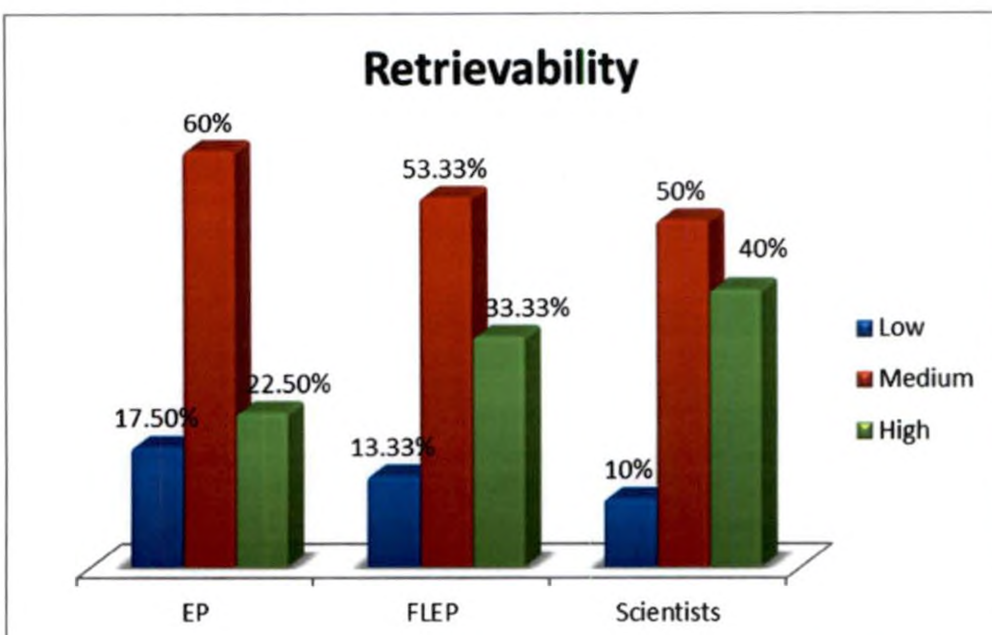



Fig.10. Retrievability

respectively. In case of scientists 46.66 per cent of the respondents perceived that Kissan Kerala expert system was having medium accessibility followed by high accessibility (36.66%) and low accessibility (16.66%) respectively.

Hence it was inferred from the table 6 that 43 per cent of the respondents pronounced KAU expert systems was having high accessibility in comparison to Kissan Kerala expert system wherein the category of high accessibility was 30 per cent. This result was again attributed to the perceived advantage of KAU expert system in terms of its off line availability and ease of use for general recommendations on farming practices.

### 4.1.7 Retrievability

Retrievability was operationalized as finding out the required information without much effort. It was the extent to which the information was easily drawn from the system. The distribution of respondents based on retrievability of agri-expert systems is furnished in Table 8.

**Table 8. Distribution of respondents based on retrievability of agri-expert systems.**

N=100

| Category | Extension professionals. n=40 | | Front line extension personnel's. n=30 | | Scientists. n=30 | | Total | |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % |
| Low (<Mean-S.D) | 7 | 17.5 | 4 | 13.33 | 3 | 10 | 14 | 14 |
| Medium (Mean ±S.D) | 24 | 60 | 16 | 53.33 | 15 | 50 | 55 | 55 |
| High (>Mean + S.D) | 9 | 22.5 | 10 | 33.33 | 12 | 40 | 31 | 31 |
| | Mean-8.92 S.D-1.60 | | Mean-9.33 S.D-1.51 | | Mean-9.46 S.D-1.47 | | | |

It could be apparent from the table 8 that more than half of the respondents i.e. 55 per cent pronounced that retrievability of agri-expert systems were medium followed by high (31%) and low (14%) respectively.

On observing the extension professionals' distribution, more than half of the respondents *i.e.* 60 per cent marked that retrievability of agri-expert systems were medium followed by high (22.5%) and low (17.5%) respectively. With respect to front line extension personnel, more than half of the respondents i.e. 53.33 per cent stating that retrievability were medium followed by high (33.33%) and low (13.33%) respectively. In case of scientists, half of the respondents opined that retrievability of agri-expert systems were medium followed by high (40%) and low (10%) respectively.

Hence it was inferred that 55 per cent of the respondents were of the opinion that retrievability of agri-expert systems were medium followed by 31 per cent rating it as high and 19 per cent opining it as low. This might be because most of the respondents did not feel any difficulty in locating and retrieving information from agricultural expert system. It also indicated that the information provided in the system is user friendly.

### 4.1.8 Relevancy

Relevancy of the information was meant as the relation of something to the matter at hand. It was assessed whether the system was able to provide information suitable to the users' resources and appropriate to the users' needs. The distribution of respondents based on relevancy of agri-expert systems is furnished in Table 9.

**Table 9. Distribution of respondents based on relevancy of agri-expert systems.**

N=100

| Category | Extension professionals =40 | | Front Line Extension personnel's. n=30 | | Scientists. n=30 | | Total | |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % |
| Low(<Mean-S.D) | 11 | 27.5 | 7 | 23.33 | 5 | 16.66 | 23 | 23 |
| Medium (Mean ±S.D) | 17 | 42.5 | 13 | 43.33 | 14 | 46.66 | 44 | 44 |
| High (>Mean + S.D) | 12 | 30 | 10 | 33.33 | 11 | 36.66 | 33 | 33 |
| | Mean-9.62 S.D-1.35 | | Mean-9.1 S.D-1.66 | | Mean-9.3 S.D-1.53 | | | |

Table 9 revealed that 44 per cent of the respondents percieved that relevance of agri-expert systems were medium followed by high (33%) and low (23%) respectively with special reference to extension delivery.

On observing the extension professionals' distribution, 42.5 per cent respondents marked that relevancy of agri-expert systems was medium followed by high (30%) and low (27.5%) respectively. With respect to front line extension personnel, 43.33 per cent respondents stated that relevancy of agri-expert systems were medium followed by high (33.33%) and low (23.33%) respectively. In case of scientists, 46.66 per cent respondents opined that relevancy of agri-expert systems were medium followed by high (36.66%) and low (16.66%) respectively.

Hence it could be inferred that in all the categories of respondents, most of the respondents felt that relevancy of agri-expert system was medium. This might be because, even though most of the respondents felt that agricultural expert system could serve the information needs of users like researchers, extension professionals, scientists, students and farmers it was not a substitute for field level extension or otherwise validating or reinforcing that these ICT tools was only an aide to improve the effectiveness of field level extension.

### 4.1.9 Format clarity

Format clarity means the organization of information, font size, font color, picture clarity, and back-ground color of expert systems. If the format is of clarity it is effective for the trainers to post messages to the learner so as to stimulate discussion, and encourage interaction.The distribution of respondents based on format clarity of agri-expert systems is furnished in Table 10.

It is ostensible from table 10 that majority of the respondents pronounced format clarity of agri-expert systems as high (42%) followed by medium (40%) and low (18%) respectively.

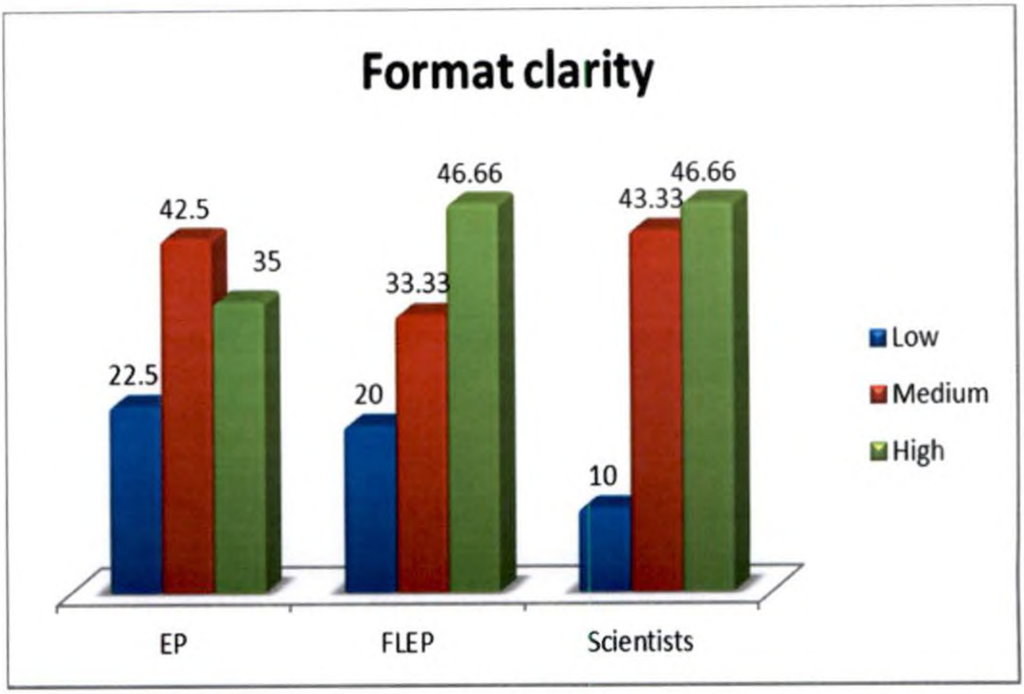



Fig.11. Format clarity

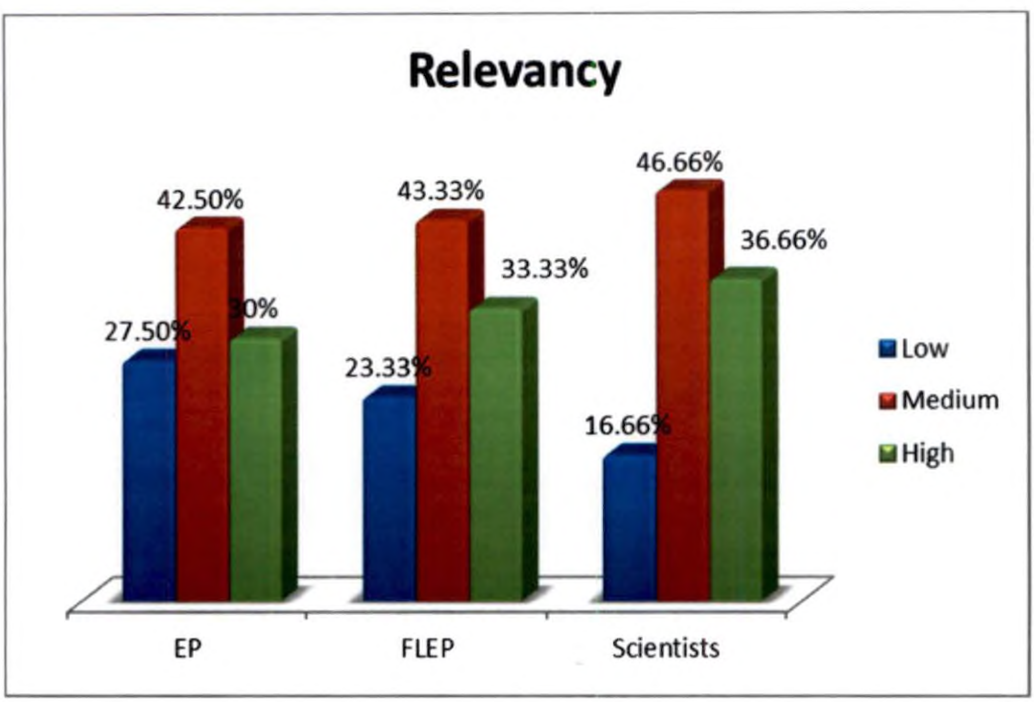



Fig.12. Relevancy

**Table 10. Distribution of respondents based on format clarity of agri-expert systems.**

N=100

| Category | Extension professionals. n=40 | | Front Line Extension personnel's. n=30 | | Scientists. n=30 | | Total | |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % |
| Low(<Mean-S.D) | 9 | 22.5 | 6 | 20 | 3 | 10 | 18 | 18 |
| Medium (Mean ±S.D) | 17 | 42.5 | 10 | 33.33 | 13 | 43.33 | 40 | 40 |
| High (>Mean + S.D) | 14 | 35 | 14 | 46.66 | 14 | 46.66 | 42 | 42 |
| | Mean-9.62 S.D-1.35 | | Mean-9.1 S.D-1.66 | | Mean-9.3 S.D-1.53 | | | |

In case of the extension professionals' distribution, 42.5 per cent respondents marked that format clarity of agri-expert systems were medium followed by high (35%) and low (22.5%) respectively. With respect to front line extension personnel and scientists category, 46.66 per cent respondents opined that format clarity of agri-expert systems were high. In case of scientists, 46.66 per cent respondents opined that format clarity of agri-expert systems were high followed by medium (43.33%) and low (10%) respectively.

Hence it was inferred that that majority of the respondents manifested that format clarity of agri-expert systems were high and medium followed by low (18%) respectively. This might be because most of the respondents perceived that the font size, color, type, information organization and background given in agri-expert system had more clarity and the text presented on a given page was limited and clear. Also, it shows that these expert systems are developed keeping in mind the need of the end users and the application of thumb rules in designing and creating the same. More over expert systems can aid in helping the extension professionals in making their own decisions more precisely and correctly if the visuals are with finest clarity. This finding is not in conformity with findings of Helen (2008) and in conformity with Nair (2004).

**4.1.10 Information content**

Information content was assessed whether the provided information was complete and understandable to the users. The distribution of respondents based on information content of agri-expert systems is furnished in Table 11.

**Table 11. Distribution of respondents based on information content of agri-expert systems.**

N=100

| Category | Extension professionals. n=40 | | Front Line Extension personnel's. n=30 | | Scientists. n=30 | | Total | |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % |
| Low(<Mean-S.D) | 5 | 12.5 | 7 | 23.33 | 4 | 13.33 | 16 | 16 |
| Medium (Mean ±S.D) | 12 | 30 | 11 | 36.66 | 11 | 36.66 | 34 | 34 |
| High (>Mean + S.D) | 23 | 57.5 | 12 | 40 | 15 | 50 | 50 | 50 |
| | Mean-9 S.D-1.70 | | Mean-9.6 S.D-1.32 | | Mean-9.43 S.D-1.52 | | | |

Table 11 revealed that half of the respondents i.e. 50 per cent opined that information content of agri-expert systems were of high completeness and understandability followed by medium (34%) and low (16%) respectively.

In case of the extension professionals' distribution, more than half of the respondents' i.e.57.5 per cent respondents marked that information content of agri-expert systems understandability were high followed by medium (30%) and low (12.5%) respectively. With respect to front line extension personnel, 40 per cent respondents opined it as high followed by medium (36.66%) and low (23.33%) respectively. In case of scientists, half of the respondents i.e. 50 per cent opined that the same was high followed by medium (36.66%) and low (13.33%) respectively.

Hence it was inferred that 50 per cent of the respondents felt, information content in terms of its completeness and understandability of agri-expert systems as

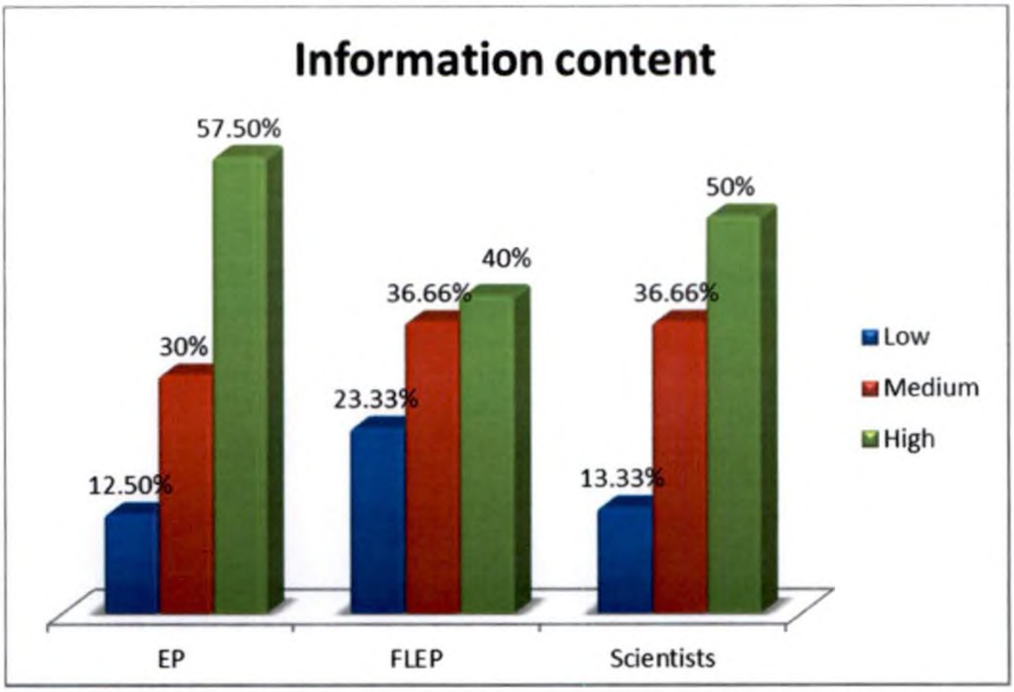



Fig.13. Information content

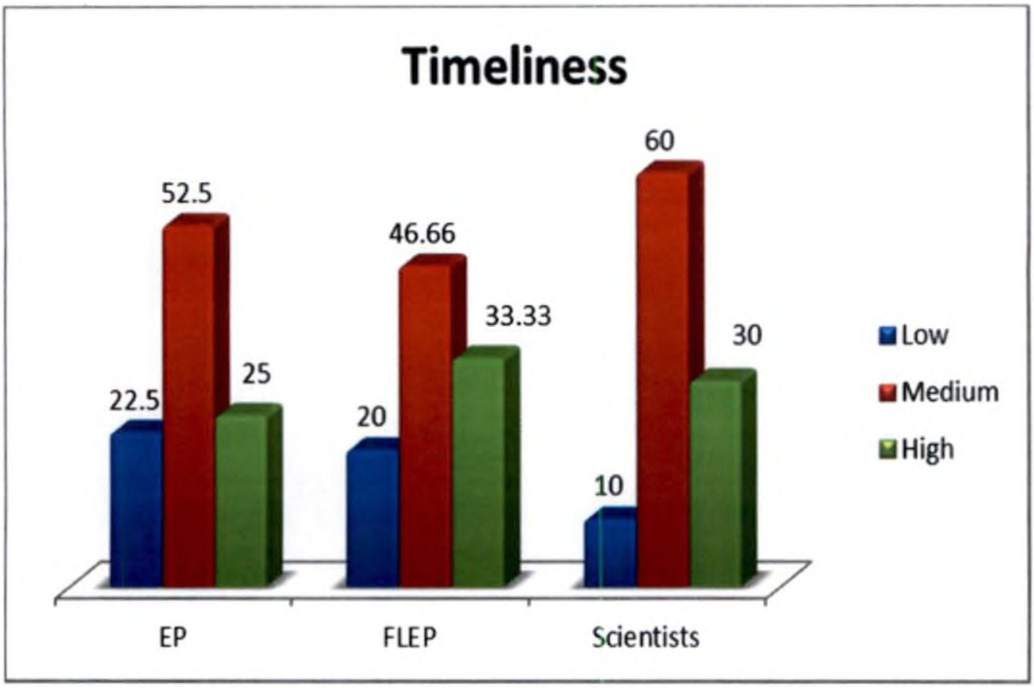



Fig.14. Timeliness

high. This might be because expert systems were highly crop specific or technology specific than general packages. They are providing more information on preventive measures, biological control measures and cultural practices that too which was very precise. In all categories most of the respondents felt that information content of agri-expert systems was complete and understandable to the users.

### 4.1.11 Timeliness

Timeliness means the time taken to get required information from agri-expert system. It was assessed whether the provided information was being provided at right time. The more pertinent and timely the information better would be the resulting decision. The distribution of respondents based on timeliness of the information from agri-expert systems is furnished in Table 12.

**Table 12. Distribution of respondents based on timeliness of the information from agri-expert systems.**

N=100

| Category | Extension professionals. n=40 | | Front Line Extension personnel's. n=30 | | Scientists. n=30 | | Total | |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % |
| Low(<Mean-S.D) | 9 | 22.5 | 6 | 20 | 3 | 10 | 18 | 18 |
| Medium (Mean ±S.D) | 21 | 52.5 | 14 | 46.66 | 18 | 60 | 53 | 53 |
| High (>Mean + S.D) | 10 | 25 | 10 | 33.33 | 9 | 30 | 29 | 29 |
| | Mean-8.95 S.D-1.81 | | Mean-9.23 S.D-1.65 | | Mean-9.46 S.D-1.47 | | | |

Scrutiny of the Table 12 revealed that more than half of the respondents i.e. 53 per cent felt that timeliness of the information from agri-expert systems were medium followed by high (29%) and low (18%) respectively.

Observing the extension professionals' distribution, more than half of the respondents' i.e.52.5 per cent respondents marked that timeliness of the information from agri-expert systems were medium followed by high (25%) and low (22.5%) almost with equal proportions respectively. With respect to front line extension personnel, 46.66 per cent respondents opined that timeliness of the information from agri-expert systems were medium followed by high (33.33%) and low (20%) respectively. In case of scientists, more than half of the respondents i.e. 60 per cent opined that timeliness of the information from agri-expert systems were medium followed by high (30%) and low (10%) respectively.

Hence it was concluded that 53 per cent of the respondents opined that timeliness of the information from agri-expert systems were medium followed by 29 per cent stating it as high and 18 per cent opining it as low. This might be because most respondents felt that the users could locate the information easily and it grabbed less time of users in diagnosing symptoms and getting suitable solutions. The higher percentage in medium category could also be attributed to the extrinsic factors like availability of power that affect timeliness of information.

### 4.1.12 Accuracy

Accuracy was assessed in terms of whether the provided information from expert system was near to true value or not. Accurate information from expert system indicated that potential improvement in the decision making process. The distribution of respondents based on accuracy of the information from agri-expert systems is furnished in Table 13.

Analysis of the Table 13 reveals the distribution of the respondents based on accuracy of the information from agri-expert systems. It could be inferred from the table that half of the respondents *i.e.* 50 per cent perceived the accuracy of the information from agri-expert systems as medium followed by high (33%) and low (17%) respectively.

**Table 13. Distribution of respondents based on accuracy of the information from agri-expert systems.**

N=100

| Category | Extension professionals. n=40 | | Front Line Extension personnel's. n=30 | | Scientists. n=30 | | Total | |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No | % |
| Low(<Mean-S.D) | 4 | 10 | 5 | 16.66 | 8 | 26.66 | 17 | 17 |
| Medium (Mean ±S.D) | 28 | 70 | 13 | 43.33 | 9 | 30 | 50 | 50 |
| High (>Mean + S.D) | 8 | 20 | 12 | 40 | 13 | 43.33 | 33 | 33 |
| | Mean-9.25 S.D-1.44 | | Mean-9.23 S.D-1.73 | | Mean-9.06 S.D-1.89 | | | |

Noting the extension professionals' distribution, majority of the respondents' i.e.70 per cent respondents marked that accuracy of the information from agri-expert systems were medium followed by high (20%) and low (10%) respectively. With respect to front line extension personnel, 43.33 per cent respondents opined that accuracy of the information from agri-expert systems were medium followed by high (40%) and low (16.66%) respectively. In case of scientists, 43.33 per cent respondents opined that accuracy of the information from agri-expert systems were high followed by medium (30%) and low (26.66%) respectively.

Hence it was concluded that 50 per cent of the respondents were of the view that accuracy of the information from agri-expert systems were of medium accuracy followed by high (33%) and low (17%) respectively. This might be because they presumed that agri-expert system would provide greater information support for taking suitable decisions, acting as a complementary extension tool for disseminating agricultural technologies with greater accuracy. Also accuracy could be further discussed based on its relativity due to varying nature of farm, farmers and practices. The finding is in conformity with findings of Nair (2004).

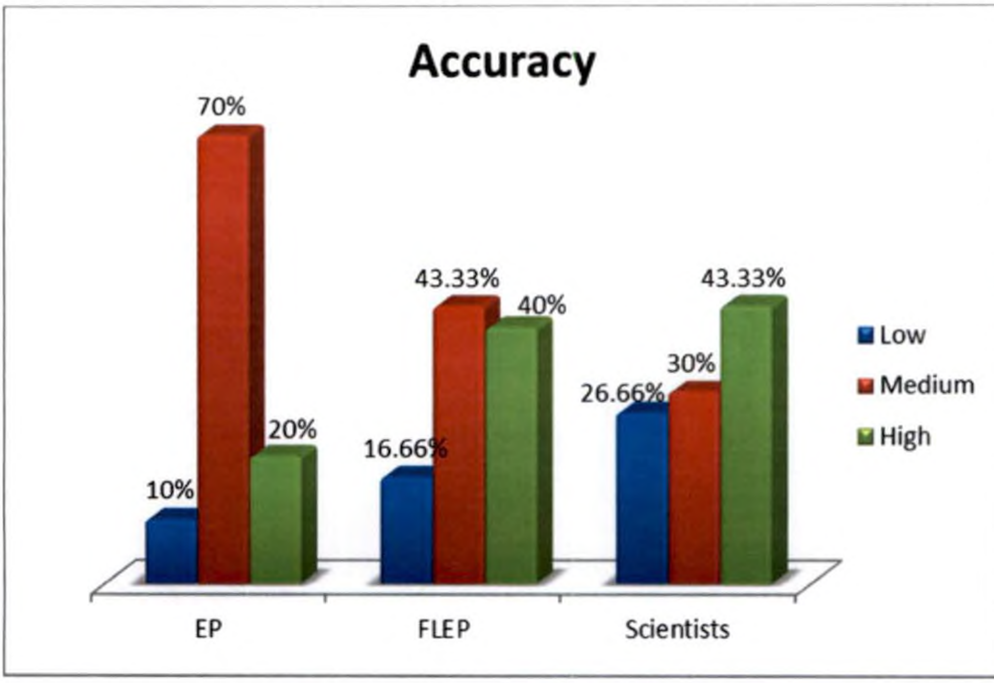



Fig.15. Accuracy

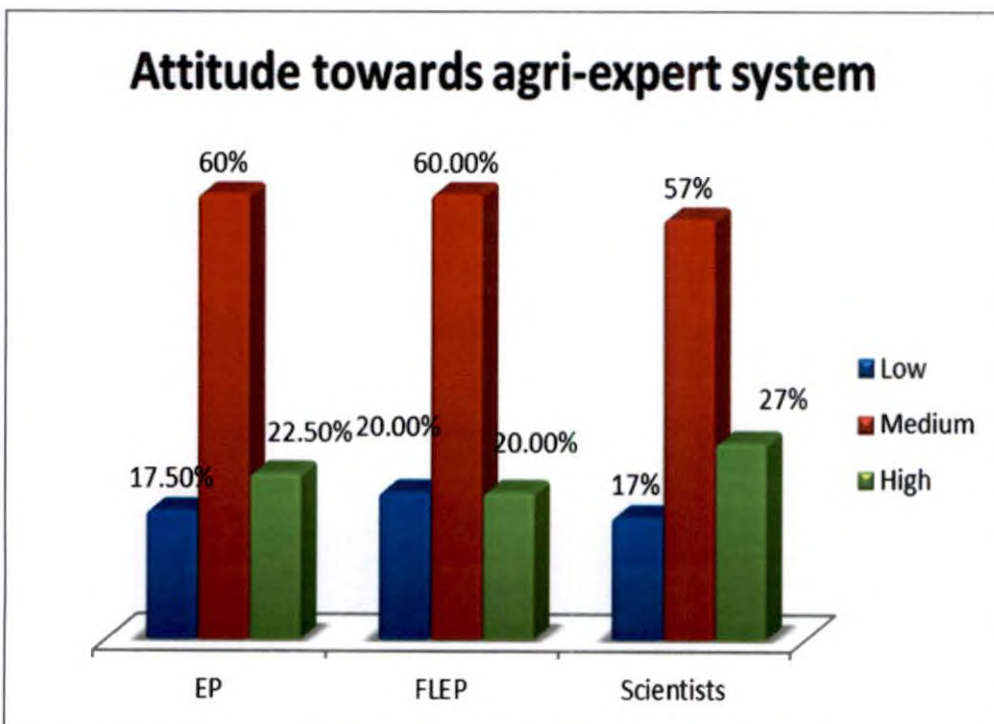



Fig.16. Attitude towards agri-expert system

## 4.2. INVENTORISATION AND CONTENT COVERAGE OF EXPERT SYSTEMS

The need of expert systems for technical information transfer in agriculture can be identified by recognizing the problems in using the traditional system for technical information transfer, and by proving that expert systems can help to overcome the problems addressed, and are feasible to be developed. Expert system of extension, which consists knowledge based information, decision rules and inference engine and available on website will help the farmers not only in taking decision to what to cultivate but also the related questions (Bahal *et al.*, 2003). An attempt was made to inventorise the expert systems related to agriculture and allied enterprises through a desk study accessing internet for three months. At least 72 agri-expert systems were identified and documented. The same is presented in Appendix 3. The popular ones are categorized and briefed as given below.

**Existing Expert Systems in Agriculture and content coverage**

### 4.2.1. Field crops

ESRICE: An expert system for management of rice pest insects – design and implementation. It was implemented in NEW language, BASIC and dBASE III. It is composed of 13 subsystems which can forecast the population dynamics and give the control recommendations for farmers. The results of the system application have shown that the level of the system ESRICE has been as high as that of the domain experts in the rice pest management. (Hu-Quansheng, 1993)

SEMAGI - an expert system for weed control decision making in sunflowers. The expert system processes and selects the herbicide(s) under the constraints of herbicide efficacy data and of a weed crop competition model. This relates weed-infested crop yield (SY,), potential weed-free yield (SY,), weed density (RD) and weed biomass (RBio). (Castro-Tender and Garcia-Torres, 1995)

The CEREAL APHID EXPERT SYSTEM AND GLANCE N' GO SAMPLING FOR GREEN BUGS: Questions and Answers. The cereal aphid pest management system is a set of computer programs to help the user manage cereal aphids in winter wheat. The expert system also has modules to help in insecticide selection, cereal aphid identification, and natural enemy identification. (Royer *et al.*, 2002)

MyPEST, Pest activity prognosis in rice fields using fuzzy expert system approach to provide information to the farmers and researchers through the Internet since rice is the main staple food of the Malaysian and Kedah is known as 'rice bowl'. On the other hand, Fuzzy Logic approach is used to forecast the pest activity level. This is important so that early treatment or action can be applied before damage to the plant becomes worst. (Nureize, 2004)

A WebGIS Expert System for Rice Brown Planthopper Disaster Early-Warning in China's Shanghai was developed for rice varieties susceptibility, pest density and climatic factors in Shanghai rice planting region. The system used a straightforward set of IF-THEN rules to classify disaster. It was developed since the brown plant hopper (BPH) *Nilaparvata lugens*, is one of the most devastating insect pests in rice planting region of China's Shanghai. (Chen Xiaobin, 2008)

A Quantitative Knowledge-based Model for Designing Suitable Growth Dynamics in Rice was developed for time-course growth dynamics including stem number, leaf area index (LAI) and aboveground dry matter accumulation with desired target yield under different conditions in rice. (Dingchun Yan *et al.*, 2011)

RULE BASED EXPERT SYSTEM in the Use of inorganic fertilizers for sugarcane crop helps the farmers to decide what kind of inorganic fertilizers should be used on the basis of symptoms appeared (due to nutrient deficiency) on the leaves of sugarcane crop. (Jadhav *et al.*, 2011)

Maize AGRIdaksh: A Farmer Friendly Device: Maize expert system has four essential components i.e. the knowledge acquisition module, the knowledge base, the inference engine and the explanatory interface. The knowledge acquisition module consists of gathering of knowledge from the panel of experts of different field of maize e.g. varieties, insects, diseases, etc. It also stores the facts from textbooks, technical /extension /research bulletins. (Yadav *et al.*, 2012)

A FUZZY EXPERT SYSTEM for Diagnosis and Treatment of Maize Plant Diseases deals with how to combat or disinfectant the infested maize plantation in order to get the desired quantity and quality of maize productivity. (Agbonifo and Olufolaji, 2012)

An expert system for rice kernel identification using optimal morphological features and back propagation neural network was developed for identifying five different varieties of rice, using the morphological features. The algorithm consists of several steps: image acquisition, segmentation, feature extraction, feature selection, and classification. (Mousavirad *et al.*, 2012)

**4.2.2. Fruits**

DIANA is an expert system for pineapple disorder diagnosis that provides help in the diagnosis of pineapple disorders. The diagnostic method is based on a three level logic: the field level (distribution of the symptoms in the field), the plant level, and the organ level (leaves, stems etc.). The user interacts with the system, in order to describe the symptoms accurately. (Perrier *et al.*, 1993)

PIEX, an expert system to classify pineapple varieties in breeding studies contains botanic and genetic elements on species, cultural practices, variety images, and glossary of terminology. (Gutierrez and Guevara, 1997)

CITRUS, a computerized expert system used in nutritional diagnosis of orange trees, is user friendly and permits the diagnosis of nutrient deficiencies when visual symptomology is introduced by the user while interacting with the system through question and answer. A module called DIAGFOL was constructed with Visual Basic language and annexed. (Corona *et al.,* 2000)

Expert system of the multimedia orange planting (MOES) was developed for expert decision making in orange viz., breed choice, alter earth and build orchard, breed seeding, planting and engrafting, field management, prevention and cure of the plant diseases and insect pests and to pick and store. (Li-qing *et al.,* 2001)

Field Note: A Disease Specific Expert System for the Indian Mango Crop is a computerized expert system developed to help the agriculturists and the field scientists tackle the menace of the mango malformation disease. (Chakrabarti and Chakraborty, 2007)

An Object-Oriented Expert System for Diagnosis of Fungal Diseases of Date Palm to provide intelligent computer-based support for farmers or agricultural specialists was developed based on O-O database and O-O rule base. (Ayman, 2009)

A Web Based Sweet Orange Crop Expert System using Rule Based System and Artificial Bee Colony Optimization Algorithm. This Expert System contains two main parts one is Sweet Orange Information System and the other is Sweet Orange Crop Expert System where information system, the user can get all the static information about different species, diseases, symptoms, chemical controls, preventions, pests, virus of sweet orange fruits and plants. (Prasad *et al.,* 2010)

Non-pollution orange fruit expert system software based on ASP.NET could simulate and decide an annual fertilization plan for young and mature trees in terms of geographical position and climate. Farmer using the system saved N input by 41-

238 g/plant, P2O5 input 3-24 g/plant and K2O input 1-36 g/plant and got higher yield by 6-17 kg/plant. (Yi-shan LI and Li-fang HONG, 2011)

**4.2.3. Vegetables**

N-EXPERT - A decision support system for vegetable fertilization in the field. Field studies in Germany showed that vegetable growers often make nitrogen fertilizer decisions by rules of thumb, which means that they regularly use too much nitrogen. Fertilization which meets the requirements of environment protection and prevents leaching of nitrogen is only possible if it is made after a detailed analysis. (Fink and Scharpf, 1993)

VEGES—A multilingual expert system for the diagnosis of pests, diseases and nutritional disorders of six greenhouse vegetables: aubergine, bean, cucumber, lettuce, pepper and tomato. It is developed on a PC-based shell and distributed to extension services and individual farmers for a nominal charge, accompanied by a new language translation module which allows a non-specialist user (e.g. extension officer) to translate the knowledge base to the native language or dialect of the local farmers. (Yialouris *et al.*, 1997)

DIBAMOTEX is an expert system developed for the control of the diamondback moth, a pest/parasite prevalent in crucifer cops, particularly cabbage. DIBAMOTEX was developed in consultation with Caribbean experts in the field of plant pathology and pest management. (Musaazi and Reichgelt, 1999)

Fertilizer Adviser Crops: an expert system for Tasmanian crops designed to advise consultants and sales staff about the appropriate fertilizer program for crops grown in Tasmania from the knowledge drawn from many sources, including results from fertilizer trials conducted in the State and elsewhere, and theoretical knowledge about nutrient removal and soil chemistry. (Gillard and Salardini, 2001)

DIARES-IPM: a diagnostic advisory rule-based expert system for integrated pest management in Solanaceous crop systems serves as a diagnostic, extension and educational tool in vegetable IPM and it includes the most economically important diseases, insects (noxious and beneficial insects) and nutritional deficiencies that affect these crops.( Mahaman *et al.*, 2003)

This Expert System contains two main parts one is Tomato Information System and the other is Tomato Crop Expert System where in Information system, the user can get all the static information about different species, diseases, symptoms, chemical controls, preventions, pests, virus of tomato fruits and plants. In crop expert system, the user is having an interaction with the expert system online; the user has to answer the questions asked by the expert system. (Prasad *et al.*, 2010)

An implementation of expert system in garlic using (ABC) Algorithm deals with the design of garlic expert systems using machine learning algorithms to advice the farmers in villages through online. This system is mainly aimed to identify the diseases and disease management in garlic crop production to advise the farmers in the villages on line to obtain standardized yields. (Selvakumar *et al.*, 2011)

An expert system for diagnosing chilling injury of vegetables: Temperature management is the most widely used method to extend the postharvest life of vegetables. An expert system was developed to diagnose CI symptoms for several commodities. Diagnosis is determined by applying rules and certainty factors based on user responses to queries on the type and extent of visual symptoms. (Bergsma *et al.*, 2013)

**4.2.4. Spices**

Expert System for Identification of Red Pepper Plant (Capsicum annum L.) designed and developed for identification of 12 general diseases of red pepper plant. Disease identification in this software system was based on the visual symptom of disease(s) in various plant growth stages, similar to the standard rules in plant protection science. (SittiEhaFaihah *et al.*, 1999)

Expert system for integrated plant protection in pepper *(Capsicum annuun L.)* was developed for improving decision-making by pepper growers. The system is supported by a data base containing information for the identification of 11 weeds, 20 insects, 14 diseases, three abiotic factors and control measures. The system is enhanced with 87 photos and drawings that assist the user in the identification process and choosing control measures. (Gonzalez-Diaz *et al.*, 2009)

**4.2.5. Plantation Crops**

A knowledge based expert system for planning and design of agroforestry systems. UNUAES is a prototype Knowledge-Based Expert System (KBES) designed to support land-use (agricultural, forestry, etc.) officials, research scientists, farmers, and individuals interested in maximizing benefits gained from applying agroforestry management techniques in developing countries.( Merrill *et al.*, 1990)

CROPES: A rule based expert system for crop selection in India. Crop selection is a crucial and decisive task, given the dynamic environment of agricultural systems created by differences in climate, soils, topography, cultivation practices, and available resources. It is a PC-based expert system (CROPES) for selecting crops in a region in Tamil Nadu, India. It recommends crops to a farmer at an early stage of crop planning based on location, climate, and farm level information pertaining to soils and available resources. (Mohan and Arumugam, 1994)

TEAPEST: an expert system for insect pest management in tea. It is a rule–based, object–oriented expert system for insect pest management in tea which identifies major insect pests of tea and suggests appropriate control measures. 'TEAPEST' shows good performance as evident from its performance evaluation.

(Ghosh *et al.*, 2003)

An information technology enabled Poultry Expert System: Perceptions of veterinarians and veterinary students. The Poultry Expert System (PES) was developed using Visual Basic 6.0 and MS Access on selected dimensions of poultry farming. Its efficacy was tested among the Veterinarians and Veterinary students. (Thammi Raju and Sudhakar, 2006)

CPEST: An expert system for the management of pests and diseases in the Jamaican coffee industry. The sheer amount of knowledge required on climate, topography, soil type of the farm, agronomic practices, crop phenology, biology and damage potential of the pests and options available for suppressing their population below the economic injury levels typically resides within a few experts and is not easily available to farmers. (Mansingh *et al.*, 2007)

Expert system for pests, diseases and weeds identification in olive crops was developed for improving decision-making by olive oil growers. The system is supported by a database containing information for the identification of 9 weeds, 14 insects and 14 diseases. The system is enhanced with 150 photos and drawings that assist the user in the identification process. (Gonzalez, 2009)

Expert System for Identification and Management of Abiotic Stresses in Tobacco (Nicotiana tabacum).Symptoms of the tobacco leaf affected by abiotic factors sometimes resemble biotic factors, misleading in identification of actual causes for taking remedial measures. The information on abiotic factors on tobacco and their symptoms was established and an expert system was developed for identification and management of abiotic stresses in tobacco. (Ravisankar *et al.*, 2010)

Expert System Land Evaluation for Oil Palm Cultivation (ESLEOP). Land evaluation assesses the suitability of land for specified land uses. This software was developed using climate, land qualities and land characteristics as diagnostic criteria in order to speed up the process of land assessment for oil palm cultivation in tropical regions. The results showed that ESLEOP evaluated land suitability for oil palm cultivation faster than the conventional method and can be used in Peninsular Malaysia. (Adzemi *et al.,* 2012)

An expert system for planning and designing dairy farms in hot climates was developed, which is able to plan and design several dairy farm facilities; specify their different dimensions; and compute the required amounts of construction. It plans the farmstead layout; and determines the water and electricity requirements versus the available sources on site. (Samer *et al.,* 2012).

This content analysis and inventorisation shows that great efforts have been taken up by different organizations under the support of government and private establishments to ensure to enhance the capability of extension professionals in utilizing agricultural expert systems for the benefit of farming community for decision making in various aspects of agriculture.

## 4.3. LEVEL OF AWARENESS ON EXPERT SYSTEM SPECIFIC FOR KERALA AGRICULTURE

The distribution of respondents based on level of awareness towards expert systems is furnished in Table 14.

Assessment of Table 14 revealed the level of awareness among the respondents on expert system specific for Kerala agriculture. It could be observed from the table that majority of the respondents *i.e.* 75 per cent were aware about KAU expert systems with only 25 per cent un-aware about it. In case of Kissan Kerala expert system it can be seen that majority of the respondents (67%) of the respondents were aware about Kissan Kerala expert system and the rest unaware about it.

**Table 14. Level of awareness on expert system specific for Kerala agriculture**

N=100

| Category | Extension professionals. n=40 | | Front Line Extension personnel's. n=30 | | Scientists. n=30 | | Total | |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % |
| KAU expert systems (KAU Fertulator, E- Crop doctor) | | | | | | | | |
| Aware | 29 | 72.5 | 22 | 73.33 | 24 | 80 | 75 | **75** |
| Un aware | 11 | 27.5 | 8 | 27.67 | 6 | 20 | 25 | 25 |
| Kissan Kerala expert system | | | | | | | | |
| Aware | 25 | 62.5 | 19 | 63.33 | 23 | 76.67 | 67 | **67** |
| Un aware | 15 | 37.5 | 11 | 36.67 | 7 | 23.33 | 33 | 33 |

A careful analysis of the table revealed that it was the scientists who were more aware (75% and 67% respectively) about expert systems; either it was KAU or Kissan Kerala expert systems. Conversely, the level of awareness on either expert systems among Front line Extension Professionals and Extension Professionals were found to be on par. However, it can be seen that the level of awareness of all three categories of respondents was more for KAU expert system when comparing with Kissan Kerala Expert system.

The result can be interpreted differentially as there could be no comparison between different expert systems. The varying systems attributes and purpose of expert system might be the reason for different level of awareness for different expert systems. Also, the generality, relative easiness to access and offline availability KAU expert systems could also be a reason for greater level of awareness (on KAU expert system in comparison to Kissan Kerala expert system) among the different respondent categories.

## 4.4. ATTITUDE OF EXTENSION PROFESSIONALS TOWARDS EXPERT SYSTEM

Attitude is the positive or negative effects of an individual towards an object. Only positive attitude can lead to full adoption of any innovation. The distribution of respondents based on attitude towards expert systems is furnished in Table 15.

**Table 15. Attitude of extension professionals towards expert system**

N=100

| Category | Extension professionals. n=40 | | Front line extension personnel. n=30 | | Scientists. n=30 | | Total | |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % |
| Low(<Quartile$_1$) | 7 | 17.5 | 6 | 20 | 5 | 16.66 | 18 | 18 |
| Medium($Q_1$-$Q_3$) | 24 | 60 | 18 | 60 | 17 | 56.66 | 59 | 59 |
| High(>Quartile$_3$) | 9 | 22.5 | 6 | 20 | 8 | 26.66 | 23 | 23 |
| **Quartiles under each class of respondents** | Quartile$_1$-55 Quartile$_2$-57.5 Quartile$_3$-62 | | Quartile$_1$-54 Quartile$_2$-56 Quartile$_3$-58 | | Quartile$_1$-55 Quartile$_2$-56 Quartile$_3$-57.5 | | | |

Perusal of the Table 15 revealed the attitude of extension professionals towards expert systems. It could be ostensible from the table that more than half of the respondents i.e. 59 per cent were having medium attitude towards agri-expert systems followed by high (23%) and low (18%) respectively.

Perceiving the extension professionals' distribution, more than half of the respondents i.e. 60 per cent respondents were having medium attitude towards agri-expert systems followed by high (22.5%) and low (17.5%) respectively. With respect to front line extension personnel, more than half of the respondents *i.e.* 60 per cent respondents were having medium attitude towards agri-expert systems followed by high (20%) and low (20%) which was on par. In case of scientists, 56.66 per cent respondents were having medium attitude towards agri-expert systems followed by high (26.66%) and low (16.66%) respectively.

Hence it was inferred that 59 per cent of the respondents were having medium attitude towards agri-expert systems followed by high (23%) and low (18%) respectively. This might be because agri-expert system had the potential of transferring knowledge from scientists to extension workers and in turn to farmers.

They also agreed that agri-expert system had the potential of reducing the time gap of transferring technologies from extension personnels/scientists to farmers. The finding is in conformity with findings of Chetsumon (2005).

### 4.4.1 Relationship between attitude of respondents and independent variables

The results of simple correlation analysis were taken into consideration for analysing the influence of independent variables on the attitude of respondents towards expert system. The results are presented in table 16.

**Table 16. Results of correlation between attitude of extension professionals of State Department of Agriculture, front line extension personnel of NGO's and KVK's and scientists of agricultural research institutes and independent variables**

| S.No. | Variable | Correlation co-efficient 'r' value | | |
|---|---|---|---|---|
| | | Extension professionals | Front line extension personnel | Scientists |
| $X_1$ | Age | -0.246 | 0.277 | 0.057 |
| $X_2$ | Education | -0.169 | 0.145 | 0.202 |
| $X_3$ | Training | 0.509** | 0.673** | 0.569** |
| $X_4$ | Innovativeness | 0.686** | 0.684** | 0.688** |
| $X_5$ | Availability | 0.091 | 0.768** | 0.722** |
| $X_6$ | Accessibility | 0.049 | 0.298 | 0.508** |
| $X_7$ | Retrievability | 0.091 | 0.257 | 0.282 |
| $X_8$ | Relevancy | 0.309 | 0.551** | 0.296 |
| $X_9$ | Format clarity | 0.006 | 0.362 | 0.216 |
| $X_{10}$ | Information content | 0.510** | 0.584** | 0.641** |
| $X_{11}$ | Timeliness | 0.030 | 0.730** | 0.629** |
| $X_{12}$ | Accuracy | 0.299 | 0.571** | 0.581** |

*: Significant at 0.05 level of probability; **: Significant at 0.01 level of probability

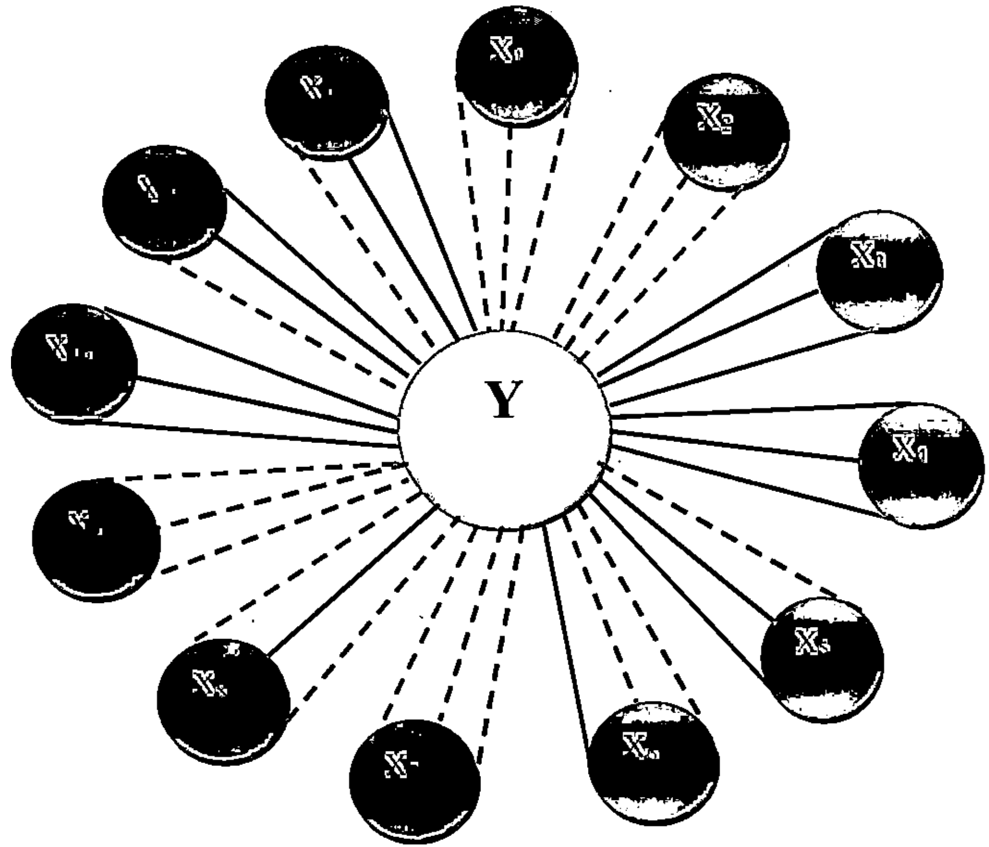
The results of correlation analysis are presented in Table 16 and Fig.17. Correlation analysis revealed that out of 12 independent variables, three variables

**Dependent variable**
**Y=Attitude towards agri-expert systems**

**Independent variables**

- $X_1$=Age
- $X_2$=Education
- $X_3$=Training
- $X_4$ = Innovativeness
- $X_5$ = Availability
- $X_6$ = Accessibility
- $X_7$ = Retrievability
- $X_8$ = Relevancy
- $X_9$ = Format clarity
- $X_{10}$ = Information content
- $X_{11}$ = Timeliness
- $X_{12}$ = Accuracy

Extension professionals from SDA
Front line extension personnel from KVK and NGO's
Scientists from KAU, ICAR institutes and Commodity boards




Negatively significant relationship
Positively significant relationship
Non-significant relationship

**FIG.17.Relationship between attitude of respondents and independent variables**

namely innovative proneness, Training and Information content were positively and significantly related with extent of attitude towards expert systems among all three categories of respondents *viz.*, extension professionals of state department of agriculture, front line extension professionals of KVK's and NGO's and Scientists at one per cent level of probability.

However a detailed analysis shows that when three out of 12 independent variables were positively and significantly correlated to the attitude of extension professionals of SDA towards agri-expert systems; seven out of 12 independent variables were positively and significantly correlated to the attitude of front line extension personnels and scientists towards agri-expert systems at one per cent level of probability. When, 'availability, timeliness, innovative proneness, training, information content, accuracy and relevancy' were the independent variables influencing the attitude of front line extension professionals towards expert system; 'availability, innovative proneness, information content, timeliness, accuracy, training and accessibility' were the variables that influenced the attitude of scientists. In case of frontline extension personnels, format clarity was positively and significantly related to the attitude at 5 per cent level of probability.

Hence, table 16 revealed that the co-efficient of correlation between independent variables *viz.*, 'training, innovative proneness, availability, accessibility, relevancy, information content, timeliness and accuracy' and the dependent variable 'attitude towards agri-expert systems' among all categories of respondents was greater than the table value of 'r' at 0.01 level of probability. Hence, null hypothesis was rejected and empirical hypothesis was accepted. It could, therefore, be inferred that there was a positive and significant relationship between the stated independent variables and attitude towards agri-expert system.

Training on Information Communication Technologies were the best and reliable sources for developing attitude towards agri-expert systems. Extension professionals from SDA, front line extension personnel from KVK and NGO's and scientists perceived that training programmes on ICT tools helped to attain more knowledge which in turn develops favourable attitude towards agri-expert systems and hence positive and significant relationship.

Innovative proneness of all three categories of respondents was an important attribute for developing attitude towards agri-expert systems. This might be because most of the people always have urge to do new things and attain new achievements which helps to develop favourable attitude towards agri-expert systems.

Availability of agri-expert systems to the respondents was an important attribute for developing attitude towards agri-expert systems. This might be because most of the respondents were having desktop or laptop in their home or office. KAU expert systems are available in off-line forever once after down loaded from the website which helped to develop favourable attitude towards agri-expert systems.

Accessibility of agri-expert systems by the scientists was influencing the attitude towards agri-expert systems. This might be because most of the respondents perceived agri-expert system to be easy to access, use and get the needed information.

Relevancy of agri-expert systems by the scientists was influencing the attitude towards agri-expert systems.This might be because most of the respondents felt that agricultural expert system could serve the information needs of users like researchers, extension professionals, scientists, students and farmers which enhance the attitude of respondents towards agri-expert systems.

Information content of agri-expert system was an important attribute which can influence the attitude of respondents towards agri-expert systems. Extension professionals from SDA, front line extension personnel from KVK and NGO's and scientists perceived that information content of agri-expert systems was complete and understandable to the users which develops favourable attitude towards agri-expert systems.

Timeliness of the information from agri-expert systems was an important attribute for developing attitude towards agri-expert systems. This might be because most respondents felt that the users could locate the information easily and it consumed less time which develops favourable attitude towards agri-expert systems.

Accuracy of the information from agri-expert systems was an important attribute for developing attitude towards agri-expert systems. This might be because most respondents presumed that agri-expert system would provide greater information support for taking suitable decisions with greater accuracy which develops favourable attitude towards agri-expert systems.

## 4.5. FREQUENCY AND NATURE OF AGRI-EXPERT SYSTEM USE BY THE RESPONDENTS.

### 4.5.1. Frequency of agri-expert system use by the respondents.

The distribution of respondents based on frequency of agri-expert system use by the respondents is furnished in Table 17.

It could be evident from the table that more than half of the respondents *i.e.* 60 per cent were using KAU expert systems occasionally, followed by 23 per cent using it rarely and 17 per cent using regularly. In case of Kissan Kerala expert system, majority of the respondents *i.e.* 64 per cent were using Kissan Kerala expert system occasionally followed by 26 per cent using it rarely and 10 per cent using the same regularly.

**Table 17. Frequency of agri-expert system use by the respondents**

N=100

| Category | Extension professionals. n=40 | | Front Line Extension personnel's. n=30 | | Scientists. n=30 | | Total | |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % |
| KAU expert systems (KAU FERTULATOR and E- crop doctor) | | | | | | | | |
| Regular | 7 | 17.5 | 5 | 16.66 | 5 | 16.66 | 17 | 17 |
| Occasional | 23 | 57.5 | 20 | 66.66 | 17 | 56.66 | 60 | 60 |
| Rarely | 10 | 25 | 5 | 16.66 | 8 | 26.66 | 23 | 23 |
| Kissan Kerala expert system | | | | | | | | |
| Regular | 3 | 7.5 | 6 | 20 | 1 | 3.33 | 10 | 10 |
| Occasional | 26 | 65 | 19 | 63.33 | 19 | 63.33 | 64 | 64 |
| Rarely | 11 | 27.5 | 5 | 16.66 | 10 | 33.33 | 26 | 26 |

Viewing the extension professionals' distribution, more than half of the respondents *i.e.* 57.5 per cent respondents were using KAU expert systems occasionally followed by 25 per cent using it rarely and 17.5 per cent using the expert system regularly. In case of front line extension personnels distribution, majority of the respondents *i.e.* 66.66 per cent were using KAU expert systems occasionally, followed by 16.66 per cent whose usage level in terms of rarely and regularly was on par. In case of scientists, more than half the respondents *i.e.* 56.66 per cent were using KAU expert systems occasionally followed by 26.66 per cent using it rarely and 16.66 per cent using the same regularly.

From Kissan Kerala expert system's point, with reference to the extension professionals' distribution, 65 per cent respondents were using Kissan Kerala expert systems occasionally followed by 27.5 per cent rarely and few respondents i.e. 7.5 per cent were using it regularly. With respect to front line extension personnel, majority of the respondents i.e. 63.33 per cent were using Kissan Kerala expert systems occasionally followed by 20 per cent using it regularly and 16.66 per cent using it rarely. In case of scientists, majority of the respondents i.e. 63.33 per cent were using Kissan Kerala expert systems occasionally followed by 33.33 per cent using it rarely and very few respondents i.e. 3.33 per cent using it regularly.

Hence it was inferred that more than half of the respondents i.e. 60 per cent were using KAU expert systems occasionally followed by rarely (23%) and regularly (17%) respectively. In case of Kissan Kerala expert system it was revealed that majority of the respondents *i.e.* 64 per cent were using Kissan Kerala expert system occasionally followed by rarely (26%) and regularly (10%) respectively. This might be because KAU expert systems could be used in off-line for ever after once downloaded from the site. Though Kissan Kerala expert system was available in on-line only, it can also be accessed in local language *i.e.* Malayalam. However the fact remains that irrespective of any type of expert systems or any category of respondents, the use of these innovative platforms for better, faster and timely decision making stands less and suitable strategies needs to be designed in order to scale up the use of expert system. Also a comparison of table 13 and 16 reveals a glaring fact that even though the level of awareness is high about expert systems by the respondents of study, the frequency of agri-expert system use (especially 'regular use') by the respondents was very low. This further more reiterate the need for popularizing the advantages of expert systems especially among the field level extension personnels through design and implementation of hands on training programmes etc., so as to scale up its use and improve the adoption level among all categories of respondents of study.

**4.5.2. Nature of usefulness of agri-expert system by the respondents.**

The distribution of respondents based on nature of usefulness of agri-expert system is furnished in Table 18.

It could be evident from the table that more than half of the respondents i.e. 53 per cent perceived KAU expert systems to be very useful followed by 47 per cent perceiving it as useful. However none of the respondents opined it as not useful.

**Table 18. Nature of usefulness of agri-expert system by the respondents**

N=100

| Category | Extension professionals. n=40 | | Front Line Extension personnel's. n=30 | | Scientists. n=30 | | Total | |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % |
| KAU expert systems. (KAU FERTULATOR and E- crop doctor) | | | | | | | | |
| Very Useful | 22 | 55 | 15 | 50 | 16 | 53.33 | 53 | 53 |
| Useful | 18 | 45 | 15 | 50 | 14 | 46.66 | 47 | 47 |
| Not Useful | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Kissan Kerala expert system | | | | | | | | |
| Very Useful | 12 | 30 | 10 | 33.33 | 11 | 36.66 | 33 | 33 |
| Useful | 26 | 65 | 19 | 63.33 | 19 | 63.33 | 64 | 64 |
| Not Useful | 2 | 5 | 1 | 3.33 | 0 | 0 | 3 | 3 |

[Note: Nature of usefulness of agri-expert system by the respondents were rated after giving training to all the respondents to enable them with the capacity to use it.]

In case of Kissan Kerala expert system's majority of the respondents i.e. 64 per cent opined that Kissan Kerala expert system was useful followed by 33 per cent opining it as very useful and very few i.e. 3 per cent opined that it was not useful.

Observing the extension professionals' distribution, more than half of the respondents i.e. 55 per cent respondents perceived KAU expert systems as very useful followed by 45 per cent perceiving it as useful and with none opining as not useful. About front line extension personnel distribution, half of the respondents *i.e.* 50 per cent perceived KAU expert systems as very useful and remaining half of the respondents perceived it as useful. In case of scientists, more than half of the respondents i.e. 53.33 per cent perceived that KAU expert systems were very useful followed by 46.66 per cent perceiving it as useful.

In case of usefulness of Kissan Kerala expert system, the extension professionals' distribution shows that majority of the respondents *i.e.* 65 per cent respondents perceived that Kissan Kerala expert systems were useful followed by 30 per cent rating it very useful and very few respondents *i.e.* 5 per cent perceived it as not useful. With respect to front line extension personnel, majority of the respondents i.e. 63.33 per cent perceived that Kissan Kerala expert systems were useful followed by 33.33 per cent perceiving it as very useful and negligible respondents i.e. 3.33 per cent are stating it as not useful. In case of scientists, majority of the respondents i.e. 63.33 per cent respondents perceived that Kissan Kerala expert systems were useful followed by 36.66 per cent perceiving it as very useful.

Hence in general it was inferred that perceived usefulness of expert system was rated very high by all category of respondents. Hence, it throws light to the need of scaling up its use through proper training to extension professionals so that the adoption level could be increased and sustained helping them to render timely and precise service to the farming community.

**4.5.3. The reasons for using the expert systems**

The reasons for using expert systems and the rating of those reasons by the respondents are furnished in Table 19.

Perusal of the Table 19 revealed the reasons for using the expert systems and ranking of those reasons by the respondents. It could be evident from the table that lowest mean score statement was the first ranked statement and most of the respondents ranked 'saves a lot of time' as first ranked statement with the mean score 6.299 for using the expert systems followed by ease of use (9.607), correctness and reliability of advice (10.675), credibility of the developer (13.441), user interface (13.858), credibility of domain expert(s) (13.866) and price of the systems (16.191) respectively.

**Table 19. Ranking the reasons for using the expert systems**

| Sl. No | Statements | Extension professionals. n=40 | | Front line extension personnel's. n=30 | | Scientists. n=30 | | Total | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean Scores | Rank | Mean Scores | Rank | Mean Scores | Rank | Mean Scores | Rank |
| 1 | Correctness and reliability of advice | 2.975 | 3 | 3.5 | 3 | 4.2 | 3 | 10.675 | 3 |
| 2 | Ease of use | 2.675 | 2 | 3.366 | 2 | 3.566 | 2 | 9.607 | 2 |
| 3 | Price of the systems | 5.725 | 7 | 5.833 | 7 | 4.633 | 7 | 16.191 | 7 |
| 4 | Credibility of domain expert(s) | 4.9 | 5 | 4.366 | 5 | 4.6 | 6 | 13.866 | 6 |
| 5 | Credibility of the developer | 5.175 | 6 | 3.933 | 4 | 4.333 | 4 | 13.441 | 4 |
| 6 | User interface | 4.825 | 4 | 4.533 | 6 | 4.5 | 5 | 13.858 | 5 |
| 7 | Saves a lot of time | 1.7 | 1 | 2.466 | 1 | 2.133 | 1 | 6.299 | 1 |

In case of all the respondent categories, it was observed that most of the respondents ranked 'saves a lot of time' as first ranked statement with the mean score 1.7 for using the expert systems followed by ease of use (2.675) and correctness and reliability of advice (2.975). All the other statements were ranked differentially by different categories of respondents. In case of extension professionals, user interface (4.825) was ranked the fourth followed by credibility of domain expert(s) (4.9), credibility of the developer (5.175) and price of the systems (5.725) respectively. With respect to front line extension personnel ranking, most respondents ranked credibility of the developer (3.933) as the fourth important reason for using expert systems followed by, credibility of domain expert(s) (4.366), user interface (4.533) and price of the systems (5.833) respectively. In case of scientists, most of the respondents ranked credibility of the developer (4.333) as the fourth ranked statement followed by user interface (4.5), credibility of domain expert(s) (4.6) and price of the systems (4.733) respectively.

Hence it was inferred that three categories of respondents ranked 'saves a lot of time' as first ranked statement for using the expert systems followed by 'ease of use' and 'correctness and reliability of advice'. All other items were ranked differentially by the different categories of respondents except for the statement 'Price of the systems' that was ranked last by all three categories of respondents.

The mandate of field level extension professionals are tailor made such that helping farmers with timely, precise and clear advice without any ambiguity becomes the primary focus. Traditional way of advising farmers on fertiliser recommendations and use of chemicals for pest and disease management consumed a lot of time as manual calculations was resorted to with the help of Package of Practice recommendations. Each recommendation had to be worked out differently for different crops and field situations. With the advent of expert system and information pre-stored within; it was easy to get recommendations within seconds in a key stroke or a move of the mouse through interaction between man and the digital world. Also, the extension professional's time is largely consumed by other routine activities pertaining to administrative concerns. This could be the reason for all the three categories of respondents ranking 'saves a lot of time' as first ranked statement for using the expert systems followed by ease of use and correctness and reliability of advice.

### 4.5.4. Agreement among the extension professionals, front line extension personnel and scientists in rating the reasons for using agri-expert systems.

The Kendal's coefficient of concordance of reasons (N=7) for using agri-expert systems for judgments made by extension professionals (k=40), front line extension personnel (k=30) and scientists (k=30) was found out. The results in this regard are presented in Table 20.

Glance of the Table 20 reveals the Kendall's co-efficient of concordance which was used to verify whether there was agreement among the respondents in providing their rankings to the statements for using the expert systems. We can see that there was concordance in the rating/ranking of reasons for using agri-expert systems by extension professionals, front line extension personnel and scientists either at 0.05 or 0.10 percent level of significance.

**Table 20. Consistency among extension professionals, front line extension personnel and scientists in rating reasons for using agri-expert systems**

| Category | $K_C$- Kendall's co-efficient of concordance | $X^2$ |
|---|---|---|
| Extension professionals. k=40 | 0.498 | 119.51** |
| Front line extension personnel. k=30 | 0.1726 | 31.05* |
| Scientists. k=30 | 0.2424 | 43.62** |

** Significant at 5% level *Significant at 10 % level

## 4.6. DIFFUSION-ADOPTION STAGES IN TERMS OF EXTENT OF USE OF EXPERT SYSTEM TECHNOLOGY *VIS A VIS* EXTENSION PROFESSIONALS

The distribution of respondents based on adoption stages in terms of extent of use of expert system are furnished in Table 21.

It could be evident from the table 21 that 10 per cent of the sampled respondents belonged to innovators category followed by early adopter category (19%), early majority category (32%), late majority category (24%) and laggards (15 %). A detailed and careful perusal of table and figure 2 further revealed that the front line extension personnel from KVK and NGO's belonged to innovator category with the highest percentage (13.33%) when compared to Scientists of Institutes and Extension Professionals of SDA. A similar pattern was observed in case of early majority category.

**Table 21. Adopter categorisation of respondents with reference to expert systems**

N=100

| Category | Extension professionals n=40 | | Front line extension personnel n=30 | | Scientists n=30 | | Total | |
|---|---|---|---|---|---|---|---|---|
| | No | % | No | % | No | % | No | % |
| Innovators (>P80) | 3 | 7.5 | 4 | 13.33 | 3 | 10 | 10 | 10 |
| Early adopters (P80-P60) | 6 | 15 | 5 | 16.66 | 8 | 26.66 | 19 | 19 |
| Early Majority (P60-P40) | 11 | 27.5 | 11 | 36.66 | 10 | 33.33 | 32 | 32 |
| Late Majority (P40-P20) | 12 | 30 | 6 | 20 | 6 | 20 | 24 | 24 |
| Laggards (<P20) | 8 | 20 | 4 | 13.33 | 3 | 10 | 15 | 15 |
| **Percentiles under each class of respondents** | $P_{20}$-9.33,$P_{40}$-20,$P_{60}$-40,$P_{80}$-66.66 | | $P_{20}$-6.66,$P_{40}$-20,$P_{60}$-40,$P_{80}$-66.66 | | $P_{20}$-20,$P_{40}$-40,$P_{60}$-40,$P_{80}$-66.66 | | | |

Observing the 'extension professionals' stage in the diffusion-adoption process, 7.5 per cent of the sampled respondents belonged to innovators category followed by 15 per cent to early adopters' category, 27.5 per cent to early majority category, 30 per cent to late majority category and 20 per cent to laggards' category. In case of 'front line extension personnels' stage in the diffusion-adoption process, 13.33 per cent of the sampled respondents belonged to innovators category followed by 16.66 per cent to early adopters' category, 36.66 to early majority category, 20 per cent to late majority category and 13.33 per cent to laggards' category. In case of 'scientists' stage in the diffusion-adoption process, 10 per cent of the sampled respondents belonged to innovators category followed by 26.66 per cent to early adopters category, 33.33 per cent to early majority category, 20 per cent to late majority category and 10 per cent to laggards category.

A detailed analysis of Table 21 revealed that a minority of the respondents in general (10%) only were in the real adoption stage, who can be considered as 'Innovators' as far as the e – Agricultural Extension Technology (e-AET) in Kerala is considered. Highest in that category were extension professionals of KVK and NGOs (13.33%). Remaining respondents were in the potential adoption category with 19%

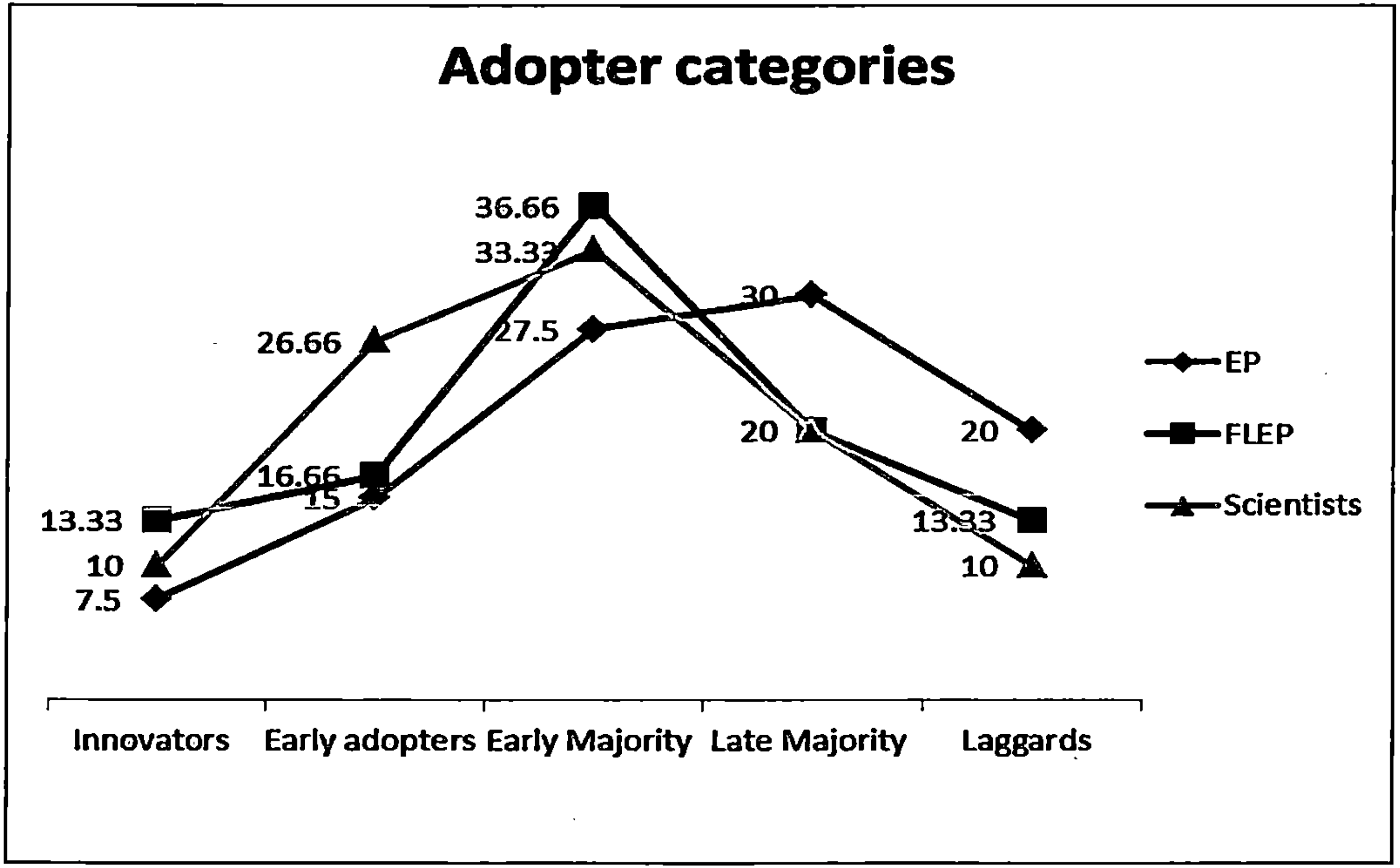



Fig.18. Adopter categorisation of respondents

in the trial stage (Early adopters), 32% in the evaluation stage (Early majority), 24% in the interest stage (Late majority) and 15% in the awareness stage (Laggards). This might be because respondents were more interested in using e-agricultural extension technology for solving farmer's problems and they perceived that relatively less expertise is needed for using expert system. Based on studies of characteristics that determine success of expert system innovation, it is identified that it is expedient to emphasize the following information for communication through expert system to facilitate adoption with special reference to innovators, early adopters and early majority.

- Expert systems were more relatively advantageous
- End-users wishes and needs that the innovation is oriented towards.
- Overall benefit provided by the innovation.
- Exclusiveness and value of exclusiveness of the innovation.
- Economy, affordability and durability of the innovation.
- Complexity or the degree of ease of use of the innovation.

Traditional way of advising recommendations was time consuming as it had to consider many variables such as varieties, spacing, area, package of practice recommendations etc. for giving specific fertilizer recommendation or pesticide/fungicidal or herbicidal recommendations. With the advent of KAU expert systems these recommendations could be made within seconds through confirmative option selections. Also, system being available offline, net connectivity was not a problem for its use when compared to many crop specific and online expert systems. These qualities reaffirmed the innovation characteristics with special reference to KAU expert systems. According to Ortt *et al* (2004) the diffusion curves for breakthrough communication technologies have historically taken a decade or more to accelerate after the first introduction. However, in this study diffusion and adoption of KAU expert systems *viz*. 'KAU fertulator and e-crop doctor' took place relatively faster than other communication technologies which is slightly in deviation to the finding by Ortt *et al* (2004) and is actually a positive aspect of this expert system. However, expert system needs to be further popularised through an 'awareness/hands on- training' to further scale up the use of expert system for the assistance of farming community.

### 4.6.1 Relationship between extent of expert system's adoption by respondents and independent variables

The results of simple correlation analysis were taken into consideration for analysing the influence of independent variables on the extent of adoption of expert system by respondents. The results are presented in table 22.

**Table 22. Results of correlation between extent of expert system's adoption by extension professionals of State Department of Agriculture, front line extension personnel of NGO's and KVK's and scientists of agricultural research institutes and independent variables**

| S.No. | Variable | Correlation co-efficient 'r' value | | |
|---|---|---|---|---|
| | | Extension professionals | Front line extension personnel | Scientists |
| $X_1$ | Age | -0.126 | 0.339 | 0.130 |
| $X_2$ | Education | 0.052 | 0.157 | 0.199 |
| $X_3$ | Training | 0.065 | 0.593** | 0.317 |
| $X_4$ | Innovativeness | 0.327** | 0.589** | 0.615** |
| $X_5$ | Availability | 0.062 | 0.601** | 0.535** |
| $X_6$ | Accessibility | 0.221 | 0.150 | 0.435 |
| $X_7$ | Retrievability | 0.298 | 0.241 | 0.327 |
| $X_8$ | Relevancy | 0.116 | 0.491** | 0.483** |
| $X_9$ | Format clarity | 0.451** | 0.144 | 0.144 |
| $X_{10}$ | Information content | 0.253 | 0.467** | 0.662** |
| $X_{11}$ | Timeliness | 0.105 | 0.460* | 0.337* |
| $X_{12}$ | Accuracy | 0.301 | 0.472** | 0.469** |

*: Significant at 0.05 level of probability; ** : Significant at 0.01 level of probability

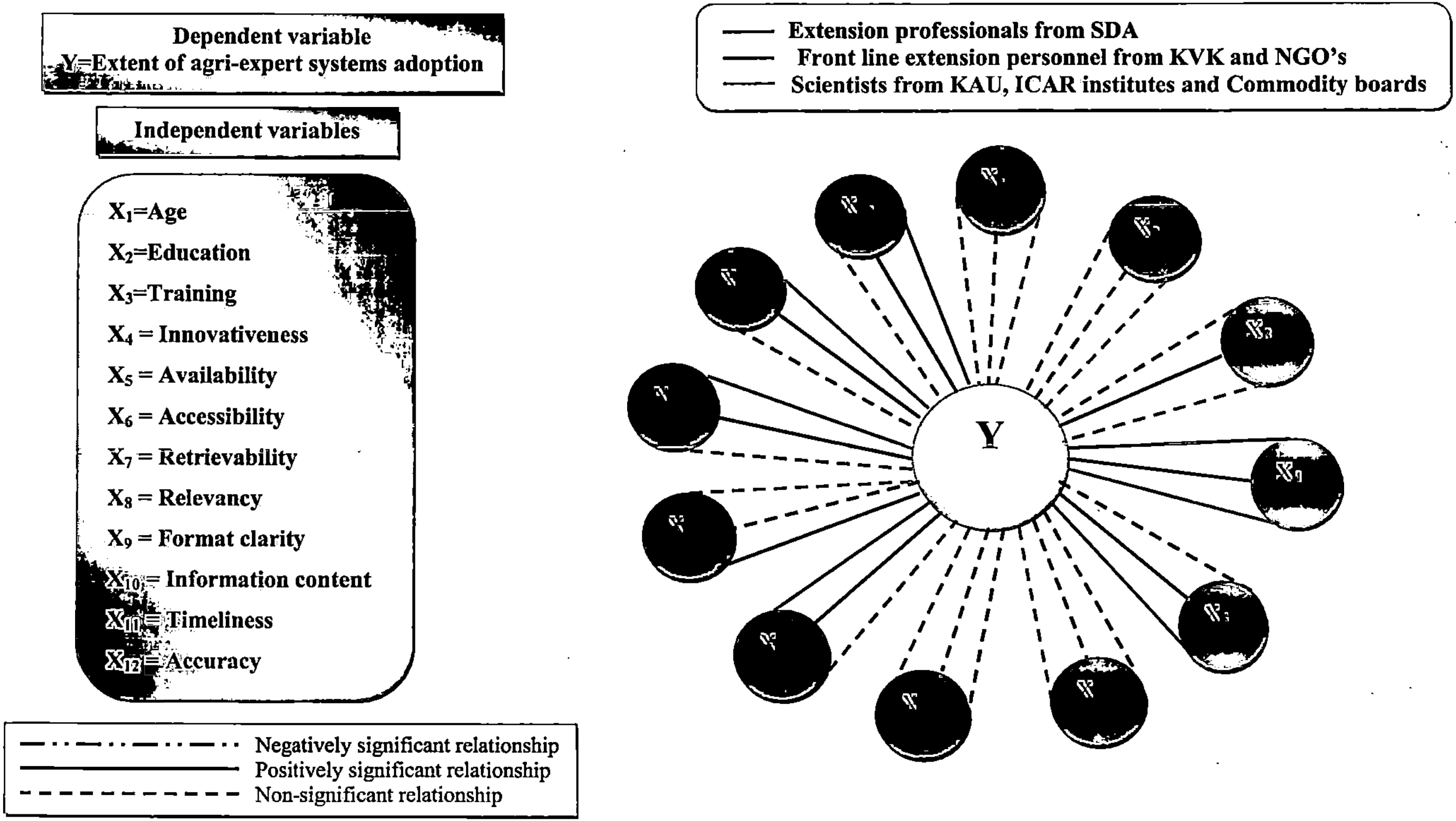



**Figure.19.Relationship between extent of expert system's adoption by respondents and independent variables**

The results of correlation analysis are presented in Table 22 and Fig 19. Correlation analysis revealed that out of 12 independent variables, only one variable namely innovative pronenesswas positively and significantly related with extent of expert system's adoption among all three categories of respondents *viz.,* Extension professionals of state department of agriculture, front line extension professionals of KVK's and NGO's and scientists at one per cent level of probability.

However a detailed analysis shows that when two out of 12 independent variables were positively and significantly correlated to the extent of expert system's adoption by extension professionals of SDA; six out of 12 independent variables were positively and significantly correlated to the extent of adoption by front line extension personnels at one per cent level of probability. When, Availability, Innovativeness, Training, Information content, Accuracy and Relevancy were the independent variables influencing the extent of adoption by front line extension professionals; Availability, Innovative proneness, Information content, Accuracy and Relevancy were the influencing variables of scientists. In case of frontline extension personnels and scientists timeliness was positively and significantly related to the extent of adoption at 5 per cent level of probability. Accessibility was positively and significantly related to the extent of adoption by scientists at 5 per cent level of probability.

Hence, table 22 revealed that the co-efficient of correlation between independent variable *viz.,* 'Innovativeness' and the dependent variable 'extent of expert system's adoption' among all categories of respondents was greater than the table value of 'r' at 0.01 level of probability. Hence, null hypothesis was rejected and empirical hypothesis was accepted. It could, therefore, be inferred that there was a positive and significant relationship between the innovativeness and extent of expert system adoption. In case of front line extension personnel and scientists, availability, relevancy, information content and accuracy was the variables which were increased might have had high adoption of agri-expert systems. The similar trend of increased training of respondents will increase the adoption of agri-expert systems by front line extension personnel at 0.01 level of probability. Timeliness was the variable which was influencing agri-expert systems rate of adoption by front line extension personnel and scientists' at 0.05 level of probability. Hence, null hypothesis was rejected and empirical hypothesis was accepted. It could, therefore, be inferred that there was a positive and significant relationship between the stated independent variables and extent of adoption of agri-expert systems.

Training on Information Communication Technologies would enhance the usage of agri-expert systems. Front line extension personnel from KVK and NGO's perceived that training programmes on ICT tools would make them aware about new agri-expert systems and could impart knowledge and skill to adopt agri-expert systems. Hence positive and significant relationship was observed.

Innovativeness was the variable which was directly influencing the extent of adoption among all categories of respondents. This might be because extension professionals from SDA were keener to know about new ICT aspects. Front line extension personnel and scientists were directly involved in developing new ICT tools which motivated them to adopt agri-expert systems. Hence positive and significant relationship was observed.

Availability of agri-expert systems among front line extension personnel and scientists was directly influencing the extent of expert system's adoption. This might be because most of the respondents felt that availability of hardware and software to operate expert systems were ease in use, which prompts them to adopt the expert system. Hence positive and significant relationship was observed.

Relevancy of agri-expert systems among front line extension personnel and scientists was directly influencing the extent of expert system's adoption. This might be because most of the respondents felt that the expert system was able to provide information suitable to the users' resources and appropriate to the users' needs which would enhance the usage of agri-expert systems. Hence positive and significant relationship was observed.

Format clarity of agri-expert systems among extension professionals from SDA was directly influencing the extent of expert system's adoption. This might be because most of the extension professionals felt that it was effective for the trainers to post messages to the learner to stimulate discussion, and encourage interaction, if the format is of clarity which would enhance the adoption of agri-expert systems.

Information content of agri-expert systems among front line extension personnel and scientists was directly influencing the extent of expert system's adoption. This might be because most of the respondents felt that the information content from expert system was clear, easily understandable and adequate enough to adopt agri-expert systems among the respondents.

Timeliness of the information from agri-expert systems among front line extension personnel and scientists was directly influencing the extent of expert system's adoption. This might be because most of the respondents felt that the information was being provided at right time and front line extension personnels and scientists were also involved in development of expert systems, thereby they were good enough to retrieve the information with less time to adopt agri-expert systems.

Accuracy of the information from agri-expert systems among front line extension personnel and scientists was directly influencing the extent of expert system's adoption. This might be because most of the respondents from these two categories perceived that information from expert system indicated that potential improvement in the decision making process and the information from agri-expert system near to true value with greater accuracy to adopt agri-expert systems for betterment of farming community.

## 4.7. EFFECTIVENESS INDEX OF EXPERT SYSTEM APPLICATION IN AGRICULTURE (KAU/ KISSAN KERALA)

The distribution of respondents based on effectiveness index of expert system application in agriculture is furnished in Table 23

**Table 23. Distribution of respondents based on effectiveness index of expert system application in agriculture**

N=100

| Category | Extension professionals. n=40 | | Front line extension personnel. n=30 | | Scientists. n=30 | | Total | |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % |
| Low(<Quartile$_1$) | 5 | 12.5 | 2 | 6.66 | 5 | 16.66 | 9 | 9 |
| Medium(Q$_1$-Q$_3$) | 24 | 60 | 18 | 60 | 18 | 60 | 62 | 62 |
| High(>Quartile$_3$) | 11 | 27.5 | 10 | 33.33 | 7 | 23.33 | 29 | 29 |
| Quartiles under each class of respondents | Quartile$_1$-57.14<br>Quartile$_2$-62.5<br>Quartile$_3$-67.85 | | Quartile$_1$-57.14<br>Quartile$_2$-64.28<br>Quartile$_3$-67.85 | | Quartile$_1$-57.14<br>Quartile$_2$-64.28<br>Quartile$_3$-66.96 | | | |

Perusal of Table 23 revealed the distribution of respondents based on effectiveness index of expert system application in agriculture. It could be ostensible from the table that majority of the respondents i.e. 62 per cent perceiving that effectiveness index of expert system application in agriculture were medium followed by high (29%) and low (9%) respectively.

Observing the extension professionals' distribution, more than half of the respondents i.e. 60 per cent respondents opined that effectiveness index of expert system were medium followed by high (27.5%) and low (12.5%) respectively. With respect to front line extension personnel, more than half of the respondents i.e. 60 per cent respondents opined that effectiveness index of expert system were medium followed by high (33.33%) and low (6.66%) respectively. In case of scientists, majority of the respondents i.e. 62 per cent opined that effectiveness index of expert system were medium followed by high (29%) and low (9%) respectively.

Hence it was inferred that majority of the respondents i.e. 62 per cent perceived that effectiveness index of expert system application in agriculture were medium followed by high (29%) and low (9%) respectively. This might be because more than half of the respondents among all categories perceived that expert system was able to provide distant users with scientific information using modern tools at a much lower cost. Computer assisted instruction can increase the knowledge gain when delivered in an organised and well-planned approach covering adequate information in easily understandable manner. To impart knowledge to the target group, it is necessary to supplement verbal messages with visual messages. The visual messages in the form of illustrative material enables the learner to see and form correct concept, conceive an idea, overcome language barrier and get motivated to computer-based expert system as a tool for effective decision making against complex problem and technology transfer in various field of agriculture and allied areas.

Perusal of the Table 24 revealed the effectiveness index of expert system application in agriculture and ranking of those statements by the respondents. It could be evident from the table that highest mean score statement was the first ranked statement and most of the respondents ranked 'pedagogy (as a means to effective learning through expert system)' as first with the mean score 11.08 followed by 'expert systems ability to exploit a considerable amount of knowledge' (10.845), quick availability and opportunity of the expert system to programme itself (10.69), expert systems ability on preservation and improvement of knowledge (10.545), reliability of the expert system (10.265), expert systems ability to address the new areas neglected by conventional computing (10.25) and scalability of the expert system (10.115) respectively.

**Table 24. Effectiveness index of expert system application in agriculture**

| Sl. No | Statements | Extension professionals. n=40 | | Front line extension personnel. n=30 | | Scientists. n=30 | | Total | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean Scores | Rank | Mean Scores | Rank | Mean Scores | Rank | Mean Scores | Rank |
| 1 | Quick availability and opportunity of the expert system to programme itself. | 3.5 | 4 | 3.66 | 2 | 3.53 | 4 | 10.69 | 3 |
| 2 | Expert systems ability to exploit a considerable amount of knowledge. | 3.62 | 2 | 3.56 | 3 | 3.66 | 2 | 10.84 | 2 |
| 3 | Reliability of the expert system. | 3.37 | 7 | 3.53 | 4 | 3.36 | 5 | 10.26 | 5 |
| 4 | Scalability of the expert system. | 3.42 | 6 | 3.43 | 7 | 3.26 | 7 | 10.11 | 7 |
| 5 | Pedagogy (As a means to effective learning through expert system) | 3.65 | 1 | 3.7 | 1 | 3.73 | 1 | 11.08 | 1 |
| 6 | Expert systems ability on preservation and improvement of knowledge. | 3.52 | 3 | 3.46 | 6 | 3.56 | 3 | 10.54 | 4 |
| 7 | Expert systems ability to address the new areas neglected by conventional computing. | 3.45 | 5 | 3.5 | 5 | 3.3 | 6 | 10.25 | 6 |

While reviewing the extension professionals' ranking, most respondents ranked pedagogy (As a means to effective learning through expert system) as first ranked statement with the mean score 3.65 followed by expert systems ability to exploit a considerable amount of knowledge (3.62), expert systems ability on preservation and improvement of knowledge (3.525), quick availability and opportunity of the expert system to programme itself (3.50), expert systems ability to address the new areas neglected by conventional computing (3.45), scalability of the expert system (3.425) and reliability of the expert system (3.375) respectively. With respect to front line extension personnel, most respondents ranked pedagogy (As a means to effective learning through expert system) as first ranked statement with the mean score 3.7 followed by quick availability and opportunity of the expert system to programme itself (3.66), Expert systems ability to exploit a considerable amount of knowledge (3.56), reliability of the expert system (3.53), expert systems ability to address the new areas neglected by conventional computing (3.50), expert systems ability on preservation and improvement of knowledge (3.46) and scalability of the expert system (3.43) respectively. In case of scientists, most of the respondents ranked pedagogy (As a means to effective learning through expert system) as first ranked statement with the mean score 3.73 followed by expert systems ability to exploit a considerable amount of knowledge (3.66), expert systems ability on preservation and improvement of knowledge (3.56), quick availability and opportunity of the expert system to programme itself (3.53), reliability of the expert system (3.36), expert systems ability to address the new areas neglected by conventional computing (3.3) and scalability of the expert system (3.26) respectively.

Hence, 'pedagogy (As a means to effective learning through expert system)' was rated as first ranked statement by all categories of respondents. This might be because majority of the respondents perceived that expert system can impart the knowledge and skill for decision making in various fields. It will work like expert to give the solution for problems when expert is not available. As users of a technology, relevant expertise is needed to solve a particular problem or to take a suitable decision. The major problems in accessing a human expert in a particular subject area are non-availability or scarcity of experts. Even if the human expert is available, there may be problem of access for common people to contact the expert. Thus, agri-expert system is needed even for an expert to update his knowledge and get help in decision-making process.

## 4.8. CONSTRAINTS EXPERIENCED BY EXTENSION PROFESSIONALS IN USING AGRI-EXPERT SYSTEMS

Perusal of the Table 25 revealed the constraints experienced by extension professionals in using agri-expert systems and ranking of those constraints by respondents. It is evident from the table that 'lack of proper training' is a major constraint which was ranked first followed by 'not yet covered all farmers' practices', internet connection is very slow, some information needed further explanation, no support from authorities, accessibility problem, not convenient to use as there is a big gap between the perspective of both developer and users, availability of electricity, the costs of using expert system might be expensive, no internet connection, research is not yet approved by all the users, expert's advice is not clear, no supporting budget to buy computers, difficult to understand and don't know how to operate a computer respectively in decreasing order of ranking.

Examining the extension professionals' ranking, 'lack of proper training' was a major constraint which was ranked first in using agri-expert systems followed by 'not yet covered all farmers' practices', internet connection is very slow, no support from authorities, the costs of using expert system might be expensive, not convenient to use as there is a big gap between the perspective of both developer and users, accessibility problem, research is not yet approved by all the users, no internet connection, some information needed further explanation, expert's advice is not clear, availability of electricity, no supporting budget to buy computers, don't know how to operate a computer and difficult to understand respectively in decreasing order of ranking.

With respect to front line extension personnel ranking, 'lack of proper training' was a major constraint which was ranked first in using agri-expert systems followed by some information needed further explanation, availability of electricity, expert's advice is not clear, not yet covered all farmers' practices, no supporting budget to buy computers, accessibility problem, no internet connection, not convenient to use as there is a big gap between the perspective of both developer and

**Table 25. Constraints experienced by extension professionals in using agri-expert systems**

| Sl. No. | Statements | Extension professionals. N=40 | | Front line extension personnel. N=30 | | Scientists. N=30 | | Total | |
|---|---|---|---|---|---|---|---|---|---|
| | | No. | Rank | No. | Rank | No. | Rank | No. | Rank |
| 1 | Don't know how to operate a computer | 3 | 14 | 1 | 14.5 | 1 | 14.5 | 5 | 15 |
| 2 | No supporting budget to buy computers | 4 | 13 | 6 | 5.5 | 1 | 14.5 | 11 | 13 |
| 3 | Lack of proper training | **22** | **1** | **13** | **1** | **14** | **1** | **49** | **1** |
| 4 | Availability of electricity | 4 | 12 | 8 | 3 | 5 | 8.5 | 17 | 8 |
| 5 | Difficult to understand | 1 | 15 | 4 | 10 | 4 | 11.5 | 10 | 14 |
| 6 | Expert's advice is not clear | 4 | 11 | 7 | 4 | 3 | 13 | 14 | 11.5 |
| 7 | Accessibility problem | 7 | 7 | 5 | 7.5 | 5 | 8.5 | 18 | 6.5 |
| 8 | No support from authorities | 10 | 4 | 2 | 12.5 | 8 | 4.5 | 20 | 5 |
| 9 | Not yet covered all farmers' practices. | **15** | **2.5** | 6 | 5.5 | **10** | **2** | **32** | **2** |
| 10 | Some information needed further explanation. | 5 | 10 | **10** | **2** | 9 | 3 | 24 | 3.5 |
| 11 | No internet connection. | 6 | 9 | 5 | 7.5 | 4 | 11.5 | 15 | 10 |
| 12 | Internet connection is very slow. | **15** | **2.5** | 1 | 14.5 | 8 | 4.5 | 24 | 3.5 |
| 13 | Research is not yet approved by all the users. | 6 | 8 | 3 | 11 | 5 | 10 | 14 | 11.5 |
| 14 | Not convenient to use as there is a big gap between the perspective of both developer and users. | 7 | 6 | 5 | 7.5 | 6 | 6.5 | 18 | 6.5 |
| 15 | The costs of using expert system might be expensive. | 8 | 5 | 2 | 12.5 | 6 | 6.5 | 16 | 9 |

users, difficult to understand, research is not yet approved by all the users, the costs of using expert system might be expensive, no support from authorities, internet connection is very slow and don't know how to operate a computer respectively in decreasing order of ranking.

In case of scientists ranking, 'lack of proper training' was a major constraint which was ranked first in using agri-expert systems followed by not yet covered all farmers' practices, some information needed further explanation, no support from authorities, internet connection is very slow, not convenient to use as there is a big gap between the perspective of both developer and users, the costs of using expert system might be expensive, availability of electricity, accessibility problem, research is not yet approved by all the users, no internet connection, difficult to understand, expert's advice is not clear, no supporting budget to buy computers and don't know how to operate a computer respectively in decreasing order of ranking.

Hence it was inferred that all categories of respondents ranked 'lack of proper training' as first ranked constraint for using agri-expert systems.This might be because the delivery of the technology in the right form, place and time by the experts need a better understanding for capacity and confidence building. Training will help in capacity building to the trainees in terms of their knowledge, skill, attitude and understanding and it will contribute to performance back at work. Thus, all the categories of respondents might have perceived the need to have training on ICT tools to use it efficiently for effective execution of their work or services.

Apart from the major constraint *viz.,* 'lack of proper training' all other constraints were ranked differently among all categories of respondents. 'Not yet covered all farmers' practices' and 'Internet connection is very slow' were the constraints which were ranked second by extension professionals of SDA. This might be because they perceived that expert systems are not covering all crops, biological control methods and new generation chemicals which are essential to solve the problems in a sustainable way. Scientists also ranked that 'Not yet covered all farmers' practices as second major constraint because agri-expert system varied in including all the information from seed to seed that is not available in a single expert system. For pests, diseases, weeds, fertilizer calculation, irrigation management, nutrient management and weather forecasting, different expert systems exist and there remains an ambiguity with respect to the information sought by the end-users independently to tackle each problem. But there was no expert system covering all these practices in a single window mechanism.

'Some information needed further explanation' was a constraint which was ranked second by front line extension personnels from KVK and NGO's. This might be because some information in the expert system aiding advisory service is not comprehensive and adequate to understand. Hence the end users would have felt the need for further clarification to take decision. Other constraints like 'No supporting budget to buy computers', 'availability of electricity', 'accessibility problem', 'no internet connection' and 'internet connection is very slow' were physical constraints which can be improved by reforming and supplementing with more logistic supports and facilities.

### 4.8.1. Suggestive measures to enhance the capability of extension professionals in utilizing agricultural expert systems for the benefit of farming community:

Considering the above facts and to overcome the above constraints so as to enhance the capability of extension professionals in utilizing agricultural expert systems for the benefit of farming community for decision making in various aspects of agriculture, the following suggestions for improving agri-expert systems use among extension professionals was made:

- Proper training should afford for augmenting the usage of expert systems among users. This might be because trainings attended on agri-expert systems were found as the common factor with high odds ratio influencing all the categories of users.

- Expert system should cover all farmers' practices and subjects using advanced software packages and its performance shall be assessed among the users before and after release.
- Expert systems should have more location and language specific versions of software on different crops to cater the needs of various categories of users.
- Linkage connectivity of expert systems of different source would make expert systems more comprehensive and overcome the issues of inadequacies and ambiguity. This is because many expert systems available to the end users are crop specific or domain specific at different sources. Hence inter connectivity of different expert systems through internet will enable users for comprehensive use and hence better decision making.
- The information provided in the expert system should be clear and easily understandable.
- Before releasing agri-expert system among users, it is necessary to orient the prospective users about the operations of expert system in diagnosing and retrieving information to maximize the strengths and tap its opportunities effectively.
- The higher authorities should support the implementation of expert systems in all departments of agriculture for effective decision making.

## 4.9. EMPIRICAL MODEL OF THE STUDY

Based on the findings of correlation analysis the empirical model showing the relationship of independent variables with the dependent variables, namely attitude of respondents towards agri-expert systems and extent of expert system's adoption by respondents and suggestive measures are depicted in Fig. 20.

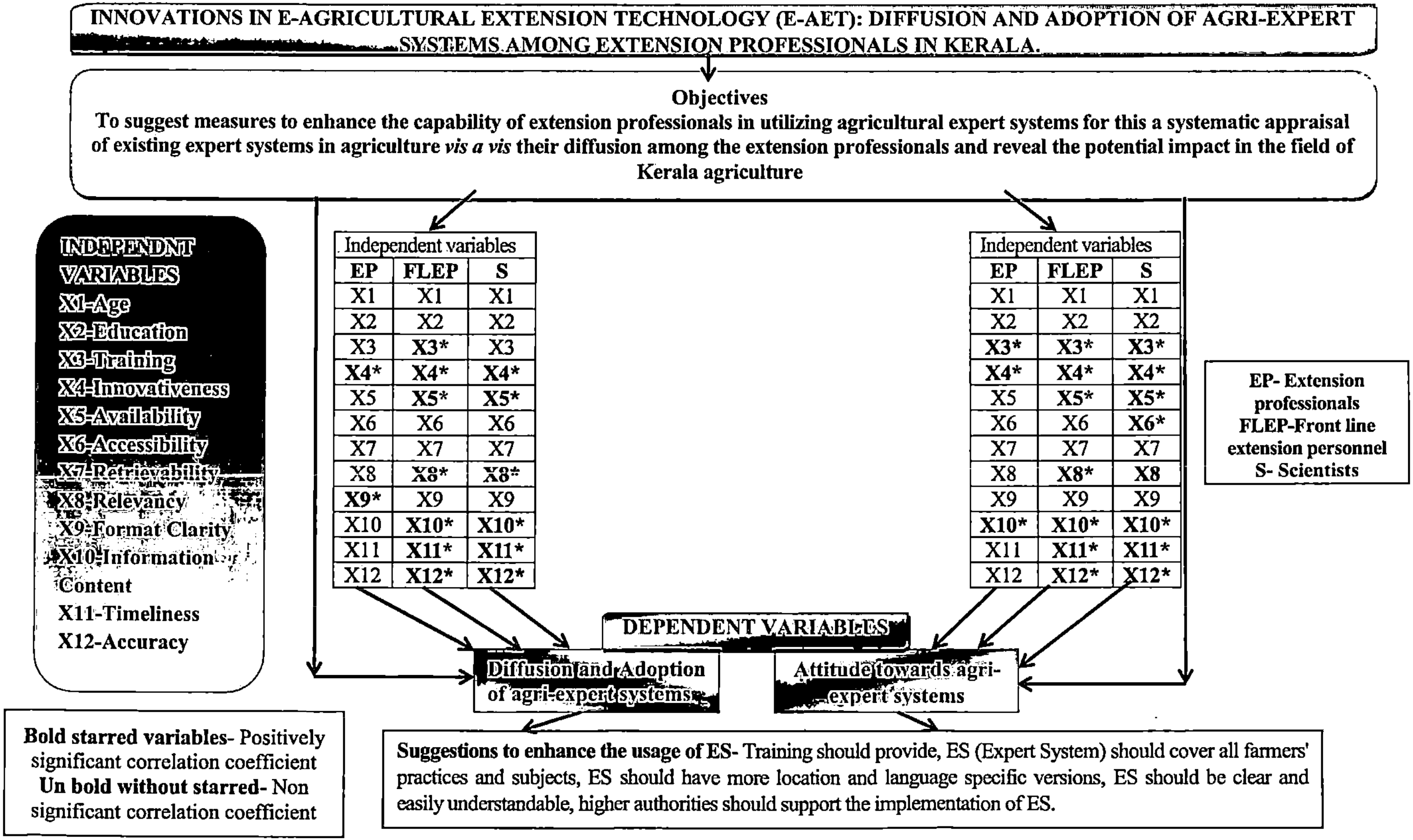



**Fig.20. EMPIRICAL MODEL OF THE STUDY**

# *Summary*

# 5. SUMMARY

Agricultural production has evolved into a complex business requiring the accumulation and integration of knowledge and information from diverse sources. In order to remain competitive, the farmer in modern days often relies on agricultural specialists and advisors to get information for decision making. Unfortunately, agricultural specialist assistance is not always available when the farmer needs it. It is true that India possesses valuable agricultural knowledge and expertise. However, a wide information gap exists between research and practice. Farmers need timely expert advice to make farming more productive and competitive. Thus there is a great need to capture the knowledge generated by vast network of scientists and encapsulate these knowledge to help in reliable decision support for solving various problems in agriculture. Emerging has provided new tools and opportunities, which could be applied in agricultural extension. A computer-based expert system is one such emerging ICT which has great potential to apply in agriculture.

An expert system is a computer programme that is designed to emulate the logic and reasoning processes that an expert would use to solve a problem in his/her field of expertise, using artificial intelligence technology (Waterman, 1986). Local information resource centers are gaining importance with computers carrying expert systems to help farmers to make decisions. The research studies at the users' level in assessing the performance of the system are limited. Keeping these points in mind, an experimental study entitled, "Innovations in e-Agricultural Extension Technology (e-AET): Diffusion and adoption of agri-expert systems among extension professionals in Kerala" was conducted with the following specific objective.

To suggest measures to enhance the capability of extension professionals in utilizing agricultural expert systems for the benefit of farming community for decision making in various aspects of agriculture.

For this a systematic appraisal of existing expert systems in agriculture *vis a vis* their diffusion among the extension professionals will be studied. This study also will attempt to reveal the potential impact in the field of Kerala agriculture with policy suggestions to scale up its use.

The study was conducted during 2013-2014 in Thiruvananthapuram district of Kerala. A total of 100 respondents were selected for the study with 40 extension professionals primarily consisting of Agricultural Officers working in the Krishibahavans were randomly selected, 30 front-line extension personnels of KVK's and NGO's actively involved in the field of agriculture and 30 Scientists involved with extension programmes of Kerala Agricultural University, ICAR Institutes and Commodity Boards were selected as the respondents for the study.

The independent variables selected for the study were age, education, training, innovativeness of the respondent, availability, accessibility, timeliness, retrievability, relevancy, accuracy, format clarity and information content of expert system in relation to sustainability of the expert systems.

Diffusion and adoption of agri-expert systems with special reference to adoption stages was found out. The procedure as followed by Ahmed (2012) with slight modification. The test constituted 5 questions which were provided with Yes or No answers. The adoption stage was administered to the respondents and was ask to tick mark to the statements. Based on the stage, respondents were classified into five stages i.e. awareness, interest, evaluation, trial and adoption. Based on the stage of adoption respondents were categorized into innovators, early adopters, early majority, late majority and laggards for adopter categorization using percentiles, as measure of check. Attitude towards expert systems was found out procedure as followed by Chetsumon (2005) with slight modification. This scale has 14 statements among these 7 were positive statements and 7 statements were negative. Based on the total scores the respondents were classified into high, medium and low using quartiles, as measure of check. Based on the relevant review of literature and discussion with experts of Department of

Agriculture and Kerala Agricultural University, items related to expert system applications in agriculture were identified and effectiveness index of expert system was developed. The 7 statements were ranked based on their mean scores in decreasing order of importance. Some of the constraints faced by expert system respondents were identified. A list containing fifteen such constraints was included in the final interview schedule. The list was open ended so that the additional constraints expressed by the expert system respondents at the time of interview could also be included. The independent variables were quantified using already existing scales or following established procedures. The data were collected using a well-structured interview schedule prepared for the purpose (Appendix IV). A draft interview schedule was prepared which was pre-tested by conducting a pilot study in non-sample area and suitable modifications were made in the final interview schedule which was then directly administered to the expert system respondents by the investigator and responses recorded at the time of interview. Percentage analysis, means, quartile deviation, percentile analysis, correlation analysis and Kendall's co-efficient of concordance were employed in the analysis of the data and interpreting the results.

The salient findings of the study are furnished below.

1. Majority of the extension personnel were in middle age category.
2. Half of the extension personnel were holding master degrees and remaining half of the respondents possessed graduation and doctoral degrees.
3. More than half of the respondents had undergone training on ICT related aspects and majority of trainees had undergone 1-3 days training programme.
4. Majority of the respondents were under high innovativeness category.
5. Majority of the respondents perceived that KAU expert systems were always and sometimes available in equal proportions.
6. Majority of the respondents perceived that Kissan Kerala expert system as sometimes available.
7. Majority of the respondents pronounced that KAU expert systems accessibility were high.

8. Majority of the respondents perceived that Kissan Kerala expert system was having medium accessibility.
9. Majority of the respondents expressed that retrievability of agri-expert systems were medium.
10. Majority of the respondents pronounced that relevance of agri-expert systems were medium.
11. Majority of the respondents pronounced that format clarity of agri-expert systems were high.
12. Majority of the respondents expressed that information content of agri-expert systems was high.
13. Majority of the respondents expressed that timeliness of the information from agri-expert systems was medium.
14. Majority of the respondents expressed that accuracy of the information from agri-expert systems was medium.
15. Majority of the respondents were having medium attitude towards agri-expert systems.
16. Correlation analysis revealed that out of 12 independent variables, three variables namely innovativeness, training and information content were positively and significantly related with extent of attitude towards expert systems among all three categories of respondents *viz.*, extension professionals of state department of agriculture, front line extension professionals of KVK's and NGO's and Scientists at one per cent level of probability.
17. Frequency of agri-expert system use by the respondents was found out. It could be evident that more than half of the respondents *i.e.* 60 per cent were using KAU expert systems occasionally and majority of the respondents i.e. 64 per cent were using Kissan Kerala expert system occasionally.
18. Nature of usefulness of agri-expert system by the respondents was found out. It could be evident that more than half of the respondents i.e. 53 per cent perceived that KAU expert systems were useful and majority of the respondents i.e. 64 per cent opined that Kissan Kerala expert system was useful.

19. The reasons for using the expert systems and ranking of those reasons by the respondents were done. It could be evident that most of the respondents ranked saves a lot of time as first ranked statement with the mean score 6.299 for using the expert systems. The Kendall's co-efficient of concordance which was used to verify whether there was agreement among the respondents in providing their rankings to the statements for using the expert systems. It was found that there was concordance in the rating/ranking of reasons for using agri-expert systems by extension professionals, front line extension personnel and scientists.
20. Regarding the respondent's stage in the different adopter categories, it was found that 10 per cent of the sampled respondents belonged to innovators category followed by early adopter category (19%), early majority category (32%), late majority category (24%) and laggards (15 %).
21. Correlation analysis revealed that out of 12 independent variables, only one variable namely innovativeness was positively and significantly related with extent of expert system's adoption among all three categories of respondents *viz.*, Extension professionals of state department of agriculture, front line extension professionals of KVK's and NGO's and scientists at one per cent level of probability.
22. Distribution of respondents based on effectiveness index of expert system application in agriculture was found out. It could be ostensible that majority of the respondents i.e. 62 per cent perceived that effectiveness index of expert system application in agriculture were medium. Effectiveness index of expert system application in agriculture and ranking of those statements by the respondents was done. It could be evident that most of the respondents' ranked pedagogy (As a means to effective learning through expert system) as first ranked statement.
23. The constraints experienced by extension professionals in using agri-expert systems and ranking of those constraints by respondents were done. It could be evident from the table 49 that the respondents ranked lack of proper training as the most important constraint.

In general, the results revealed a positive attitude towards expert system by most of the extension professionals either in State Department, NGO or University. Training, innovativeness, availability, accessibility, relevancy, format clarity, information content, accuracy and timeliness affect extension professionals' attitudes. The respondent's stage in the adopter categorisation with reference to expert systems revealed that 10 per cent of the sampled respondents belonged to innovators category, 19 per cent respondents belonged to early adopters' category, 32 per cent respondents belonged to early majority category, 24 per cent respondents belonged to late majority category and 15 per cent respondents belonged to laggards' category. Training, innovativeness, availability, accessibility, relevancy, format clarity, information content, accuracy and timeliness affect extension professionals' stage of adoption. Effectiveness index of expert system application worked out using seven statements showed that pedagogy (as a means to effective learning through expert system) had highest effectiveness index. The findings demonstrated that most of the respondents belonged to middle age category, holding with master degrees; attended training on ICT. It was also found that most of the respondents had high innovativeness and perceived that expert system had high accessibility, format clarity and information content. Availability, retrievability, relevancy, timeliness, accuracy and effectiveness index of expert system application were perceived medium by the respondents.

## 5.1. IMPLICATIONS OF THE STUDY

1. Results of the study accentuate the need for conducting still more comprehensive explorations among the different categories of users separately regarding the performance of agri-expert system in providing knowledge, solving problems and supporting for decision making.
2. Trainings attended on agri-expert systems were found as the common factor with high odds ratio influencing all the categories of users. Hence, proper training should afford for augmenting the usage of expert systems among users.

3. Expert system should cover all farmers' practices and subjects using advanced software packages and its performance shall be assessed among the users before and after release.
4. Expert systems should have more location and language specific versions of software on different crops to cater the needs of various categories of users.
5. The information provided in the expert system should be clear and easily understandable.
6. Before releasing agri-expert system among users, it is necessary to orient the prospective users about the operations of expert system in diagnosing and retrieving information to maximize the strengths and tap its opportunities effectively.
7. The study has pointed out that the application of agri-expert system has got tremendous scope among extension personnel to clarify their doubts, confirm their knowledge and provide real time information to the technology users. It could be used as a distance learning tool.
8. The study indicated that the users were most satisfied about the expert system and expressed that it has got field relevance. Because, the field problems and need of the user group were considered while constructing the questions. Therefore it is essential for computer-based decision aids to be more widely accepted, it must be developed in consultation with the potential user groups and other stakeholders early in the development process to address real problem and user demand.
9. The higher authorities should support the implementation of expert systems in all departments of agriculture for effective decision making.

## 5.2. SUGGESTIONS FOR FUTURE RESEARCH

1. As this study was confined to Thiruvananthapuram district of Kerala and similar studies should be initiated in other parts of the state.
2. Research activities can be initiated to develop more expert systems covering all crops for tackling the needs of users.

3. Maximum potential can be explored by making the users as partners in the development of agri-expert systems so that user friendliness of expert system can be ensured.
4. Similar studies should be done to assess the performance of other expert systems and to enhance the capability of extension professionals in utilizing agricultural expert systems for the benefit of farming community for decision making in various aspects of agriculture.
5. Since expert systems are viewed as tools for decision making, all the agri-expert systems can be used to assess the nature of support provided by these modules in making decision among the various categories of prospective users.

# *References*

## 6. REFERENCES

Abdon, B., Raab, R., and Ninomiya, S. 2006. E-Learning for International Agriculture Development: Dealing with Challenges, Conference paper, University of Tsukuba, Japan, pp. 25-31.

Abeyrathne, B.G.A., Najim, M.M.M. and Jayatissa, D.N. 2005. Development of a simple sprinkler system designing and pump selection expert system *(SSSDPS* Expert), Department of Agricultural Engineering, Faculty of Agriculture, University of Peradeniya, Peradeniya. Sri Lanka. Available: *http://www.gissl.lk/waterprofday/2005/webpaperswpd05.doc.* [23-02-14]

Aboh, C.L. 2008. Assessment of the frequency of ICT tools usage by Agricultural Extension agents in IMO state, Nigeria. *J. Agri. Soc. Res. (JASR)*, **8** (2):215

Adesope, O.M., Agumagu, A.C., and Adebayo, E.L. 2007. Extensionists and Researchers Proficiency Requirements in Information and Communication Technologies in South eastern Nigeria. *J. Extn. Systems*, **23** (1):55-69.

Adesope, O.M., Asiabaka C.C., and Agumagu, A.C. 2007. Effect of personal characteristics of extension managers and supervisors on information technology needs in the Niger Delta area of Nigeria. *International J. Educ. and Development using ICT*, 3 (2):68-72

Adhiguru, P. and Birthal P.S. 2006. ICT in agricultural development: Issues and Strategies, [abstract] In: *International Conference on Social Science Perspectives in Agricultural Research and Development,* February 15-18, 2006, IARI, New Delhi, India. 221p.

Adhiguru. P., Mruthunjaya and Birthal, P.S. 2003. Innovative Institutions for Agricultural Technology Dissemination: Role of Information and Communication Technology, National Center for Agricultural Economics and Policy Research, New Delhi.

Adzemi, M. Mustika, E.A and Abdullah, M. 2012. Expert System Land Evaluation for Oil Palm Cultivation (ESLEOP). *Journal of Environmental Science and Engineerin,* 1:216-227.

Agbonifo, O.C. and Olufolaji, D.B. 2012. A fuzzy expert system for diagnosis and treatment of maize plant diseases. *International Journal of Advanced Research in Computer Science and Software Engineering,* **2** (12):83-89.

Agwu, A.E., Uche M.U.C. and Akinnagbe, O.M. 2008. Use of Information Communication Technologies (ICTs) among Researchers, Extension Workers and Farmers in Abia and Enugu States: Implications for a National Agricultural Extension Policy on ICTs. *J. Agricultural Extn,* **12** (1):218-223.

Ahmadpour, A., Mirdamadi, M., Jamal, Hosseini, F. and Chizari, A. 2010. A Factor Influencing the Design of Electronic learning System in Agricultural Extension. *American J. Agric. Biol. Sci.,* **5** (2): 122-127.

Ahmed, M. 2012. Diffusion and Adoption of E-Extension Technology (Computers and the Internet) among Extension Agents in Extension Work in Sohag Governorate, Egypt. *Journal of Advanced Social Research,* **2** (2): 80-92.

Alemna, A.A. and Sam, J. 2006. Critical Issues for Rural Development in Ghana. Information Development, **22** (4): 236-241.

Ali, G.A. and Magalhaes. L. 2008. "Barriers to implementing e-learning: A Kuwaiti case study", *International Journal of Training and Development,* **12** (1): 36-53.

Al-Rani, S. 1990. An Examination of the Attitudes and Achievement of Students Enrolled in the Computers in Education Programme in Saudi Arabia. DAI, 51: 2715-A.

Amir, A. 2012. Agricultural extension workers attitude to and experience of e-learning. *African Journal of Agricultural Research,* **7** (24): 3534-3540.

Annamalai, K. and Rao, S. 2003. "What works: ITC's e-Choupal and profitable rural transformation: Web-based information and procurement tools for Indian farmers." World Resources Institute, Washington, D.C.

Arumugham, N.1995. Expert systems for irrigation management. PhD Thesis, Department of civil engineering, I1T, Madras, India, 154p.

Ayman, A.M. 2009. An Object-Oriented Expert System for Diagnosis of Fungal Diseases of Date Palm. *International Journal of Soft Computing,* **4** (5):201-207.

Bahal, R., Marwaha, S. and Wason, M. 2003. Expert system of extension. International Conference on Communication for Development in the

Information Age: Extending the Benefits of Technology for All, 07-09 January, Banaras Hindu University, Varanasi, India.

Balasubramanian, N., chandrakandan, K., Senthil kumar. M., Padma, S.R. and Padma, C. 2003. Expert system: an emerging tool for technology transfer in agriculture. [Abstract] In: *International Conference on agricultural policies and strategies for profitable farming,* 5-7th Dec; 2003. Gujarat Agricultural University, India. 90p.

Balasubramanian, N. 2004. 'Designing and testing the relative effectiveness of computer-based expert system *vis-a –vis* human expert on cognitive and connotative domains of rubber growers'. Ph.D. Thesis, Tamil Nadu Agricultural University, Coimbatore, 165p.

Baldwin-Evans, K. 2004. Employees and e-learning: What do the end users think? *Industrial and Commercial Training*, **36** (7): 269–274.

Batchelor, W.D., R.W.McClendon, J.W.Jones and D.B.Adams. 1989. An Expert Simulation System for Soybean Insect Pest Management. *Trans. ASAE*, **32** (1): 335-342.

Batchelor, W.D., Wetzstein, M.E. and McClendon, R.W. 199I. Economic theory and expert system information technologies in agriculture. *European Rev. of Agric. Econ,* **18** (2): 245-261.

Bell, Dhaliwal, R.B. and Atkimon, A. 2001. TropRice. *IRRIN,* 26 (2):13.

Bennett, T.B. and R.E.Sneed. 1988. An Expert System for Irrigation Planning and Design. *Trans. ASAE*, **88**: 5021.

Bergsma, K., Sargent, S., Brecht, J. and Peart, R. 2013. An expert system for diagnosing chilling injury of vegetables. HortScience, 48(2). February 2013.

Bertrand, S. 1987. "Expert systems accessible to all". Le Monde Informatique. November 23, 90p.

Bhatty, M. 1990. Hybrid Expert System and Optimization Model for Multi-purpose Reservoir Operation. Ph.D. Thesis, Dept. of Civil Engineering, Colorado State University, USA, 172p.

Boggess, W.G., Van, P.J., Blokland and Moss, S.D. 1989. FinARS: A Financial Analysis Review Expert System. Agricultural Systems, **31**: 19-34.

Bralts, V.F., Driscoll, M.A. Shayya, W.H. and Cao, L. 1993. An Expert System for the Hydraulic Analysis of Micro Irrigation Systems, 9 (4): 275-285.

Brenda, L. M. 1998. Computer Anxiety Levels of Virginia Cooperative Extension Field. Ph.D. Thesis, Virginia Polytechnic Institute and State University, Verginia.

Bundy. 1984. Intelligent Front-Ends. In: Expert System. Fox, J. (Editor), State of the Art Report, 12 (7), Perkshire, UK.

Castro-Tender, A. J. and Garcia-Torres, L. 1995. SEMAGI - an expert system for weed control decision making in sunflowers. Crop Protection, Elsevier Science Ltd, **14** (7):543-548.

Chakrabarti, D.K and Chakraborty, P. 2007. Field Note: A Disease Specific Expert System for the Indian Mango Crop. *Journal of Agricultural Education and Extension,* **13** (1):81-82.

Cheng-gang, Z., Zhao, N., Tian, G. and Yue, Y. 2004. The function of multi-medium and internet in the rural information services in the developing country. Jilin academy of agricultural sciences, Gong zhu ling, China. [On-line]. Available: *www.informatik.uni-trier.de/~ley/db/indices/a-tree/c/chen:Ganghtml.* [4.12.13]

Chen Xiaobin, Luo Qingwen, Jiang Yaopei, Lv Zhenmei and Wu Shuwen, A. 2008. , The 2nd International Conference on Web GIS Expert System for Rice Brown Plant hopper Disaster Early-Warning in China's Shanghai. Bioinformatics and Biomedical Engineering, ICBBE 2008: 2485-2488.

Chetsumon, S. 2005. Attitudes of extension agents towards Expert systems as decision support tools in Thailand. Ph.D. Thesis, Lincoln University, Thailand, 284p.

Christov. 1997. Precision of Information Technology for Crop Irrigation Scheduling and Fertilizing (ITCISF). In: *First European Conference for Information Technology,* 27-28th, June, 1997; Copenhagen.

Clarke, N.D., Tan, C.S. and Stone, J.A. 1992. Expert System for Scheduling Supplemental Irrigation for Fruits and Vegetable Crops in Ontario. *Can. Agric. Eng.,* **34**: 27-31.

Corona Saenz, T., Almaguer Vargas, G., and Maldonado Torres, R. 2000. Computerized expert system in nutritional diagnosis of orange trees. *Journal Terra,* **18** (2):173-178.

Cosmin, P. 2011. Adoption of Artificial Intelligence in Agriculture. *Bulletin UASVM Agriculture,* **68** (1): 284-293.

Cotrell, J. and Eisenberg, M.B. 1997. Web design for information problem-solving: Maximizing value for users. *Computers in libraries,* **17** (5): 52-57.

DeBra, P.M. 1996. Hypermedia structures and systems. (Web Course, Eidenhoven University of Technology). http://wwwis.win.tue.nl/ 2L670/static.

Dingchun, Yan., Yan, Z., Shaohua, W. and Weixing, C. 2006. A Quantitative Knowledge-based Model for Designing Suitable Growth Dynamics in Rice. Plant Production Science, **9** (2): 93-105.

Doluschitz, R. and Schmisseur, W.E. 1988. Expert systems: Applications to agriculture and farm management. Computers and Electronics in Agriculture, **2** (3): 173-182.

Durkin. 1994. *Expert System Design and Development.* Prentice Hall, New Jersy, 206p.

Eastmond, D.V. 1995. *Alone but together: Adult distance study through computer conferencing.* Hampton Press, New Jersey, 237p.

Edress, S.A., El-Sayed, E. and. Rafea, A. 2002. Expert system for paddy production, management. Central Lab for Agricultural Expert System (CLAES), El-Noor St., Dokki, Giza, EGYPT. [On-line]. Available: *http://www.claes.sci.eg/publication/AllPublications.* [24.11.13]

Elango, K., Honert, R. Kumar, C.N. and Suresh, V.1992. PC-based Management Game for Irrigated Farming. *J. Micro Computer Civil Engineering,* **7**: 243-256.

Elbert, C. and Antonie, J. 2012. An evaluative study of the United States cooperative extension services role in bridging the digital divide. *Journal of Advanced Social Research,* **2** (2): 80-92.

Engelhard, R. 2003. ICTS. Transforming agricultural extension, CTAS observatory on ICTs. 6th consultative expert meeting, Wageningen. 23-25 September, 2003. Available: http://www.cta.int/observatory2003/index.html

Everhart, N. 1997. Web page evaluation: Views from the field. *Technology Connection*, **4** (3): 24-26.

Express News Service (ENS). 2012. Agri info now a mouse click away. The New Indian Express. 29th Oct 2012. pp.5.

FAO. 1993. Production Year Book. 43: 8.

Fermanian, T.W., Michalski, R.S. and Katz, B.1985. An expert system to assist turf grass managers in weed identification. In: Summer Computer Conference, 22-24 July, Chicago, IL American Society of Agricultural Engineers, ST Joseph, MI: 499-502.

Fink, M. and Scharpf, H.C. 1993. N-Expert - a decision support system for vegetable fertilization in the field. *ISHS Acta Horticulturae*, **339**: 67-74.

Floris, V., D.Simons and R.Simons. 1988. Development of an Expert System for Mark Twain Reservoir Operation. In: Computerized Decision Support System for Water Managers. American Society of Civil Engineers, NY, USA.

Frempong, F.A., kwarteng, J., Agunga, R. and Zinnah, M.M. 2006. Challenges of Infusing Information and Communication Technologies in Extension for Agricultural and Rural Development in Ghana. *J. Extn. System*, **22**: 69-82.

Ganesan, V. 2007. Decision Support System "Crop-9-DSS" for identified crops. *World Academy of Science, Engineering and Technology*, **12**: 947-949.

Getforth, G. and Macvicer, T. 1988. An Operation's Advisor for Regional Water Management. In: Critical Water Issues and Computer Applications. American Society of Civil Engineers, NY, USA.

Ghosh, I. and Samanata, R.K. 2003. TEAPEST: An expert system for insect pest management in Tea. *Applied Eng Agric*, **19** (5): 619-625.

Gillard, P. and Salardini, A.A. 2001. Fertiliser Adviser Crops: an expert system for Tasmanian crops. Proceedings of the 10th Australian Agronomy Conference, Tasmania, Australia.

Gilmore, J.H. 1993. CD-ROM Technology and its uses. In: Swaminathan, M.S. (ed.), *Information Technology - A Dialogue.* Macmillan India Ltd, Madras, 264p.

Gonzalez-Diaz, L., Martinez-Jimenez, P., Bastida, F. and Gonzalez-Andujar, J.L. 2009. Expert system for integrated plant protection in pepper (*Capsicum annuun* L.). *Expert Systems with Applications,* **36** (5):8975–8979.

Gonzalez, A.J.L. 2009. Expert system for pests, diseases and weeds identification in olive crops. *Expert System with Applications: An International Journal*, **36** (2): 3278-3283.

Gutierrez Rojas, I. and Guevara Lopez, G.P. 1997. PIEX, an expert system to classify pineapple varieties. *ISHS Acta Horticulturae*, **425**:145-152.

Hadi, A.Z. 2006. Expert systems can reduce dependence on harmful pesticides. CGIAR News. September, 2006. [On-line]. Available: *http://www.cgiar.org/enews/september2006/story.html* [15-02-14]

Haie, N. and R.W. Irwin. 1988. Diagnostic Expert Systems for land drainage decisions. Irrigation and Drainage Systems, **2** (2): 139-146.

Hailemicheal, H.E. 2002. Decision making process of non-government organizations in Dharwad District. M.Sc (Ag.) Thesis, University of Agricultural Sciences, Dharwad, Karnataka (India), 136p.

Halterman, S.T. J.R.Barrett and M.L. Swearingin. 1988. Double cropping expert system. *Trans. ASAE*, **31** (3): 234-239.

Han, Y.J., J.Boomaerts, S.Nugroho, M.G.D.Christenbury and F.J.Wolak.1991. Development of an Expert System for Sprayer Diagnostics. *J. Applied Engineering in Agriculture*, **7** (5): 22-27.

Hart, W.E., Ekholt, B.A. and Kim, T.G. 1989. Irrigation System Selection. *Trans. ASAE,* paper No.89-7042. American Society of Agricultural Engineers, St. Joseph, MI.

Hasbini, B.A., G.W.Buchleiter and H.R.Duke. 1991. Expert System for Improved Irrigation Management. Proc. Int. Summer Meet. American Society of Agricultural Engineers, Albuquerque, New Mexico, June 23-26, pp. 1-17.

Hassan, N.S. 2008. Effective agricultural information delivery system-An action research among farmers. Ph.D Thesis, Kerala Agricultural University, Trivandrum, Kerala, 195p.

Hedjazi, Y., Rezaee, R. and Zamani, N. 2006. Factors Affecting the Use of ICTs by Iranian Agriculture Extension Specialists. *J. Extn System,* **22**:1-15.

Helen, S. 2008. Agricultural Expert System- A Participatory Assessment. Ph.D. Thesis, Kerala Agricultural University, Trissur, 158p.

Helms, G.L., J.W.Richardson, M.J.Cochran and M.E.Rister. 1990. A Farm Level Expert Simulation System to Aid Farmers in Selecting among Crop Insurance Strategies. Computers and Electronics in Agriculture, **4** (3): 169-190.

Hershaeur, J., Karim, A., Owens, H. and Philipakis, A.1989. A Field Observation Study of an Expert System Prototype Development. Inform. Manage, **17**: 107-116.

Heong, K.L., Harris, K.M. and Scott, P.R. 1989. Sources of Rice Crop Protection Information. Crop Protection Information: An International Perspective. In: Proceedings of the International Crop Protection Information Workshop held at CAB International, Wallingford, UK, April 1989. pp.51-66.

Hicks, H.G. and Gullet C.R. 1981. *Management.* Mc Graw. Hill Kogkusha Ltd, Tokyo. 571p.

Hinge, R.B. 2009. Diffusion and adoption of wine grape production technology in Maharashtra. M. Sc (Agri.) Thesis, University of Agricultural Sciences, Dharwad, Karnataka (India), 135p.

Hogan, R., Scott, S., Kelly, B. and James, M. 2005. Reducing the cost of cotton production. Delta Farm Press. [On-line]. Available: *http://www.aaai.org/AITopics/newstopics/expert.html* [23-02-14]

Huber, U. 1990. A Review of Artificial Intelligence and its Potential Uses in Farming. Berichte uber Landwirtschaft, **68** (4): 554-566.

Hu Quansheng and Zhang, X. 1993. ESRICE and expert system for management of rice pest insects – design and implementation. *Chinese J. Rice Sci.,* **7** (3):159-166.

Islam, S., Hari, O., Agarwal, Vipin, K.D. and Sharma, J.P. 2006. Expert system on wheat crop management: an effective tool tor transfer of Technology and Information Management. [abstract] In: *International Conference on Social*

*Science Perspectives in Agricultural Research and Development.* 15-18th Feb, 2006, Division of Computer Application, IASRI, New Delhi. p.237.

Jacobson, M.J., Maouri, C., Mishra, P. and Kolar, C. 1995. Learning with hypertext learning environments: Theory, design, and research. *Journal of Educational Multimedia and Hypermedia*, **4** (4): 321-364.

Jadhav, S.K., Yelapure, S.J. and Babar, V.M. 2011. Rule based Expert System in the Use of Inorganic Fertilizers for Sugarcane Crop. *International Journal of Computer Applications,* **36** (4): 58-64.

Jensen, R. 2007. The Digital Provide: Information (Technology) Market Performance, and Welfare in the South Indian Fisheries Sector. *The Quarterly Journal of Economics,* **122** (3): 879-924.

Jiajia, H., Dongmei, L., Shudong, H., Na Li. and Qin Mo. 2013. Construction and application of the expert system of diagnosis for orchard pests and diseases. *Journal of Chemical and Pharmaceutical Research,* **5** (11):112-117

Jones, M.G. and Farquhar, J.D. 1997. User interface design for web-based instruction. In B. H. Khan (Ed.) Web-Based Instruction, Englewood Cliffs, NJ: Educational Technology Publications, New York, 98p.

Jones, P. and J. Halderman. 1986. Management of Crop Research Facility with a Micro Computer-based Expert System. *Trans. ASAE,* **29** (1): 235-242.

Kamath, Rajagopal. 2003. A study of Management information systems in the public sector enterprises in Kerala. Univ of Kerala, Trivandrum, pp. 39-67.

Kaushik, P.D. and Singh, N. 2004. Information Technology and Broad-Based Development: Preliminary Lessons from North India. *World Development,* **32:**591-607.

Kerlinger, F.N. 1983. Foundations of Behavioural Research. Holt, Ranhart and Winston, New York, p.531

Khan, F.S., Saad, R., Kashif, I., Fahad, M., Ahmad, F., Inam, I. and Tauqeer ul, A. 2008. Dr. Wheat: A Web-based Expert System for Diagnosis of Diseases and Pests in Pakistani Wheat. Proceedings of the World Congress on Engineering WCE, 1, 2 – 4 July, London, U.K.

Kikon, W. 2010. Adoption gap in groundnut production in Northern Transition zone of Karnataka. M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad, 141p.

King, J.P., I.Broner, R.L.Croissant and C.W.Basham. 1991. Malting Barley Water and Nutrient Management Knowledge-based System. *Trans. ASAE*, **34** (6): 2622-2630.

Kiran, T.R. 2007. Perception of Organizational climate by Scientists of Univ. Agric. Sci., Dharwad. M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad, 135p.

Knight, J.D and Mumford, J.D. 1994. Decision support system in crop protection. *Outlook Agric*, **23** (4); 281 -285.

Kumar, D., Heatwole, C.D. Ross, B.B. and Dillaha, T.A. 1992. A Knowledge-based System for Preliminary Selection and Economic Evaluation of Sprinkler Irrigation Systems. *Trans. ASAE*, **35** (4): 441-447.

Kurata, K., Nakano, K., Higuchi,Y. and Wang, M.H. 1989. Studies on development of expert systems for the agricultural field. In: International Proseedings of the Symposium on Agricultural Engineering, Beijing, China. **2**: 1010-1013.

Lakshminarayan, M. T. 1992. Extension Teaching methods used by Agricultural Assistants. M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Bangalore, 146p.

Lemmon, H.E. 1986. COMAX : An Expert System for Cotton Crop Management. Science, **233**: 29-33.

Liping, Z. 2003. Preliminary research on the method of identifying accuracy of agricultural expert system. Anhui academy of agricultural sciences. 354p. [On-line]. Available: *http://www.zoitshoku.narc.affrc.go.jp/adr/p354.pdf.* [07-12-13]

Lippke, L.A. and Rister, M.E. 1992. *Use of in/ormation systems by Texasfarmers and ranchers [Abstract]*. Faculty Paper Series No. FP-92-4. Department of Agricultural Economics, Texas A and M university.

Li-qing, HUANG Xi-yue, GU Qing-jun and ZHENG, G. 2001. Expert System of Multimedia Orange Planting. *Journal of Chongqing University*, Natural Science Edition, 3: 235-239.

LI Quan. 2008. Research Development of Agriculture Expert System in Chinese Country. *Journal of Henan Mechanical and Electrical Engineering College*, **6**: 64-78

Lukeeram, I., Bheenick, K.J. and Travailleur, C. 2000. Combining audio files and graphics on the web to increase accessibility to agricultural information for the non-english speaking and the non- literate farmers in Mauritius: a practical example with PETIS (Potato Extension and Training Information System). In: *Proceedings of 2nd Global Knowledge Conference*, 7-10th Mar, Kuala Lumpur, Malaysia. 222p.

Lynch, T., Gregor, S. and Midmore, D. 2000. Intelligent Support Systems in Agriculture: How Can We Do Better? Special Issue: Improving Agricultural Practices and Decisions. *Australian Journal of Experimental Agriculture*, **40** (4): 609-620.

Mabe, L.K and Oladele, O.I. 2012. Awareness level of use of Information Communication Technologies tools among Extension officers in the North-West Province, South Africa. *Life Science Journal*, **9** (3):440-444.

Mahaman, B.D., Passam, H.C., Sideridis, A.B. and Yialouris, C.P. 2003. DIARES-IPM: a diagnostic advisory rule-based expert system for integrated pest management in *Solanaceous* crop systems. Agricultural Systems, **76** (3):1119–1135.

Mansingh, G. Reichgelt, H. and Kweku-Muata, O.B. 2007. CPEST: An expert system for the management of pests and diseases in the Jamaican coffee industry. *Expert Systems with Applications*, **32** (1):184–192.

McClendon, R.W., W.D.Batchelor and J.E.Hook. 1989. An Expert Simulation System for Irrigation Management. Proc. Int. Winter Meet. American Society of Agricultural Engineers, 12-15 December, New Orleans, LA.

McGregor, M.J. and P.K.Thornton. 1990. Information Systems for Crop Management: prospects and problems. *Journal of Agricultural Economics*, **41** (2): 172-183.

Meera, S.N., Jhamtani, A., and Rao. 2004. Information and Communication Technology in Agricultural Development: A comparative analysis of three projects from India. Agricultural research and extension network, IARI, New Delhi, paper no. 135, pp. 20-27

Meera, S.N., Sain, M., Muthuraman, P., Kumar, A.S., Sailaja, B., Jyothi, S.S.P. and Viraktamath, B.C. 2010. Critical analysis of e-Learning Opportunities and e-Readiness in the public extension system: Empirical Evidence from Tamil Nadu. *J. Global Communication*, **3** (2):11-18.

Mercy, N.R.P., Rajesh, T and Saravanan, R. 2011. Expert Systems in Agriculture: A Review. *Journal of Computer Science and Applications.* ISSN 2231-1270. **3**: 59-71.

Merrill. E.W., Nair, P.K.R., Stephen, R.R. and Kristopher. S. 1990. A knowledge based expert system for planning and design of agroforestry systems. Agroforestry Systems, **11** (1):71-83.

Michailidis, A. 2007. Adoption of internet in agriculture. *J. Extn. System*, **23** (1): 1-13.

Mohan, S. and Arumugam, N. 1994. CROPES: A Rule-based Expert System For Crop Selection In India. *Trans. ASAE*, **37** (4): 1355-1363.

Mohan, S. and Arumugam, N. 1995. An Intelligent Front-End for Selecting Evapotranspiration Estimation Methods. Comp. Electron. Agric., **12**(4): 295-310.

Morgan, C.T., King, A.R., Weisz, R.J. and Schopter, J. 1956. Sensory processes and perception. *Introduction to Psychology.* ($7^{th}$ ed). $25^{th}$ reprint 2004. Tata Mc Graw- Hill Publishing Company Limited, New Delhi. 724p.

Morgan, O.W., M.J.McGregor, M.Richards and K.E.Oskouri. 1989. SELECT : An Expert System Shell for Selecting amongst Decision or Management Alternatives. Agricultural Systems, **31**: 97-110.

Mousavi R,S.J., Akhlaghian Tab, F. and Mollazade, K. 2012. Design of an Expert System for Rice Kernel Identification using Optimal Morphological

Features and Back Propagation Neural Network. *International Journal of Applied Information Systems (IJAIS),* 3 (2): 2249-2268.

Muilenburg, L.Y. and Berge, Z.L. 2005. "Student barriers to online learning: A factor analytic study". Distance Education. **26** (1): 29-48.

Murali, G. and Venkataramaiah, P. 2008. Relationship between profile characteristics of students with their exposure to agricultural websites. *Indian Psychological Review,* **70** (2): 91-94.

Murthy, L. and Srinivasacharyulu, A. 1998. Transferring agricultural information. *Ext. Digest,* **5** (5): 3.

Musaazi. E. and Reichgelt. H. 1999. An expert system for controlling the diamondback moth in Jamaica. *Jamaican Journal of Science and Technology,* **10**: 86-93.

Nagalaksmi. C. 2008. Integrating ICT with multiple functions for Agriculture Development. M.Sc. (Agri.) Thesis. University of Agricultural Sciences. Bangalore. 152p.

Nair, R.R. 2004. An investigative and evaluative study of factors affecting quality of agricultural and farm information services in Kerala. Ph.D Thesis, University of Kerala, TVM. pp 37-129.

Nakamura, R. and Tsukiyama, H. 1992. Analysis by an Expert System of Initial Irrigation Canal Renovation Project Planning. Water Resource Research, **6** (3): 223-233.

Ndag, I., Sanusi, R.A. and Aigbekaen, E.O. 2008. Comparative Analysis of Information and Communication Technology (ICT) Use by Agriculture Extension Workers. Paper presented in: *19th Annual International Information Management Association*, October, Carlifornia, United States of America, pp. 13-15.

Ndubisi, N. 2004. Factors influencing e-learning adoption intention: Examining the determinant structure of the decomposed theory of planned behaviour constructs, University Malaysia Sabah, F.T. Labuan, Malaysia, pp. 252-261.

Nebandahl, D. 1988. Expert Systems: Introduction to the Technology and Applications, Wiley, London, 209 p.

Nevo, A. and I.Amir. 1991. CROPLOT : An Expert System for Determining the Suitability of Crops to Plots. Agricultural System, 37: 225-241.

Nielson, J. 1997. Be succinct! (Writing for the web). Alertbox [WWW document]. http://www.useit.com/alertbox/9703b.html

Nitin, K., Binod, K. and Keshao, K. 2013. An expert system approach for improvement of agriculture decision. *International Journal of Artificial Intelligence and Expert Systems (IJAE),* **5** (1): 8-12

Nokker, D. 2004. Horti-plan Mobile Gully System, *Fruit and Vegetable Technology*, **4** (5): 10-13.

Nureize Binti Aibaiy. 2004. Pest activity prognosis in rice fields using fuzzy expert system approach. M. Sc. Thesis. University of Utara Malaysia.

Nuthall, P.O. and G.J. Bishop-Hurley. 1996. Expert Systems for Animal Feeding Management - Part II - Farmer's Attitudes. Computers and Electronics in Agriculture. **14**: 23-41.

Omidi Najafabadi. M.. Farajollah Hosseini. J.. Mirdamadi, M. and Moghadasi, R. 2008. Designing an Efficient Information and Communication Technology (ICT) System to Train Private Agricultural Insurance Brokers in Iran. *Australian J. Basic Appl. Sci.,* **2** (4): 1041-1051.

Ortt, J. and Schoormans, J. P. L. 2004. The Pattern of Development and Diffusion of Breakthrough Communication Technologies. *European Journal of Innovation Management*, **7** (4): 292.

Oswald, O.1990. An Expert System for the Diagnosis of Tank Irrigated Systems: A Feasibility Study. Ph.D. Thesis, Center for Water Resources, Anna University, Madras, India, 184p.

Paarlberg, D. and Paarlberg, P. 2000. The agricultural revolution of the 20th Century. Ames, Iowa: Iowa State University Press, Ames, 154p.

Palmer, R.G. 1986. How Expert System can Improve Crop Production. *Agric. Eng.,* **67** (6): 28-29.

Pandey, R. and Mehta, S. 2002. Awareness of Educational Technologies in Open Learning System by Target Group. *Indian Journal of Social Research*, **43** (3):183-189.

Paris, P. 2004. E-Learning: A study on Secondary Students' Attitudes towards Online Web Assisted Learning. Int. Educ. J., **5** (1): 98-112.

Pasqual, G.M. 1994. Development of an Expert System for the Identification and Control of Weeds in Wheat, Barley and Oat Crops. *Computers and Electronics in Agriculture,* **10** (2): 117-134.

Patterson, D.W. 2004. Introduction to Artificial Intelligence and Expert Systems. Prentice-Hall: New Delhi, 174p.

Perrier, X., Lacoeuilhe, J.J. and Malézieux, E. 1993. An expert system for pineapple disorder diagnosis. ISHS Acta Horticulturae. **334**: 197-204.

Plant. R.E.. Horrocks. R.D.. Grimes. D.W. and Zelinski. L.J. 1992. CALEX/Cotton: An Integrated Expert System Application for Irrigation Scheduling. American Society of Agricultural Engineers, **35** (6): 1833-1838.

Plant. R.E. and Stone. N.D. 1991. *Knowledge-based systems in agriculture.* McGraw-Hill. New York. 245p.

Prasad Babu. M.S.. Anitha and Hari Krishna, K. 2010. A Web Based Sweet Orange Crop Expert System using Rule Based System and Artificial Bee Colony Optimization Algorithm. *International Journal of Engineering Science and Technology*, **2** (6):2408-2417.

Prasad Babu M.S., Ramana Murty, N.V and Narayana, S.V.N.L. 2010. A web based tomato crop expert information system based on artificial intelligence and machine learning algorithms. *International Journal of Computer Science and Information Technologies*, **1** (1):6-15.

Prasad, G. N. R. and Vinaya Babu, A. 2006. A Study on Various Expert Systems in Agriculture. *Computer Sci. and Telecommunications. Georgian Electronic Scientific Journal,* **4** (11): 81-86. [On-line]. Available: *http://www.intue.ac.uk/sciences/cgi-ibn/search.* [18-11-13]

Prasad, R and Sinha, A.K. 2003. Role of expert systems in natural resources management. [On-line]. Available: *http://www.gisdevelopment.net/application/nrm/overview/ma03130.htm.* [11-02-14]

Rafea, A. 1994. Agricultural expert systems development in Egypt. *Proceedings of International Conference on Expert Systems for Development*, Egypt, pp. 281-285.

Rafea, A., El–Azhari. S., Ibrahim, I., Edres, S and Mahmoud, M. 1995. Experience with the development and deployment of expert systems in agriculture. Paper presented at the Conference on Innovative Applications of Artificial Intelligence (IAAI), Montreal Quebec, Canada

Rafea, A. 1996. Natural Resources Conservation and crop management Expert Systems. *Paper presented at the Workshop on Decision Support Systems for Sustainable Development*. UNU/IIST. Macau.

Rafea, A. 1996. LIMEX: An Integrated Expert System with Multimedia. [Online]. Available: *http://www.claes.sci.eg/claes/limex.html.* [21-12-13]

Rafea. A.. Ali. A.S.. Jon. A. M. and Rick. W. 2000. Expert systems in agriculture. [On-line]. Available: *http://www.claes.sci.eg/expertsystem/cuptex.html.* [23.12.13]

Rajotte, E.G., Bowser, T., Travis, J.W., Crassweller, R.M., Musser, W., Laughland, D. and Sachs, C. 2005. Implementation and adoption of an agricultural expert system: In: Symposium on Computer Modeling in Fruit Research and Orchard Management. Ishs Acta Horticulturae. The Penn State Apple Orchard Consultant. 313p.

Raman, H., Mohan, S. and Rangacharya, N.C.V. 1992. Decision Support for Crop Planning During Droughts. *J. Irrig. and Drain. Engng,* **118** (2): 229-241.

Rao, M. 2000. A Study on the Communication Techniques used by the Agricultural Assistants of KSDA in Dharwad district. M. Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad, 135p.

Rao, P. J. 2003. Expert sytems in agriculture. MANAGE. [Online]. Available: *http://www.manageagri.com.* [04-01-14]

Rao, V.K.J., Ramachander, M.J., Gowda, C. and Achalaparipuma. 1999. Extension through expert system: new Vistas. *J. Ext. Edn.,* **10** (4): 2626-2627.

Ravisankar, H., Sivaraju, K., Krishnamurthy, V. and Raju, C.A. 2010. Expert System for Identification and Management of Abiotic Stresses in Tobacco (*Nicotiana tabacum*). *Indian Journal of Agricultural Sciences,* **80** (2).154-159.

Risdon, P. 1994. Transferring technology through the Internet channel. *Journal of Extension,* [On-line], 32(1). Available at: *http://www.joe.org/joe/1994june/a1.html* [12-02-14]

Robinson, B. 1996. "Expert systems in agriculture and long-term research". Can. *J. Plant Sci.,* **76**: 611–617.

Rogers, M.E. and Shoemaker, F. 1971. *Communication of Innovations – A Cross Cultural Approach.* The Free Press. New York, 252p.

Rolling, N. 1980. *Extension Science–Information Systems in Agricultural Development.* New York: Cambridge, 189p.

Royer. T.A.. Giles. K.L.. Elliott. N.C. and Kindeler. D. 2002. The cereal aphid expert system and glance n' go sampling for green bugs: questions and answers. Cooperative Extension Service. Extension factsheets. CR-7191.

Sadagopan, S. 1998. *Management Information Systems.* Prentice Hall of India Pvt Ltd, New Delhi. 217p.

Salau, E.S. and Saingbe, N. D. 2008. Access and Utilization and Communication Technologies (ICT) Among Agricultural Researchers and Extension Workers. *PAT:* **4** (2):1-11.

Samer, M., Hatem, M., Grimm, H., Doluschitz, R. and Jungbluth, T. 2012. An expert system for planning and designing dairy farms in hot climates. *Agric Eng Int: CIGR Journal*, **14** (1): 65-72.

Saravanan, R. 2010. *ICTs for Agricultural Extension- Global Experiments, Innovations and Experiences*, New India Publishing Agency (NIPA), New Delhi. p. 557.

Sarma, M.V.S. 2003. Present Scenario, gaps and thrust areas of ICT in Agriculture. In: *Compendium of Lectures of workshop on Information technology for dissemination of scientific knowledge in agriculture.* 17th Sep, 2003. National Research Center on Equines, Hissar. pp 12-19.

Sathiyaseelan, R. 1998. An Experimental Study on Sunflower Extension Methodology. Ph.D. Thesis, TNAU, Coimbatore.154p.

Schultz, T.W. 1981. *Investing in People – The Economics of Population Quality.* Berkeley: University of California Press, California.

Selvakumar, A., Arul, L.N. and Mohammed, G. 2011. An implementation of expert system in garlic using (ABC) Algorithm. Electronics Computer Technology (ICECT), 3rd International Conference. **1**:45-48.

Senthilkumar, M. 2000. Mass media utilisation behaviour of farmers- An analysis. Unpub, AC&RI, TNAU, Coimbathore.

Senthilkumar, M. 2003. Field testing Cyber Extension Techniques for Transfer of Farm Technology - A Feasibility Study. Ph.D. Thesis, TNAU, Coimbatore.160p.

Senthilkumar, S. 2004. Information technology in extension education. *Agrl. Ext. Rev.*, **16** (3): 3-5.

Shashaani, L. 1994. Gender-differences in computer experience and its influence on computer attitudes. *J. Educ. Comput. Res.*, **11** (4): 347-367.

Shen, Z. 2003. CD-ROM products of information and identification systems for pest management. IPMIST Laboratory, Department of Plant Protection, The China Agricultural University, Beijing, China. [On-line]. Available: *http://www.zin.ru/conferences /irsb/irsbk-i.htm.*[24.11.05]

Shroyer, J.P., S.C.Young and T.S.Cox. 1987. WHEAT WIZ: A Computer-based Cultivar Selection Tool. Applied Agricultural Research, **2** (4): 242-247.

Singh, R.K.J., Devi, T.M. and Raychaudhury. 2009. Use of Internet based e-Resources at Manipur University: A Survey. Annuals of Library and Information Studies. **56**: 52-57.

Sittieha, F., Kudang B.S and Suryo, W. 1999. Expert System for Identification of Red Pepper Plant (*Capsicum annum* L.). Buletin Keteknikan Pertanian. **13**(3): 26-30.

Soekartawi. 2005. "Constraints in implementing 'e-learning' using WebCT: Lessons from the SEAMEO Regional Open Learning Center". *Malaysian Online Journal of Instructional Technology.* **2**(2): 97-105.

Srinivasan, R., Engel, B.A. and Pandyal. G.N. 1991. Expert System for Irrigation Management (ESIM). Agricultural Systems, **36**: 297-314.

Stone, N.D. and T.W.Toman. 1989. A Dynamically Linked Expert-Data base System for Decision Support in Texas Cotton Crop Production. Comput. Electron. Agric., **4:** 139-148.

Sudaryanto. 2011. The need for ICT education for managers or agri-businessmen for increasing farm income: Study of factor influences on computer adoption in East Java farm agribusiness. *International Journal of Education and Development using Information and Communication Technology (IJEDICT),* **7** (1): 56-67.

Sunil, V.G. 2006. Design and Validation of an Information and Decision Support System for Banana Cultivation. Ph.D Thesis. Indian Institute of Agriculrure Research. New Delhi. 118p.

Thambiratti. 2008. Teaching English using Information and Communication Technology. *Journal of Extension and Research*, 10(1and2): 99-101.

Thammi Raju, D. and Sudhakar Rao, B. 2006. An information technology enabled Poultry Expert System: Perceptions of veterinarians and veterinary students. *International Journal of Education and Development using Information and Communication Technology.* (IJEDICT), **2** (2): 100-107.

Thangaraja, K., Karthikeyan, C., Asokhan, M. and Rajasekaran, R. 2008. Study on the Utilization Behaviour of Online Journals by the Students of TNAU. *The Madras Agric. J.*, **95** (1-6): 114-119.

Thomas, J. and Daney, J. 2002. What is the Role of Extension Educations in the First Decade of the 21st century (Online). http://www. aiaee.org/2002/thomas442-450.pdf.

Thomson, R. and Cats-Baril, W. 2003. *Information technology and management.* (2nd ed.), McGraw-HillIrwin, New York, 165p.

Travis, J.W. 1992. A Working Description of the Penn State Apple Orchard Consultant, An Expert System. *Plant Dise.,* **76** (6):37.

Turban and Aronson. 2001. *Expert systems and applied artificial intelligence.* Maxwell Macmillan international, Newyork. [online]. Available: *http://www.aaai.org/AITopics/html/expert.html#readon* [05-04-13]

Turban, E. 1993. *Decision support and expert systems: Management support systems.* Macmillan, New York, 164p.

Uma Rani, K. and Sai Maheswari, K. 2010. Awareness and Adoption of Technologies by Women Headed Households. *Journal of Agricultural Extension Management,* **11** (2): 71-76.

USDA. [United States Department of Agriculture]. 2005. Maximum yield/minimum resources farm advisors. EXSYS case study. Agricultural Research Service. US Dept. of Agriculture and National Peanut Research Laboratory. [On-line]. Available: *http://www.exsys.com/pdf/CaseStudies.pdf* [02.11.13]

Vecino. BJ. 1989. Artificial intelligence in agriculture: prospects for expert systems. *Revista-de-Estudios-Agro-Sociales.* **1** (4): 60-77.

Vinod, K., Sushma, L., Ashok, K.S., Meena, P.D. and Arvind. K. 2008. Image Based Rapeseed-Mustard Disease Expert System: An Effective Extension Tool. *Indian Res. J. Ext. Edu.*, 8 (2&3). May & September 2008.

Wagner, W.P., Chung, Q.B. and Najdawi, M.K. 2003. The Impact of Problem Domains and Knowledge Acquisition Techniques: A Content Analysis of P/OM Expert System Case Studies, **24** (1): 79-86.

Wai, K.S., Abd, L.B., Abdul, R., Mohd, F.Z and Azwan, A.A. 2000. Expert System in Real World Applications. [On-line], Available: *http://www.scolar.lib.vt.edu/thesis/available/etd.pdf.* [13-3-14].

Warren, M. 1999. Virginia Integrated Pest Management expert for Wheat. Ph.D Thesis. Blacksburg, Virginia. [On-line]. Available: *http://www. Scholar.lib.vt.edu/theses/available/etd-071699152027/* [09.02.2013].

Waterman, D. A. 1986. *A guide to expert systems.* Addison Wesley Reading, MA. p. 419.

Wegner, D.M. and Guliano, T. 1982. The Forms of Social Awareness. *Personality and Social Psychological Bulletin,* **19** (3): 320-330.

Wims, P. 2007. Analysis of Adoption and Use of ICTs among Irish Farm Families. *J. Extn. Systems,* **23** (1):14-27.

Woods, J., Raab, R.T. and Abdon, B. 2002. ICTs, e-learning, and simulations: Bringing knowledge-intensive management to Asian agriculture, Paper presented at International Federation of Information Processing 9.4 Conference, Bangalore, India, pp. 28-31.

Yadav,V.K., Sudeep, M., Sangit, K., Kumar, P., Jyoti K., Parihar, C.M. and Supriya, P. 2012. Maize AGRIdaksh: a farmer friendly device. *Indian Res. J. Ext. Edu.*, **12** (3): 69-75.

Yaghoubi, J. 2009. Assessment of agricultural extension and education graduate students' perceptions of e-learning in Iran. *Procedia Soc. Behav. Sci.*, **1** (1): 1914-1918.

Yaghoubi, J., Shokri, M.E. and Gholiniya, M. 2011. Assessing agricultural insurance agents attitude towards e-learning application in teaching them. Procedia Soc. Behav Sci., **15**: 2923–2926.

Yelapure, S. J. and Kulkarni, R.V. 2012. Literature Review on Expert System in Agriculture. *International Journal of Computer Science and Information Technologies*, 3 (5): 5086-5089.

Yialouris, C.P., Passam, H.C., Sideridis, A.B. and Mėtin, C. 1997. VEGES-A multilingual expert system for the diagnosis of pests, diseases and nutritional disorders of six greenhouse vegetables. Computers and Electronics in Agriculture, **19** (1): 55-67.

Yi-shan LI and Li-fang HONG. 2011. Development of a non-pollution orange fruit expert system software based on ASP.NET. Agricultural Sciences in China, **10** (5): 805-812.

Zijp, W. 1994. Improving the Transfer and Use of Agricultural Information: A Guide to Information Technology. World Bank Discussion Papers. 105 p.

# *Appendices*

# APPENDIX I

**KERALA AGRICULTURAL UNIVERSITY**
College of Agriculture, Vellayani, Thiruvananthapuram. 695 522
DEPARTMENT OF AGRICULTURAL EXTENSION

**Dr. Allan Thomas**
**Assistant Professor and Chairman**

Date: 27/9/2013

Sir,

**Greetings.**

Sir/Madam,

**Sri. M. Ravi Kishore (Ad. No. 2012-11-161)**, one of the M.Sc. Scholar, Department of Agricultural Extension, College of Agriculture, Vellayani is undertaking a research study entitled "Innovations in e-Agricultural Extension Technology (e-AET): Diffusion and adoption of agri-expert systems among extension professionals in Kerala" as part of his PG research work.

After extensive review of the available literature and discussion with extension scientist's and other experts, variables supposed to have close association with the study have been identified.

Considering your vast experience and professional expertise you have been selected as a judge to rate the relevancy of the variables. I request you to kindly spare some of your valuable time for examining the questionnaire critically. Kindly return the list duly filled at the earliest.

Thanking you.

Yours sincerely

(Allan Thomas)

## OPERATIONAL DEFINITION AND OBJECTIVES OF THE STUDY

In this study an expert system is operationally defined as a computer programme that is designed to emulate the rational thinking processes that an expert would use to solve a structured problem in his/ her field of expertise in agriculture, using specific software technology for the benefit of farming community.

The objective of the study is to suggest measures to enhance the capability of extension professionals in utilizing agricultural expert systems for the benefit of farming community for decision making in various aspects of agriculture. For this, a systematic appraisal of existing expert systems in agriculture vis a vis their diffusion among the extension professionals will be studied. This study also will attempt to reveal the potential impact in the field of Kerala agriculture with policy suggestions to scale up its use.

**Please rate the independent variables to be included in the study based on its relevancy from the most relevant to the least relevant by ticking against each variable under the respective rating scale.**

| Sl. No. | Independent variables | Most Relevant | Relevant | Least Relevant |
|---|---|---|---|---|
| 1 | **Age**- number of calendar years completed by the respondent at the time of investigation | | | |
| 2 | **Education**- It refers to highest academic qualification possessed by the extension personnel | | | |
| 3 | **Occupation**- the main vocation and other additional vocations that the respondents were possessing at the time of interview | | | |
| 4 | **Quick Availability**- Expert system can be written much faster than a conventional program, by users or experts, bypassing professional developers and avoiding the need to explain the subject. | | | |
| 5 | **Reliability**- it was defined as information free from errors and biases at acceptable degree of | | | |

| | | | | |
|---|---|---|---|---|
| | confidence | | | |
| 6 | **Retrievability-** It is operationalized as finding out the required information without much effort. It is the extent to which the information was easily drawn from the Agricultural Expert System. | | | |
| 7 | **Relevancy-** Relevancy was defined as the opinion of the respondents about the suitability of the information provided in Agricultural Expert System to the users' situation. | | | |
| 8 | **Experience-** It refers to the total years of experience in the use of expert systems. | | | |
| 9 | **Practicability-** The dimension of practicability was measured whether the information provided in the AES was adoptable in the real situation and feasible to the users. | | | |
| 10 | **Information content-** Information content was measured as the extent to which the information on the subject matter was covered in the AES. | | | |
| 11 | **Availability-** It is operationalized as expert system offered with reasonable proximity and appropriate hardware and software | | | |
| 12 | **Knowledge gain-** Knowledge gain was the quantity of information gained by the respondent. A standardized knowledge test was conducted among the respondents to assess the information gain from the Agricultural Expert System. | | | |
| 13 | **Achievement motivation-** It is defined as the degree of the respondent to excel in using expert system regardless of social rewards | | | |
| 14 | **Extension participation-** Extension personnel gain a lot of information especially on expert systems by participating in extension programmes organized by state and national departments of agriculture, which would help them in problem solving. | | | |
| 15 | **Extension contribution-** extent of contribution of technology for expert systems as perceived by the extension agents | | | |
| 16 | **Inventorisation** - extent of inventorisation of expert systems in the field of agriculture. | | | |
| 17 | **Extension experts' skill related to e-learning** extent of skills possessed by respondents related to e-learning. | | | |
| 18 | **Attitude towards expert systems-** type of attitude possessed by the respondents towards expert systems. | | | |

| | | | | |
|---|---|---|---|---|
| 19 | **Awareness on expert systems-** extent of awareness possessed by extension professionals on different expert systems using in the agriculture. | | | |
| 20 | **Risk orientation-** degree of uncertainty involved in expert system's usage for problem solving in the field of agriculture. | | | |
| 21 | **Mass media participation-** degree of exposure to different mass media sources by the extension professionals to get the information on expert systems and its applications. | | | |
| 22 | **Accessibility-** it refers to ability to access the expert system | | | |
| 23 | **Credibility-** It meant the extent to which a communication source was preferred as trustworthy and important by receivers of the information | | | |
| 24 | **Timeliness-** It defines timeliness as the information provide when it is needed | | | |
| 25 | **Adequacy-** if a report or information delivered covers all related aspects about a particular event or situation it is reporting has adequacy | | | |
| 26 | **Accuracy-** any inaccurate information leads to faulty decisions, so accurate information is needed for successful decision making | | | |
| 27 | **Explicitness-** it refers to the content in the expert system that does need further classification | | | |
| 28 | **Format clarity-** it refers to the extent to which the information given is in clear format which help the receiver to solve problem | | | |
| 29 | **Cost effectiveness-** it states that cost effectiveness of information is derived when its benefits outweighed its cost of gathering | | | |
| 30 | **Interactiveness-** it is operationalized as the extent to which the system provides for interacting with the user, experts | | | |
| 31 | **Up to datedness-** It refers to the currency of information delivered by the expert system | | | |
| 32 | **Efficiency-** efficiency of an expert system is defined by its ability in obtaining information in the right manner | | | |
| 33 | **Physical compatibility-** it is the degree to which the expert system is perceived as consistent with the infrastructural availability, past experience and needs of the respondent | | | |
| 34 | **Flexibility-** this is operationalized as the degree to | | | |

| | | | | |
|---|---|---|---|---|
| | which the expert system is characterized by a ready capability to adopt to new alternative or changing requirements or conditions | | | |
| 35 | **Scalability-** Evolving an expert system is to add, modify or delete rules. Since the rules are written in plain language, it is easy to identify those to be removed or modified. | | | |
| 36 | **Cosmopoliteness-** It was operationalized as the frequency, purpose and duration of visit to nearby ICT centres by the respondent. | | | |
| 37 | **Level of aspiration-** It is operationally defined as the future level of achievement in his job, which he is expecting, based on the knowledge about the level of past performance. | | | |
| 38 | **Desirability-** It is the degree to which the technology is desired and perceived as worth | | | |
| 39 | **Social acceptability-** It is the degree to which an expert system is considered useful, practical and feasible by majority of the members of the social system. | | | |
| 40 | **Simplicity-** It is the degree to which the expert system is simple to be adopted by the respondents | | | |
| 41 | **Training-** It refers to the training received by the respondents on expert system | | | |

# APPENDIX II

## The variables with their mean relevancy score

| Sl. No. | Independent variables | Mean relevancy score |
|---|---|---|
| 1 | Age | **2.61** |
| 2 | Education | **2.56** |
| 3 | Training | **2.56** |
| 4 | Accessibility | **2.94** |
| 5 | Awareness | 2.5 |
| 6 | Retrievability | **2.89** |
| 7 | Relevancy | **2.78** |
| 8 | Availability | **2.67** |
| 9 | Reliability | 2.44 |
| 10 | Practicability | 2.5 |
| 11 | Information content | **2.61** |
| 12 | Credibility | 2.5 |
| 13 | Timeliness | **2.61** |
| 14 | Accuracy | **2.72** |
| 15 | Format clarity | **2.67** |
| 16 | Innovative proneness | **2.67** |
| 17 | Up to datedness | 2.44 |
| 18 | Simplicity | 2.44 |
| 19 | Social acceptability | 2.5 |
| 20 | Knowledge gain | 2.44 |
| 21 | Cost effectiveness | 2.39 |
| 22 | Physical compatibility | 2.33 |
| 23 | Flexibility | 2.33 |
| 24 | Extension participation | 2.39 |
| | Mean | **2.56** |

## APPENDIX III

The works carried out on expert System in agriculture and allied field and various soft wares used to develop an expert System by authors were collected worldwide and presented as follows.

| S. No. | Authors | Name of ES | Utility | Software/ Shell used |
|---|---|---|---|---|
| 1. | Fermanian *et al.* (1985) | PLANT/tm | Diagnosis of weed in turf | - |
| 2. | Jones and Haldeman (1986) | CHAMBER | Management of environmentally controlled crop research facility | - |
| 3. | Lemmon (1986) | COMAX | ES for cotton crop management | - |
| 4. | Palmer (1986) | COMAX | Soybean crop variety selection | PROLOG |
| 5. | Shroyer *et al.* (1987) | WHEAT WIZ | Cultivator selection tool | - |
| 6. | Bennett and Sneed (1988) | COMAX | Planning, design and evaluation of irrigation systems | PASCAL |
| 7. | Floris *et al.* (1988) | COMAX | Real-time operation; real-time meteorological data handling | PASCAL |
| 8. | Getforth and Macvicer (1988) | OASIS | Operation of control structures; real-time meteorological data handling | PASCAL |
| 9. | Haie and Irwin (1988) | EXSYS | Drainage diagnosis | PASCAL |
| 10. | Halterman *et al.* (1988) | ES | Double cropping management | - |
| 11. | Boggess *et al.* (1989) | FinsARS | Financial analysis for farm business management | - |
| 12. | Stone and Toman (1989) | COT FLEX | Cotton crop management; coupled with SOYGRO model | PASCAL |
| 13. | Batchelor *et al.* (1989) | SMART SOY | Soybean crop management | Insight 2+ |
| 14. | McClendon *et al.* (1989) | SMART SOY-IRRIG | Soybean irrigation | Insight 2+ |
| 15. | Morgan *et al.* (1989) | CUE | Crop variety selection | SELECT |
| 16. | Hart *et al.* (1989) | CUE | Irrigation system selection | LISP |

| Sl. No. | Authors | Name of ES | Utility | Software/ Shell used |
|---|---|---|---|---|
| 17. | Hershaeur *et al.* (1989) | CUE | Canal water distribution; canal network incorporated | LISP |
| 18. | Bhatty (1990) | RESEXP | Reservoir operation; DP model integrated | PROLOG |
| 19. | Helms *et al.* (1990) | CIRMAN | Crop insurance strategies | - |
| 20. | McGregor and Thornton (1990) | CVSES | Wheat crop variety selection | CRYSTAL |
| 21. | Oswald (1990) | TANK | Tank systems diagnostic analysis | PROLOG |
| 22. | Han *et al.* (1991) | ES | Sprayer diagnostics | - |
| 23. | Hasbini *et al.* (1991) | PUMP | Operational guidelines for center pivot systems | PASCAL |
| 24. | King *et al.* (1991) | MKBS | Fertilizer and irrigation applications | Turbo C |
| 25. | Nevo and Amir (1991) | CROPLOT | Multiple crop selection | Rabbi |
| 26. | Srinivasan *et al.* (1991) | ESIM | Delivery system operation; canal network incorporated | EXSYS |
| 27. | Clarke *et al.* (1992) | IRRIGATOR | Irrigation scheduling; ET method selection | PC PLUS |
| 28. | Elango *et al.* (1992) | BDM-EXPERT | Drought management integrated with CASIMBOL model | IITM RULE |
| 29. | Kumar *et al.* (1992) | KBS | Economic feasibility of irrigation system selection | Level 5 |
| 30. | Nakamura and Tsukiyama (19 92) | ES | Irrigation canal renovation project planning | - |
| 31. | Plant *et al.* (1992) | CALEX/cott on | Cotton irrigation scheduling | CALEX |
| 32. | Raman *et al.* (1992) | BDM-EXPERT | Crop planning under droughts; LP model inferencing | Insight 2+ |
| 33. | Bralts *et al.* (1993) | ES | Hydrologic analysis of micro irrigation system | - |
| 34 | Hu-Quansheng, (1993) | ESRICE | An expert system for management of rice pest insects | BASIC and dBASE III |
| 35 | Fink and Scharpf (1993) | N-EXPERT | A decision support system for vegetable fertilization in the field | - |

| S. No. | Authors | Name of ES | Utility | Software/ Shell used |
|---|---|---|---|---|
| 36 | Perrier *et al.* (1993) | DIANA | For pineapple disorder diagnosis | - |
| 37. | Mohan and Arumugam (1994) | CROPES | Multiple crop selection | IITM RULE |
| 38. | Nevo *et al.* (1994) | CROPLAN | Optimal crop planning; LP model integrated | PROLOG |
| 39. | Pasqual (1994) | ES | Identification and control of weeds in wheat, barley and oats | - |
| 40. | Arumugam (1995) | TANKES | Tans system operational guidelines; real-time operation | VP-EXPERT |
| 41. | Mohan and Arumugam (1995) | ETES | ET estimation method selection | VP-EXPERT |
| 42 | Castro-Tender and Garcia-Torres (1995) | SEMAGI | An expert system for weed control decision making in sunflowers | - |
| 43. | Nuthall and Bishop-Hurley (1996) | - | ES for animal feeding management | VP-EXPERT |
| 44. | Yialouris *et al.* (1997) | VEGES | A multilingual Expert System for the diagnosis of pests and diseases and nutritional disorders of six greenhouse vegetables | AUA-ES |
| 45 | Gutierrez and Guevara (1997) | PIEX | An expert system to classify pineapple varieties | - |
| 46 | Musaazi and Reichgelt (1999) | DIBAMOTE X | An expert system developed for the control of the diamondback moth in Cabbage. | - |
| 47 | Corona *et al.* (2000) | CITRUS | Used in nutritional diagnosis of orange trees, is user friendly and permits the diagnosis of nutrient deficiencies | Visual Basic |
| 48. | Gillard and Salardini (2001) | Fertilizer Adviser Crops | E.System for Tasmanian crops designed to advise about the appropriate fertilizer dosage for crops | - |
| 49 | Li-qing *et al.*(2001) | MOES | Expert decision making in orange *viz.*, breed choice, and build orchard | - |

| S. No. | Authors | Name of ES | Utility | Software/ Shell used |
|---|---|---|---|---|
| 50 | Ganesan (2002) | AGRES | Diagnosis of pests and diseases of major crops of Kerala | - |
| 51 | Mahaman *et al.* (2003) | DIARES-IPM | Expert system for integrated pest management in Solanaceous crops | |
| 52 | Ghosh *et al.* (2003) | TEAPEST | An expert system for insect pest management in tea. | - |
| 53 | Nureize (2004) | MyPEST | Pest activity prognosis in rice fields | - |
| 54 | Balasubramani (2004) | RUBEXS-04 | Diagnosis of Rubber plant Diseases | VB 6.0 |
| 55 | Prasad *et al.* (2005) | AMRAPALI KA | Diagnosis of pests, disease and disorders of Indian mango | - |
| 56 | Chakrabarti *et al.* (2006) | ESMMDM | Management of Malformation Disease of Mango | - |
| 57 | Thammi Raju and Sudhakar (2006) | Poultry Expert System (PES) | An information technology enabled Poultry Expert System for poultry farming | Visual Basic 6.0 |
| 58 | Chakrabarti and Chakraborty (2007) | Field Note | A Disease Specific Expert System for the Indian Mango Crop | - |
| 59 | Mansingh *et al.* (2007) | CPEST | An expert system for the management of pests and diseases in the Jamaican coffee industry | |
| 60. | Vinod Kumar *et al.* (2008) | RMDI& M | Rapeseed-Mustard Disease Identification and Management | VB 6.0 |
| 61. | Khan *et al.* (2008) | Dr. Wheat | A Web-based Expert system for diagnosis of wheat diseases | - |
| 62 | Chen Xiaobin (2008) | WebGIS Expert System | Rice Brown Planthopper Disaster Early-Warning for rice varieties susceptibility and pest density . | - |

| S. No. | Authors | Name of ES | Utility | Software/ Shell used |
|---|---|---|---|---|
| 63 | Ravisankar *et al.* (2010) | Expert System for Identification and management of abiotic stresses | An expert system for identification and management of abiotic stresses in tobacco. | - |
| 64 | Jadhav *et al.* (2011) | RULE BASED EXPERT SYSTEM | Use of inorganic fertilizers for sugarcane crop to decide what kind of inorganic fertilizers should be used | - |
| 65 | Yadav *et al.* (2012) | Maize AGRIdaksh | Maize expert system for varieties, insects and diseases in maize | - |
| 66 | Agbonifo and Olufolaji (2012) | A FUZZY EXPERT SYSTEM | Diagnosis and Treatment of Maize Plant Diseases | - |
| 67 | Adzemi *et al.* (2012) | ESLEOP | Expert System for land evaluation in Oil Palm Cultivation | - |
| 68 | Centre for e-leaning, KAU, 2012 | KAU Fertulator | Fertilizer calculation for the crops of Kerala | - |
| 69 | Centre for e-leaning, KAU,2012 | E-Crop doctor | A digital plant protection advisor developed by Centre for E- Learning for the crops of Kerala based on the latest recommendations | - |
| 70 | Bergsma *et al.* (2013) | CI expert system | For diagnosing chilling injury of vegetables | - |
| 71 | KAU & DRISHTI | Farm Extension Manager | To provide comprehensive information on production and marketing of major crops of wayanad. | - |
| 72 | KAU | Kissan Kerala Crop Health Decision Support system | A digital plant protection advisor for the crops of Kerala based on the latest recommendations | - |

# APPENDIX IV

**KERALA AGRICULTURAL UNIVERSITY**
College of Agriculture, Vellayani, Thiruvananthapuram. 695 522
DEPARTMENT OF AGRICULTURAL EXTENSION

**Dr. Allan Thomas**
**Assistant Professor and Chairman**

Date: 01/11/2013

Sir,

**Greetings.**

Sir/Madam,

**Sri. M. Ravi Kishore (Ad. No. 2012-11-161)**, one of the M.Sc. Scholar, Department of Agricultural Extension, College of Agriculture, Vellayani is undertaking a research study entitled "Innovations in e-Agricultural Extension Technology (e-AET): Diffusion and adoption of agri-expert systems among extension professionals in Kerala" as part of his PG research work.

After extensive review of the available literature and discussion with extension scientist's and other experts, these statements pertaining to respondent's stage in the diffusion-adoption process with special reference to the extent of use of expert systems by extension professionals have been prepared. I request you to kindly spare some of your valuable time for examining the statements, record your responses and return the completed questionnaire back to the scholar.

Thanking you.

Yours sincerely

(Allan Thomas)

**"INNOVATIONS IN e-AGRICULTURAL EXTENSION TECHNOLOGY (e-AET): DIFFUSION AND ADOPTION OF AGRI-EXPERT SYSTEMS AMONG EXTENSION PROFESSIONALS IN KERALA"**

Code: Date:

**INTERVIEW SCHEDULE**

1. **Name and address with mobile number & email id of the respondent.**

2. **Personal and social characteristics of the respondent.**

| Sex (M/F) | Age | Educational qualification (s)-highest | Experience (years) | Possession of PC &Type (Y/N) | | | | Internet connection (Y/N) | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | O | L/D | H | L/D | Office | Home |
| | | | | | | | | | |

L- Laptop; D- Desktop; O- Office; H-Home

3. **These statements are to identify the respondent's stage in the diffusion-adoption process with special reference to the extent of use of expert systems by extension professionals. Please rate the statements accordingly.**

| Sl. No. | Statements | Response | |
|---|---|---|---|
| | | Yes | No |
| 1 | Name any expert systems you know ? | | |
| 2 | Have you got the interest to get training on use of expert systems? | | |
| 3 | Are you aware about the advantages and disadvantages of expert systems? | | |
| 4 | Have you used expert system to determine the usefulness for further adoption? | | |
| 5 | Are you solving farmer's problems mainly through the use of expert systems? | | |

4. **Level of awareness on expert system specific for Kerala agriculture** (KAU- KAU Fertulator, e-Crop doctor; Kissan Kerala- Crop Health Decision Support System- CHDSS)

| Awareness on expert systems | Aware | Un aware |
|---|---|---|
| KAU expert systems | | |
| Kissan Kerala expert system | | |

5. **Attitude of extension professionals towards expert systems. (Please rate the statements in a five point continuum with five for the most and one for the least attitude)**

| Sl. No. | Statements | SA | A | N | D | SDA |
|---|---|---|---|---|---|---|
| 1 | I enjoy using the instructional technologies in lesson. | | | | | |
| 2 | I can perform better with the advisory services when expert system is used. | | | | | |
| 3 | I feel motivated in my work when using expert systems. | | | | | |
| 4 | I feel myself more comfortable in my work when using expert systems technologies. | | | | | |
| 5 | I delighted in reading the books/materials explaining the expert systems. | | | | | |
| 6 | Usage of the expert systems in advisory services increases my learning. | | | | | |
| 7 | It is beneficial for me and my client farmers to learn the usage of the expert systems. | | | | | |
| 8 | Farmer's achievement has not increased on using expert systems. | | | | | |
| 9 | Using expert system for diagnosis and advice are not accurate and reliable. | | | | | |
| 10 | I am not interested to use expert systems in advisory services. | | | | | |
| 11 | It is a waste of time to use expert systems in advisory services. | | | | | |
| 12 | I am stressed in the advisory services using expert systems. | | | | | |
| 13 | I do not want to use computers and the internet in my advisory services. | | | | | |
| 14 | I lose my concentration in the advisory services when using expert systems or similar technologies. | | | | | |

SA- Strongly Agree; A- Agree; N-Neutral; D- Disagree; SD- Strongly Disagree

6. **Please rank the reasons why you would use the expert systems (1 = most important and 7= least important)**

| Sl. No | Statements | Rank |
|---|---|---|
| 1 | Correctness and reliability of advice | |
| 2 | Ease of use | |
| 3 | Price of the systems | |
| 4 | Credibility of domain expert(s) | |
| 5 | Credibility of the developer | |
| 6 | User interface | |
| 7 | Saves a lot of time | |

7. **Effectiveness index of expert system: (Please give your responses against each statement)**

| S.No | Items | Based on the importance | | | | |
|---|---|---|---|---|---|---|
| | | 5 | 4 | 3 | 2 | 1 |
| 1 | Quick availability and opportunity of the expert system to programme itself. | | | | | |
| 2 | Expert systems ability to exploit a considerable amount of knowledge. | | | | | |
| 3 | Reliability of the expert system. | | | | | |
| 4 | Scalability of the expert system. | | | | | |
| 5 | Pedagogy (As a means to effective learning through expert system) | | | | | |
| 6 | Expert systems ability on preservation and improvement of knowledge. | | | | | |
| 7 | Expert systems ability to address the new areas neglected by conventional computing. | | | | | |

8. **Frequency and nature of agri-expert system use by the respondents.**
(Kissan Kerala- Crop Health Decision Support System- CHDSS; KAU- KAU Fertulator, e-Crop doctor)

| **Frequency of use of agri-expert system** | **Regular** | **Occasional** | **Rarely** |
|---|---|---|---|
| KAU expert systems | | | |
| Kissan Kerala expert system | | | |
| **Nature of usefulness of agri-expert system** | **Very Useful** | **Useful** | **Not Useful** |
| KAU expert systems | | | |
| Kissan Kerala expert system | | | |

9. **Training:**

Any training received on expert systems Yes/No

If yes, please provide the following information

| Sl.no. | Name of the training programme | Organization | Duration |
|---|---|---|---|
| | | | |

**10. Innovativeness**

Please indicate your response by marking a tick mark to the following statements.

| S.no | Statements | Low | Medium | High |
|---|---|---|---|---|
| 1. | I try to keep myself up to date with the information on latest technology (ICT tools). | | | |
| 2 | I feel restless till I try out a new expert system that I have heard | | | |
| 3 | From time to time I heard of several new expert systems and tried almost most of them in the last few years. | | | |
| 4 | I am very much interested in trying new expert systems | | | |

**12. Accessibility of agri-expert system**

Please indicate your accessibility to the following agri-expert systems by putting a tick mark in the appropriate column. 3- High, 2-Medium and 1-Low.

| S.no | Items | High | Medium | Low |
|---|---|---|---|---|
| 1. | Kissan Kerala- Crop Health Decision Support System- CHDSS | | | |
| 2 | KAU expert systems- KAU Fertulator, e-Crop doctor | | | |

**13. Availability of agri-expert system**

Please indicate your availability to the following by agri-expert systems putting a tick mark in the appropriate column. 3-Always, 2-Some times and 1-Rarely available

| S.no | Items | Always | Some times | Rarely available |
|---|---|---|---|---|
| 1. | Kissan Kerala- Crop Health Decision Support System- CHDSS | | | |
| 2 | KAU expert systems- KAU Fertulator, e-Crop doctor | | | |

**14. Retrievability of the agri-expert system.**

Please tick mark the columns given based on your opinion or preference for the following questions about agri-expert system. In three point continuum, '3' indicates high, '2' indicates medium and '1' indicates low for the corresponding statements.

| S.no | Statements | Low | Medium | High |
|---|---|---|---|---|
| 1. | The information provided in the system can be easily located by any user. | | | |
| 2 | The received information can be easily understandable by the user. | | | |
| 3 | The need based information can be received by the user with in less time. | | | |
| 4 | A common man can easily retrieve the information | | | |

**15. Relevancy of the agri-expert system.**

Please tick mark the columns given based on your opinion or preference for the following questions about agri-expert system. In three point continuum, '3' indicates high, '2' indicates medium and '1' indicates low for the corresponding statements.

| S.no | Statements | High | Medium | Low |
|---|---|---|---|---|
| 1. | The system is able to provide information suitable to the user resources | | | |
| 2 | Information provided in the system is appropriate to the user needs | | | |
| 3 | Information provided in the system is applicable to the real time situation. | | | |
| 4 | Information provided in the system is feasible. | | | |

**16. Information content of the agri-expert system.**

Please tick mark the columns given based on your opinion or preference for the following questions about agri-expert system. In three point continuum, '3' indicates high, '2' indicates medium and '1' indicates low for the corresponding statements

| S.no | Statements | Low | Medium | High |
|---|---|---|---|---|
| 1. | Information in agri-expert system is classified systematically | | | |
| 2 | Supports easy learning | | | |
| 3 | Provides complete information for decision making | | | |
| 4 | Clarity of the messages given in the entire module | | | |

**17. Format clarity of the agri-expert system.**

Please tick mark the columns given based on your opinion or preference for the following questions about agri-expert system. In three point continuum, '3' indicates high, '2' indicates medium and '1' indicates low for the corresponding statements.

| S.no | Statements | High | Medium | Low |
|---|---|---|---|---|
| 1. | Expert system user interface is good. | | | |
| 2 | Photos and Wording used in expert system is clear. | | | |
| 3 | Font type, size used in expert system is appropriate. | | | |
| 4 | Font colour and background colour used in expert system is appropriate. | | | |

**18. Timeliness of the information from agri-expert system.**

Please tick mark the columns given based on your opinion or preference for the following questions about agri-expert system. In three point continuum, '3' indicates timely information, '2' indicates somewhat timely information and '1' indicates not timely information for the corresponding statements

| S.no | Statements | High | Medium | Low |
|---|---|---|---|---|
| 1. | Expert system's advice is quick | | | |
| 2 | Expert system will solve the problem whenever you needed | | | |
| 3 | Easy and convenient to use, thus more time saving | | | |
| 4 | Expert system will give location specific advices to solve the problems. | | | |

**19. *Accuracy of the information from agri-expert system.***

Please tick mark the columns given based on your opinion or preference for the following questions about agri-expert system. In three point continuum, '3' indicates highly accurate information, '2' indicates medium accurate information and '1' indicates low accurate information for the corresponding statements

| S.no | Statements | High | Medium | Low |
|---|---|---|---|---|
| 1. | Expert system's advice is free from bias and explanation facilities | | | |
| 2 | Expert system's advice was applied to real situation and the results were shown as good enough | | | |
| 3 | Expert system is a good, useful, and up to date tool for problem solving | | | |
| 4 | Expert system advice is more credible than any other ICT tools. | | | |

**20. Constraints experienced by extension professionals in using expert systems. Tick 5 for the most important and 1 for the least important constraint**

| Sl. No. | Statements | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|---|
| 1 | Don't know how to operate a computer | | | | | |
| 2 | No supporting budget to buy computers | | | | | |
| 3 | Lack of proper training | | | | | |
| 4 | Availability of electricity | | | | | |
| 5 | Difficult to understand | | | | | |
| 6 | Expert's advice is not clear | | | | | |
| 7 | Accessibility problem | | | | | |
| 8 | No support from authorities | | | | | |
| 9 | Not yet covered all farmers' practices. | | | | | |
| 10 | Some information needed further explanation. | | | | | |
| 11 | No internet connection. | | | | | |
| 12 | Internet connection is very slow. | | | | | |
| 13 | Research is not yet approved by all the users. | | | | | |
| 14 | Not convenient to use as there is a big gap between the perspective of both developer and users. | | | | | |
| 15 | The costs of using expert system might be expensive. | | | | | |
| 16 | Any other(s) [Specify and rate it] | | | | | |

**Signature with date**

## APPENDIX V

### The variables with their data range and mean values

| Sl. No. | Variables | Data range | | | Mean and Standard deviation | | |
|---|---|---|---|---|---|---|---|
| | | EP | FLEP | S | EP | FLEP | S |
| 1 | Innovativeness | 6-12 | 6-11 | 7-12 | 9.1&1.87 | 9.26&1.7 | 9.36&1.58 |
| 2 | Retrievability | 6-12 | 7-12 | 7-11 | 8.92&1.60 | 9.33&1.51 | 9.46&1.47 |
| 3 | Relevancy | 7-12 | 7-12 | 7-11 | 9.62&1.35 | 9.1&1.66 | 9.3&1.53 |
| 4 | Information content | 6-12 | 8-12 | 7-12 | 9.0&1.70 | 9.6&1.32 | 9.43&1.52 |
| 5 | Format clarity | 6-12 | 6-11 | 6-11 | 9.62&1.35 | 9.1&1.66 | 9.3&1.53 |
| 6 | Timeliness | 6-12 | 6-11 | 8-11 | 8.95&1.81 | 9.23&1.65 | 9.46&1.47 |
| 7 | Accuracy | 7-12 | 6-11 | 6-11 | 9.25&1.44 | 9.23&1.73 | 9.06&1.89 |
| | | | | | Quartiles-$Q_1$,$Q_2$ and $Q_3$ | | |
| 8 | Attitude | 52-69 | 44-64 | 53-67 | 55,57.5&62 | 54,56&58 | 55,56&57 |

EP- Extension Professional, FLEP- Front Line Extension Personnel, S- Scientists

# Innovations in e-Agricultural Extension Technology (e-AET): Diffusion and Adoption of Agri-Expert Systems among Extension Professionals in Kerala.


MODEM RAVIKISHORE

(2012-11-161)


ABSTRACT

of the thesis submitted in partial fulfillment
of the requirements for the degree of

MASTER OF SCIENCE IN AGRICULTURE


Faculty of Agriculture
Kerala Agricultural University

DEPARTMENT OF AGRICULTURAL EXTENSION
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM-695 522
KERALA, INDIA


2014

# ABSTRACT

The present study entitled 'Innovations in e-Agricultural Extension Technology (e-AET): Diffusion and adoption of agri-expert systems among extension professionals in Kerala' was conducted at Thiruvananthapuram district during 2012-2014 covering 100 extension professionals. Expert systems allows the use and application of information technology and communications technology (ICT's) to access and obtain information related to agricultural production, marketing, distribution, and prices, and the results of agricultural research, innovations, to raise the level of agricultural production and benefit the farming community. The present study, therefore, is with the objective to conduct a systematic appraisal of existing expert systems in agriculture *vis a vis* their diffusion among the extension professionals.

The findings demonstrate that most of the extension professionals either in State Department, NGO or University have positive attitudes towards expert system. Age, training, innovativeness, retrievability, relevancy, format clarity, information content, availability, accuracy and timeliness affect extension professionals' attitudes. Based on respondent's stage in the adopter categorisation with reference to expert systems, it was found that 10 per cent of the sampled respondents belonged to innovators category, 19 per cent respondents belonged to early adopters' category, 32 per cent respondents belonged to early majority category, 24 per cent respondents belonged to late majority category and 15 per cent respondents belonged to laggards' category. Effectiveness index of expert system applications was worked out using seven statements and the results showed that pedagogy (as a means to effective learning through expert system) having highest effectiveness index. The findings demonstrate that most of the respondents belonged to middle age category, holding with master degrees; attended training on ICT. It was also found that most of the respondents having high innovativeness and accessibility, format clarity and

information content of the expert system perceived as high. Availability, retrievability, relevancy, timeliness, accuracy and effectiveness index of expert system perceived as medium by the respondents.

Hence, the study undoubtedly exhibited affirmative reaction from all three categories of respondents on the applications of expert systems in the field of agriculture, because local information resource centers are gaining importance with computers carrying expert systems to help farmers to make decisions.