CHAPTER 1

INTRODUCTION

Agriculture sector of India, in spite of being the backbone of the Indian economy, is one such area where IT (Information Technology) has not been utilized to the full potential to provide its benefits to the stakeholders [1]. While most of the problems the Indian farmers are facing are due to lack of information on their part, there has not been much serious efforts to provide succour to them. A study by APAARI (Asian Pacific Association for Agricultural Research Institutions) [2] has shown that in most developing countries of the Asia-Pacific region, the mechanisms for Transfer of Technology and implementation of extension programs, usually government administered, are either slow or ineffective in connecting the resource-poor farmers with up-to-date knowledge from researchers and markets for their produce. This is primarily due to rising costs of such interventions, declining public funds for rural extension, and inadequate exploitation of new means of knowledge and information dissemination by responsible government agencies.

Knowledge has become an increasingly significant factor of production in modern agriculture. A farmer requires technological and information backup not only to survive, but also to remain competitive. The farmers are in urgent need of an information dissemination system which could provide timely and personalized information when required.

This study is an effort to utilize XML, the Extensible Markup Language to provide a framework for the dissemination of agricultural technology related information to the farmers in different formats (text, video etc.), through multiple channel devices such as web browsers, mobile phones and PDAs. XML has become the widespread universal language for data exchange among different organizations[3]. This exchange is not limited to the traditional areas such as EDI and publishing but has been extended to many other areas where a universal hierarchical data structure is needed for defining the structure of a user interface. It has been successfully utilized to develop many domain specific markup languages such as
MusicXML, MathML, CML (Chemical markup Language), GovML which has enabled interchange of data among different applications[3].

1.1 Importance of Agriculture in India

Agriculture is one of the strongholds of the Indian economy. It is due to the strong agricultural base that the worldwide recession failed to have great impact on the Indian economy. India has become the world's largest producer across a range of commodities due to its favorable agro-climatic conditions and rich natural resource base. It is the largest producer of coconuts, mangoes, bananas, milk and dairy products, tea, cashew nuts, pulses, ginger, turmeric and black pepper. It is also the second largest producer of rice, wheat, sugar, cotton, fruits and vegetables.

The importance of agriculture in the Indian economy is ascertained by the statistics which show that it accounted for 14.6 per cent of the country's gross domestic product (GDP) in 2009-10, and 10.23 per cent of the total exports [4]. Furthermore, the sector provided employment to more than half of the total workforce (58.2%) [5]. The total geographical area of India is 328.7 million hectares of which 140.3 million hectares is the net sown area, while 193.7 million hectares is the gross cropped area, according to the Annual Report (2009-10) of the Ministry of Agriculture. According to the government's agri-trade promotion body, Agricultural and Processed Food Products Export Development Authority (APEDA), India's exports of agricultural and floricultural products, fruits and vegetables, animal products and processed food products was worth US$ 8.1 billion in 2008-09, an increase of 13.88 per cent from US$ 7.11 billion in 2007-08. Exports during April-December 2009-10 were worth US$ 54.16 million. The public and private sector investment in agriculture have been steadily increasing since 2004-05. While public sector investments in agriculture have increased from US$ 3.61 billion in 2004-05 to US$ 5.5 billion in 2008-09, private sector investment has increased from US$ 14 billion in 2004-05 to US$ 25.5 billion in 2008-09, according to the Annual Report (2009-10) of the Ministry of Agriculture, Government of India.

The Indian Agriculture sector is now set for a leap with the introduction of new technologies like Information Technology, Genetic Engineering and Biotechnology. India is poised to become the world's food basket on the back of a
number of Government initiatives and investment opportunities across various areas of agriculture. To achieve that not only should the present growth be sustained, there has to be improvement in productivity (as land area cannot be increased) so that the per unit area produce of agricultural commodities is increased. Only then can the food grains be sufficient for the growing population. [4]

Indian seed companies are eyeing the export markets in SAARC (South Asian Association for Regional Cooperation) and African countries with a host of hybrid seeds and best farm practices. Some of the companies like J K Seeds, Namdhari Seeds, Nuziveedu Seeds, Nath Seeds, Rasi and Vibha Seeds have already ventured into the export markets in the region.

This presents the positive side of the Indian agriculture scenario. But farmers are facing a lot of challenges in the event of climate change, globalization and liberalization and marginalization of land holdings. This is forcing many of them to leave agriculture. These challenges, as identified in the Indian Agricultural Economic Report (2009-10) are:

- Globalization and liberalization of agricultural markets
- Privatization of agriculture and agricultural services
- Increased presence of agri-business and commercialized farming
- Environmental imperatives
- Climate change
- Food insecurity
- Increased use of biotechnologies
- Marginalization of landholdings
- Calls for “good governance” and stakeholder participation
- Access to Information and Communication Technologies
The radical weather shifts and repeated crop failures in subsequent years have forced nearly 200,000 Indian farmers to commit suicide in the last decade [1]. The same number have left agriculture and moved to cities in search of jobs. It is a very dangerous trend for the food and social security of the country in which agriculture is the stronghold of the economy providing employment to 58.2 per cent of the workforce and accounting for 14.6 percent of the country's GDP (2009-10 figures [4]).

This is happening in spite of the huge workforce and infrastructure available in the agricultural sector in India. The Department of Agricultural Research and Education (DARE) is operating through 46 Central Research Institutes, 4 National Bureaus, 11 Project Directorates, 26 National Research Institutes, 90 All India Coordinated Projects, 261 Krishi Vigyan Kendras, 8 Trainers' Training Institutes and 31 Agricultural Universities.

It is a fact that the AEs (Agricultural Experts) cannot visit each and every farm. To reach over 110 million farmers, spread over 500 districts and over 6000 blocks is an uphill task. The diversity of agro-ecological situations adds to this challenge further. The success of Green Revolution was mainly achieved due to concerted homogeneous extension approach for the assured irrigated area. For the rainfed eco-systems, the extension strategy would become more complex. The farmers' needs are much more diversified and the knowledge required to address them is beyond the capacity of the grass root level extension functionaries. It is one of the reasons why the efforts of the AEs to transmit the advances in agricultural technology to an ordinary farmer through traditional methods (magazines, newspapers, broadcast media, seminars, meetings) and even through websites has not yielded the desired results. There are some drawbacks associated with these methods. The system does not consider the cases at individual farmer's level. Also, illiterate farmers cannot be covered using these technologies. An important point is that these methods are a one-way process, i.e. any additional information desired may take a lot of time and when that particular information is accessed/received, it may become irrelevant. Another major drawback is the lack of accountability, i.e. if the advice does not give desired results, it is difficult to fix the responsibility/accountability.

Undoubtedly the emerging technologies in agriculture provide a fillip to the productivity for some time, after which the downward trend starts. Taking the
example of fertilizers, insecticides/pesticides, and growth regulators/hormones to show the importance of the farmers being kept updated as far as the agricultural information is concerned.

The cause for suicide is financial bankruptcy which is due to crop failure and inability to repay debts but a deep study is essential if the problem needs to be tackled. The study by TISS[2] has shown that there is no safety net for farmers to protect them from usurious credit suppliers, exposure to unbearable price fluctuations and spurious inputs for farming (seeds, insecticides, fertilizers etc.). They had no knowledge of MSP (minimum support price), crop insurance. The report also says that the farmer is ignorant of the appropriate and more productive techniques of farming and that he needs to be educated. The government’s scheme to provide benefit to the affected families was also widely misused by the farmers. The story depicted in a recent movie “Peepli Live”, where a farmer decides to commit suicide so that his family would get some compensation also shows that the government’s message has been misinterpreted by the farmers. In the last 200 years India suffered with famine 38 times. It was only due to the Green revolution that India reached self sufficiency in food grains. If it is desired that this self sufficiency continues and the country has enough food to feed the rising population, the problems of the Indian farmer have to be looked into and taken care of.

Data from the scientific report “Subsidizing Food Crisis” [6] showed that the indiscriminate use of synthetic fertilizers and chemical pesticides by farmers since the 1960s, spurred by huge government subsidy, have degraded India’s natural resource base of agricultural land. Same is the case with the application of pesticides. Their indiscriminate use has led the pests to become immune against them. On the other hand it has led to a host of diseases among humans, some of which are – asthma, learning disabilities, birth defects, diabetes, Parkinson’s and Alzheimer’s, and cancer. Synthetic auxins have been misused by farmers. Large scale application of defoliants used in Vietnam to expose the forests, exterminated the wild relatives of economically useful plants such as Citrus [6]. The root cause of all these problems is the lack of information on the part of a farmer. The farmer needs to be provided information related to all these aspects of agriculture so that he could use his resources justifiably.
1.2 Agricultural Extension

Agricultural Extension relates to the process of carrying the technology of scientific agriculture to the farmer in order to enable him to utilize the knowledge for a better economy. Agriculture extension service seeks to impart the necessary skills to the farmers for undertaking improved agricultural operations, to make available to them timely information regarding improved practices in an easily understandable form suited to their level of literacy and awareness, and to create in them a favorable attitude for innovation and change [1]. The Extension is an on-going process of getting useful information to people (the communication dimension) and then in assisting those people to acquire the necessary knowledge, skills and attitudes to utilize effectively this information or technology (the educational dimension). Thus Extension is a central mechanism in the agricultural development process, both in terms of technology transfer and human resources development [7].

There's no doubt that a nation’s agricultural research and extension system (NARES) is the most important single determinant of the level of its agricultural development and hence the yard stick of the quality of life of its people. In developmental studies, no country has been known to achieve any meaningful progress in agricultural development without substantial investments in agricultural research and extension. Knowledge is an increasingly significant factor of production in modern agriculture. Information and Communication Technologies (ICTs) can accelerate agricultural development by facilitating knowledge management [1].

The success of Green Revolution was mainly achieved due to concerted homogeneous extension approach for the assured irrigated area. For the rain fed ecosystems, the extension strategy required would become more complex. The farmers' needs, as seen in Table, are much more diversified and the knowledge required to address them is beyond the capacity of the grass root level extension functionaries. The cause of inefficient agricultural productivity is the lack of its global competitiveness.

The division of farms (landholdings) into smaller and smaller ones with each new generation has led to marginalization of farms. It has led to replication of resources, which has further led to increase in expenses. The lesser area available for cultivation has led to lesser production. The trend of sharing resources (as in olden
days) has vanished. Even today, in remote villages, farmers share their agricultural implements. In olden days, all farmers did not have bullocks to plough their fields. They used to share them and a nominal price was paid to the owner. This reduced the cost as all of them did not have to spend on agricultural machinery. Today, the replication of resources (machinery, marketing efforts etc.) lead to cost escalation and reduction of profits.

As mentioned in the last section, lack of information is the root cause of most of the difficulties/problems being faced by the Indian farmers. The weak linkages among extension, research, marketing network and farmers limit the effectiveness of research and extension to contribute to agricultural development. These linkages can be strengthened by harnessing the benefits of IT (Information technology). IT refers to how information is used, how information is computed, and how it is communicated to people. It can also refer to electronic equipment that stores, sends, retrieves, or manages information. This may include computers, electronic databases, scanners, digital cameras, laser discs, video cameras, and fax machines. Further, IT can also include software and computer accessories like computer-assisted instruction (CAI), web browsers, hypertext authoring tools, and multimedia software.

1.3 Role of Internet and ICT

The ICTs have started to play a significant role in the development of the rural sector. A cost reduction is expected in the different processes of agriculture if there could be a common platform for marketing, logistics and risk management. For example, a simple solution to the farm marginalization problem mentioned above could be to merge the small scale farms to create big ones. But is not possible practically due to multiple land ownerships. What can be done is to virtually integrate these small farms while keeping their financial independency. IT has revolutionized the way we communicate. Networking has made it possible to remove the barriers of physically transporting documents between sources and recipients. It has also overcome the barriers of time and distance and limitations of local information storage.

The help of internet is inevitable in realizing such a vision as it is the most appropriate media for information dissemination today. The advantage of internet is its use in information sharing between distributed resources. Internet, along with the
Data mining technology could be used to analyze the complicated agricultural data which would help the researchers mine unknown facts.

Cyber Extension means “using the power of online networks, computer communications and digital interactive multimedia to facilitate dissemination of agricultural technology” [8]. Cyber Extension includes effective use of Information and Communication technology, national and international information Networks, Internet, Expert Systems, Multimedia Learning Systems and Computer based training systems to improve information access to the Farmers, Extension Workers, Research Scientists and Extension Managers.

ICTs are defined as “a range of electronic technologies which when converged in new configurations are flexible, adaptable, enabling and capable of transforming organisations and redefining social relations” [9].

ICTs can be used to interlink information technology devices such as personal computers with communication technologies such as telephones and their telecommunication networks. The PC and laptop with E-mail and Internet provides the best example. The range of technologies is increasing every day and ‘there is a convergence between the new technologies and conventional media’ [9]. Devices such as digital cameras, digital video cameras and players, personal digital assistants, slide projectors and mobile telephones are also compatible with more traditional media such as radio (digital, satellite) and television (cable, satellite). Thus most devices can now be linked to others to share and exchange information and allow them to be used in such a way that they can also be categorized as ICTs. Even books are being incorporated into ICTs either through the potential for informal web publishing or more formal digital book publishing with designated readers or ‘e-books’. ICTs, therefore, are an expanding assembly of technologies that can be used to collect, store and share information between people using multiple devices and multiple media.

Information is at the heart of future extension strategies and the Agricultural Knowledge and Information System (AKIS) [10] adopted by the World Bank and the FAO (1998) [11] puts farmers at the heart of the information exchange process. The emphasis therefore on improving the use of information, and placing farmers at the centre of the ‘knowledge triangle’ between extension, education and research, has
been developed independently of more recent ICT experimentation. Faced with a crisis in extension and the raising of the stakes in rural development caused by structural influences such as globalisation, population growth, rural–urban migration [12], ongoing environmental degradation, the use of ICTs is seen as a pragmatic solution to many problems (e.g. VERCON and FarmNet, FAO, 1998).

The agricultural extension programmes should integrate ICTs to address the specific challenges of raising agricultural production so that Extension becomes “Cyber extension”. Examples include the importance of two-way information flows to provide users with ongoing support, improving feedback mechanisms between users and designers of the technology, avoidance of top-down and prescriptive approaches to technology transfer and the importance of local and contextual facilitation [13]. Perhaps nowhere has information been used to greater catalytic effect than in the field of agricultural development, such as the rapid spread of some new varieties in West Africa [13].

Information and communication activities are the fundamental elements of any rural development activity. While education and training develop cognitive skills, it is information that gives content to knowledge. ICTs offer unprecedented information storage capacity, increases in processing power and speed, coupled with significant reduction in costs. ICTs can facilitate the improvement of existing information management processes by improving ease of access, transparency, accountability, efficiency, speed of delivery and providing new information sharing opportunities through affordability, availability and ease of use [14].

Local information exchange can help the farmers/rural people to organize as groups, articulate needs, defend interests and increase bargaining power to influence government decisions relating to common interest. ICTs can help pro-rural institutions listen to the poor, engage in more meaningful dialogue and build consensus and mutual understanding around development objectives. ICTs provide practical opportunities for improved information exchange between different groups and new and innovative knowledge partnerships.

ICTs have emerged as an integral part of the current technological revolution, which is driving the world towards a knowledge economy. ‘Now that new technology makes (information) sharing much easier and cheaper than ever before, it is vital that
these tools are used for the public good' [14]. Improved systems of information and communication have a dual function; to supply the information required by the rural poor in order to pursue sustainable livelihood strategies, and to supply information required by institutions responsible for making decisions that affect those strategic livelihood options.

1.4 The Problem

Information not timely and reliable

The Department of Agricultural Research and Education (DARE) is operating through 46 Central research institutes, 4 national bureaus, 11 project directorates, 26 national research institutes, 90 all India coordinated projects, 261 Krishi Vigyan Kendras (KVKs), 8 trainers’ training institutes and 31 agricultural universities [15]. In spite of this huge workforce and infrastructure available in the agricultural sector in India, it is a pity that an ordinary Indian farmer is not getting the desired information when in need.

Complexity of agricultural data

Agricultural information is quite complex and its typical features make it beyond the scope of the Information Science (IS) used in industrial information systems [15].

The agricultural data is unpredictable, unstable and subjective, site specific and reliant on empirical decisions given the inherent variability of biological phenomenon. Agriculture stands on the very complex interaction between biological, climatic and geographical factors in addition to human economic activities [15]. Huge amount of data on agricultural production and experiments is available which has been recorded for over 100 years since modern agriculture started. This long term data could be the source of critical information that could give new knowledge in agricultural production. Presently, most of this data is in printed form which needs to be digitized for use in decision making in agricultural information system.

The vast array of data contained in the agricultural records consists of pest management, new varieties of seeds, latest crop management practices, mechanical equipments details, fertilizers, government schemes, weather information and data for decision making on farm, administrative and marketing and processing data at retailer
and trader levels and many more. This could be in the form of text, graphics, digital images or movies, which is quite heterogeneous and requires different media support and format representation and storage. There is an urgent need that all these data can be represented in a unified way so that it could be retrieved efficiently.

The role and potential of ICTs in support of agriculture development goes far beyond facilitating two-way flow of information between decision-makers and beneficiaries in a development project. The assumption being that information delivery from developmental agencies to rural communities presently represents an outdated mode of top-down development that was generally one-way. Also, the information that a farmer receives may or may not be of his use.

The main problem has been one of providing top-down information of limited local relevance to farmers who are also unable to ask questions or provide feedback to the extension services and research centres. These constraints have led extension services to focus on the importance of two-way information flows, together with a shift towards more participatory approaches in development more generally. The focus of attention on failing extension services in developing countries is occurring at a time when there is a recognition that globalisation and trade liberalisation is coinciding with the ICT revolution to create a peculiar climate of increased risks and opportunities for many developing countries. “Knowledge and capital are at the centre of success within this new economic system. Yet some countries have yet to consider the value of making knowledge available through revived extension services” [16].

1.5 Need of present study

It is clear from the preceding discussion that farmers can take knowledgeable decisions if timely and relevant information can be made available to them. Application of IT for providing that could be the turning point in the Indian agriculture.

Online information does not comply with a specific structure. It is not characterized by a unified presentation style and principles. On the contrary, each public authority applies its own format to present the information. Apart from presentation of agriculture related information, interoperability is an important issue
in online information. Several types of data needs to be exchanged among different stakeholders. Each authority stores its information in a proprietary data format and storage system like HTML, ASCII, RDBMS etc. Therefore data conversion must take place from the data format adopted by one authority to the format adopted by the others, whenever exchange of data is required.

The evolution of mobile phones and hand held devices have poised another challenge when implementing online information dissemination through governmental portals. It is desired that the users are provided access to the agricultural information and services through multiple communication channels which could be web browsers, mobile phones, Personal Digital Assistants (PDAs) etc. This would allow the desired information and services to be available to users 24 hours a day via multiple access devices, even when on the move.

So the main objective of the present study is to propose a framework to provide information to the farmers which is timely, accurate and accountable. The information should be accessible through multiple channel devices (web browsers, mobile phones, PDAs) and in different formats (text, video, audio etc.) 24 hours a day. The farmers are in urgent need of advisory services as the Indian Agricultural Economic Report (1991-2001) [17] shows that 8 million farmers have left farming during the period and thousands have committed suicides because of failure to repay the debts. This is a very dangerous trend which needs to be checked to sustain the growth of Indian agriculture and to maintain the food security of the country.

The complexity of agricultural data and its variability are the main reasons why many efforts of applying IT in agriculture have failed in India. Another reason is that priority was on hardware and not software, resulting in insufficient data resources and poor applications that were not useful enough to convince farmers for the beneficial effects of IT in agriculture [15]. Huge investments were made on procuring latest hardware from the west but the software available to use that hardware could not be implemented in Indian conditions as they were completely different from the western. Hence there is need that an indigenous AgIDS (Agricultural Information Dissemination System) is designed and built according to the needs of the farmers.
In the context of agriculture, the potential of information technology (IT) can be assessed broadly under two heads [18]:

(a) as a tool for direct contribution to agricultural productivity and

(b) as an indirect tool for empowering farmers to take informed and quality decisions

As a direct tool IT is being used in agriculture in precision controlled greenhouses to provide controlled environmental conditions, automatic watering, robotic harvesting. As an indirect tool, IT is being used in GIS (Geographical Information Systems), Forecasting of pests & diseases and production, and Advisory systems [18]. While these technologies are extensively being used in western countries, these are not yet much prevalent in India.

As per present status of ICT intervention in India, some experiments are being conducted. While using IT as an indirect tool in agriculture, two options are available. One way of IT intervention in Indian agriculture sector is by making use of the existing technologies of DBMS, Data Mining, Networking to provide benefit to the stakeholders. Another way is by modifying the existing technologies to suit to the particular domain and to increase their abstraction level. The second option appears to be more feasible for the climatic conditions prevalent in India.

Web technologies are extensively being used in direct as well as indirect interventions. In fact GOI has taken special initiatives for using ICT in agriculture. Introduction of low cost payphones and a specific number (eg. 1551) for availing helpline services are steps in this direction [19]. Implementation of these technologies is just the beginning of the application of IT in the agricultural sector. The agricultural sector requires timely and personalized information dissemination through the web. The traditional ways of advice dissemination through radio, newspapers, magazines, television are not meeting the expectations of the farmers due to lack of coverage, accountability and personalized advice. Since farmers are not experienced internet users, finding the relevant information and services is an error prone and time consuming task for them. This task needs simplification and the abstraction level between the IT and the farmer needs to be raised.
1.6 Scope of present study

It has been proved that “Agriculture is a Science and farmers are not scientists” [20]. There is room to reduce the negative effect of the several factors that disturb the crop. This can be achieved by providing timely expert information. Indian farmers, would then become more knowledgeable which would help them in increasing productivity and becoming more competitive. XML, which has been efficiently used to create different versions for specific purposes such as Chemical Markup Language, Mathematical Markup Language, MusicXML, Voice XML, Open Financial Exchange etc. could be used to create a domain specific version for Agricultural Information Dissemination.

The limitations of HTML in handling the ever expanding web structure (as discussed in the next chapter) led to the development of XML (Extensible Markup Language), which is a text and data - formatting language that has a tag-based syntax very similar to the HTML syntax, but which is much more capable and much more flexible. Consequently, this extensibility enables document authors to create entirely new markup languages for describing specific types of data, including mathematical formulas, chemical molecular structures, music etc., or use any of the existing extension of XML (eg. agroXML) for the purpose.

The real power of the XML Web Services is that it lets applications share data and invoke capabilities from other applications without regard to how those applications were built. XML is also independent and can work with any operating system or platform they run on and different multi-channel devices may be used to access them. Providing its ability to tag different fields, XML makes searching simpler and more dynamic. In addition, XML can handle all kinds of data, including text, images and sound, and is user-extensible to handle anything special. One of the main concerns until now has been how to manage the XML-tagged data. A suitable and convenient solution is to use databases to store, to retrieve and to manipulate XML [21].

XML can be used as a storage format for Word Processors, as a data interchange format for different programs, as a means of enforcing conformity with
intranet templates or as a way to preserve data in human-readable form. It has strongly come up as a powerful alternative to the conventional binary storage and information exchange.

The benefits of using the XML approach for agricultural information dissemination are its ability to validate documents for correct or complete content, the ability to create better electronically linked publications and simpler information harvesting from these documents.

1.6.1 Research Objectives

The study is proposed to develop a prototype for the mushroom industry and to provide a framework for information dissemination to farmers of the entire agricultural sector.

The research objectives are:

- To identify the farmers' priorities for information and services.
- To utilize XML or its existing extension to develop and test a prototype for the mushroom production sector
- To propose a framework using XML for storage and dissemination of agricultural data through different formats

In the present study, a prototype has been proposed and developed for mushroom farming. Mushroom was selected because of its growing importance due to its nutritional and medicinal qualities. Its importance in the agricultural scenario of the country has been mentioned in Annexure-II.

1.6.2 Questions attempted to be answered

Through this study some of the questions were attempted to be answered, among which the first one was, “how can IT be used to provide timely and reliable information (related to all aspects of agriculture) to the farmers?” Another was, “How to make information harvesting for farmers more simpler?” and “How can
farmers access multichannel (different forms like text, video, PDA) and multilingual (different languages) information 24 hours a day?” These questions were attempted to be answered using XML as a tool.

1.7 Published work

The study has partly or fully contributed to publications which are mentioned below:


### 1.8 Thesis Organization

The entire thesis has been organized as follows:

Chapter 1 introduces the importance of agriculture in providing food security to the country and its position in the Indian economy in terms of its share of GDP and also in terms of the massive employment it provides to the huge Indian workforce. It introduces the concept of agricultural extension, its importance and the limitations of the traditional methods of extension. The importance of internet and ICT have also been highlighted. The research problem is discussed along with the need and the scope of the study.

Chapter 2 covers the background and the related research work done in the field of agriculture information and XML. It also includes some success stories in the related field and points the research gaps.

The developments in the field of programming languages have been discussed in Chapter 3. The development of the WWW and some shortcomings of HTML, which led to many domain specific programmers switching over to XML, have also been discussed in this chapter. It included XML data storage techniques, a brief discussion of XML schema, XSL, and XLink. The interoperability and extensibility characteristics of XML have been discussed along with various DBMS architectures.
The prototype development and testing for mushroom growing constitutes Chapter 4, which also discusses the data collection techniques followed to collect information regarding the information needs of farmers. The methodology of prototype construction along with mushroom growing operations ontology and its semantics have been discussed. An example relating to the process of adding new information to the system has also been discussed in the chapter. Thereafter the prototype is tested among computer literate as well as computer illiterate (farmers) groups and the results are presented.

Chapter 5 constitutes the discussion and directions for future research.