THE ROLE OF INFORMATION TECHNOLOGY IN DISSEMINATING INNOVATIONS IN AGRIBUSINESS: A COMPARATIVE STUDY OF AUSTRALIA AND SRI LANKA

Sudath Arumapperuma

Thesis submitted in fulfilment of the requirements for the degree of
Doctor of Philosophy

Centre for Strategic Economic Studies
Victoria University
Melbourne

June 2008

DEDICATION

For my dear father

Arumapperuma K. A. Dharmadasa

A gentle courageous man who has profoundly influenced my life. He read to me every night, without fail, and nudged me to continue to believe in dreams. Although he has not been in Australia, his continuous encouragement in words over the phone and letters from Sri Lanka was, and is forever enduring. He is the reason why I hyphenate my last name in everything I have published. Without his influence, I would have never set pen to paper.

DECLARATION

'I, Sudath Arumapperuma, declare that the PhD thesis entitled The Role of Information Technology in Disseminating Innovations in Agribusiness: A Comparative Study of Australia and Sri Lanka is no more than 100,000 words in length, exclusive of tables, figures, appendices, references and footnotes. This thesis contains no material that has been submitted previously, in whole or in part, for the award of any other academic degree or diploma. Except where otherwise indicated, this thesis is my own work'.

Sudath Arumapperuma

14 November 2007

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to Victoria University for awarding me an Australian Postgraduate Award Scholarship (APA) that enabled me to undertake the research for this thesis.

I also wish to express my appreciation to the Centre for Strategic Economics Studies, Faculty of Business and Law, Victoria University, for the facilities, financial support and conducive research environment, which I enjoyed during the course of this study.

First and foremost, I would like to sincerely thank my supervisor Professor Peter J. Sheehan, Director, Centre for Strategic Economic Studies, who has been a consistent source of encouragement and support throughout this research project. I firmly believe that no one has ever had a more supportive, encouraging and generous supervisor.

I also wish to express my deepest appreciation to my co-supervisor, Professor John W. Houghton who has given me the courage to take up this higher degree. Professor Houghton has been the driving force behind this work. I am also grateful to him for his encouragement, suggestions, comments, editing and valuable advice.

More than ever I would like to thank those who not only provided comments on my work but importantly gave me emotional support to keep going, especially Professor Mahinda Wijeratne for all the discussion and help during my data collection task in Sri Lanka. My gratitude also goes to Professor Bhajan S. Grewal for his valuable suggestions and discussions related to my study. Thanks especially to Dr. Chandra P. Wijesinghe and Professor Sardar M. N. Islam for their invaluable emotional support when I had a difficult time losing my sister as a result of Tsunami disaster that occurred on 26th December 2004.

My thanks also go to the staff at the Centre for Strategic Economic Studies, especially to Mrs Margarita Kumnick. She edited my final chapters in the later stages. Mr Kim Sweeny, Ms Alison Welsh, Mr Ainsley Jolley and Ms Michelle Motton have also been very generous with assistance and support on many occasions.

Large thanks must go to my extended family members and friends who supported me during my data collection time in Sri Lanka, especially my mother, sisters, father-in-law, mother-in-law and Mr Harsha A. K. Balasooriya for their support and Mr Don Upali Jayawardane for final proof reading.

So many thanks are due to the respondents of various organizations and institutions who participated voluntarily in my survey and interviews both in Australia and in Sri Lanka.

Finally, this thesis could not have been accomplished without the love, care and encouragement of my wife Deepthika Arumapperuma. Her love, tremendous support, care and patience have been the major motivation behind my progress.

PUBLISHED WORK ASSOCIATED WITH THIS THESIS

Refereed journal article

Arumapperuma, S., 2006, 'Agricultural Innovation System in Australia', *Journal of Business Systems, Governance and Ethics*, vol. 1, no. 4, December, pp. 15-25. <http://www.jbsge.vu.edu.au/issues/vol01no4/Sudath.pdf.>

International conference paper

Arumapperuma, S., 2007, 'Role of Information Technology in the Diffusion of Innovations to the Farm Level within the Australian Agribusiness System', paper presented at the European Federation of IT in Agriculture and the World Congress on Computers in Agriculture (EFITA/WCCA), Glasgow Caledonian University, Glasgow, 2-5 July.

TABLE OF CONTENTS

List of Tables

List of Figures

List of Boxes

ABBREVIATIONS

ABARE	Australian Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
ACSA	Australian Cotton Shippers Association
ACT	Australian Capital Territory
ADB	Asian Development Bank
ADSL	Asymmetric Digital Subscriber Line
AIAST	Australian Institute of Agricultural Science and Technology
AIS	Agricultural Innovation System
Aust.	Australia
AWB	Australian Wheat Board
CARP	Council for Agricultural Research Policy
CD-ROM	Compact Disc Read Only Memory
CEO	Chief Executive Officer
CIC	Chemical Industries Ceylon
CPITT	Centre for Pest Information Technology Transfer
CRC	Corporate Research Centre
CSES	Centre for Strategic Economics Studies
CSIRO	Commonwealth Scientific and Research Organization
CWE	Co-operative Wholesale Establishment
DCIT&A	Department of Communications, Information Technology and Arts
DOA	Department of Agriculture
DSU	District Secretariat Unit
DVD	Digital Versatile Disc
FAO	Food and Agricultural Organization
GCE A/L	General Certificate of Education Advanced Level
GCE O/L	General Certificate of Education Ordinary Level
GDP	Gross Domestic Product
Ha	Hectare
HTML	Hypertext Markup Language
IGA	Independent Groceries Australia
ICT	Information and Communication Technology
ICTA	Information and Communication Technology Agency
ICTA4D	Information and Communication Technology 4 Dimension
IP	Internet Protocol
ISP	Internet Service Provider
IT	Information Technology
MD	Marketing Department
MT	Metric Ton
NARA	National Aquatic Research Authority
NASTEC	National Aquatic Research Authority
NGO	Non-governmental Organization
NIDP	New Industries Development Program
NIS	National Innovation System
NSF	National Science Foundation
NSW	New South Wales
NT	Northern Territory
OECD	Organization for Economic Cooperation and Development
PDF	Portable Document Format
PMB	Paddy Marketing Board

P&O	Pacific and Orient
Qld.	Queensland
R&D	Research and Development
SA	South Australia
TAFE	Technical and Further Education
Tas.	Tasmania
TV	Television
UNESCO	United Nations Educational, Scientific and Cultural Organization
VAP	Village Access Point
VH	Village Headman
Vic.	Victoria
WA	Western Australia

ABSTRACT

In the wake of the rapid evolution of information technology (IT), including the internet, during the last three decades, much attention has been given to the introduction of IT to the agricultural sector, and to ensuring its adoption by farmers. Given its apparent ability to provide rich information to a large number of people, hopes have been raised about the role of IT as a tool for diffusing innovations in the agricultural sector. This thesis addresses the reality of such a role in Australia and Sri Lanka.

Following the broader innovation literature, an innovations systems approach is used, and the key aspects of diffusion stressed are reach, richness and the time taken. The agricultural innovation system (AIS) is seen as a complex interactive system involving actors fulfilling eleven functions – policy, education, finance and credit, marketing, input supply, research, extension and information, logistics, processing and storage, farmers and farm organisations, and consumers. It is clear that the Australian AIS is more effective than its Sri Lankan counterpart in terms of its use of leading-edge technologies, competition in global markets with innovative products, and quick diffusion of research findings to farmers.

The use of IT in agribusiness in Australia is quite advanced, although still limited in small firms. While there are many examples of the use of IT for innovation diffusion in Australian agriculture, there is little evidence that this is yet a widely used process for the spread of innovations. The situation in Sri Lanka is quite different, with low levels of computer literacy and usage in the farm sector, with technology transfer 'across the last mile' remaining the weakest link in the Sri Lankan AIS. But farmers often go to great efforts to obtain better information, and much attention is being given by the Government and NGOs to the development of wireless networks, telecentres and other methods for promoting IT access and knowledge diffusion in the rural sector in Sri Lanka.

Given the heterogeneous nature of the actors in an AIS, together with the importance of tacit knowledge and social and peer groups factors, IT will complement existing methods of innovation diffusion for the foreseeable future, rather than substitute them.

Nevertheless, IT is likely to become increasingly important in innovation diffusion in agriculture, in both developed countries and in developing economies such as Sri Lanka.

In implementing policies to this end, Sri Lanka must give due attention to the complex interactions between the many players in the AIS, to the role of tacit knowledge and social factors, and to the low level of the IT literacy in the rural sector. While continuing efforts to build relevant infrastructure are essential, these must be supported by measures to strengthen communication between the actors in the AIS, by education and capability development for farmers and by the creation of suitably tailored digital information packages on key issues.

CHAPTER 1

INTRODUCTION

1.1 Introduction

This thesis presents a comparative study of agribusiness (the wide range on enterprises involved in producing and distributing agricultural products) in Australia and Sri Lanka, investigating and documenting innovation systems with special emphasis on the role of information technology (IT). The hypotheses to be studied are that IT can facilitate the interaction between key players in agricultural innovation systems (AIS)[1], that in disseminating innovations from invention to end-user, IT can act as an effective communication tool, particularly where time and distance are constraints, and that IT can also cost effectively replace a number of current agricultural innovation diffusion methods used by researchers, sales people and extension agents.

Recent developments in IT that make it particularly relevant for the dissemination of innovations include: ease of use, portability, declining costs, increasing data storage capacity, interactivity, speed, and links between different media and the internet. Information technology may aid the innovation-diffusion process of agricultural innovations by providing necessary information in a convenient and timely manner, in a variety of forms to suit a variety of users.

AIS diffusion partners are numerous and diverse. For example, the end-users of most agricultural innovations (i.e. farmers) are varied in terms of their age, gender, ethnicity, education, income, farming activity, etc. and they are scattered over large areas that are often sparsely populated. Therefore, it is not easy to contact them. Conventionally, innovation diffusion partners (e.g. extension and sales people) have used mass media and individual/group approaches to contact farmers.

The research undertaken for this thesis is motivated by the observation that, even though there have been a number of studies investigating how IT affects and impacts on the

[1] For a discussion of the concept of an agricultural innovation system see Chapter 2.

agribusiness sector, relatively little attention has been paid to understanding how agricultural innovation generators can diffuse innovations using IT as a communication channel. One objective of this study is to develop a better understanding of the way in which government policy can facilitate the use of IT in the diffusion of innovations in agriculture. It is hoped that this research will make a modest contribution to the body of knowledge on IT applications to the agribusiness sector in developing countries, especially in Sri Lanka where it may assist in modernising the agricultural economy.

Any discussion on innovation dissemination must first address the issue of the nature of agricultural innovation diffusion. There are a number of factors affecting agricultural innovation diffusion, including:

- cost of the innovation;
- economic benefit of the innovation;
- consistency with existing social values and norms;
- knowledge of how to use it and the cost involved in acquiring that knowledge;
- demonstrations and the opportunity to see how it works;
- information on the innovation;
- collaborative efforts of diffusion partners towards dissemination;
- after sales service, maintenance and depreciation rate for machinery and buildings;
- relative advantage;
- convenience;
- risk and uncertainty;
- suitability for present conditions;
- adaptability of the innovation to local needs; and
- the promotion efforts of extension agents and/or suppliers.

IT and the internet may enable potential adopters to find and analyze information on the factors listed above, to communicate with diffusion partners if they need more information for their decision-making and to better analyze their needs, undertake trials and monitor results, in order to reduce risks associated with ‘out of box adoption’. Furthermore, some IT applications like CD-ROMs and DVDs may assist potential adopters not only to obtain necessary information regarding the innovation, but also to trial and evaluate it on a small scale, thereby reducing the risk and uncertainty of large

scale failure. These applications have the ability to run entire extension campaigns without doing real field demonstrations close to the farmers' fields, and may therefore be cost effective in the long run.

1.2 Background: Innovation in agriculture

Agriculture can be defined as the science or practice of cultivating the soil and rearing farm animals (Moore, 2002). Agriculture, which was confined to the level of subsistence farming in days gone by, has become a multinational business. Agribusiness refers not only to farming, but to all the organisations engaged in the trade or commerce of agricultural activities, from R&D and input provision to farming to distribution, marketing and processing (Moore, 2002).

Technology has been defined as a process designed to achieve a given action while reducing the uncertainty in the cause-effect relationship involved in achieving a desired outcome (Moore, 2002). Technology transfer is the process by which innovations are exchanged between the individuals, businesses and organisations involved in research and development on the one hand, and those putting technological innovations into use on the other. However, it is not simply a one-way process as there are feedback linkages from current and potential users about their needs and about the effectiveness of existing processes.

The analysis of technical change in agriculture shows that innovation is a complex economic and social phenomenon. However, the concept of innovation is not restricted to technological innovations. For example, Schumpeter (1939) defined innovation as setting up a new production function. In other words, if we vary the production function by changing factors of production instead of quantities of factors or the form of the function, we have an innovation. This includes, for example, introducing a new product or service, a new form of organisation such as a merger, or the opening up of new markets. Technology transfer is not merely an exchange of documents or reports embodying the details of an innovation, it is a process whereby the transfer of know-how takes place from one person to another (Ratnasiri, 1984).

While there are many forces driving innovation in agriculture depending on the product, process, and unusual events, the bottom line is the price and quality of the final product. These forces operate within and outside the AIS. For instance, consumer demand for quality products can be listed as a force within the AIS, while natural disasters such as climate change, mouse plagues, etc. can be listed as forces outside the AIS. We know agriculture is a highly weather dependent activity and final production normally depends on climate, demand, pests and diseases, and other market forces – including technology.

1.3 Contribution of the study

This thesis seeks to make a contribution as the first study to compare the role of IT in disseminating agricultural innovations in Australia and Sri Lanka, where Australia is seen as representing the developed countries and Sri Lanka the developing ones. The thesis presents ideas on how IT can facilitate the dissemination of agricultural innovation, by developing a simple model of IT innovation-diffusion process within an innovation systems framework. Such a model may provide a useful guide for policy makers, extension specialists and industry practitioners who are addressing issues to do with improved innovation dissemination in agriculture.

As part of this comparative study we compare the agricultural innovation systems of a developed (Australia) and a developing (Sri Lanka) economy, and the respective roles of IT in the dissemination of agricultural innovations. This involves a systematic attempt to identify stakeholders in the agricultural innovation system in Australia and Sri Lanka, and explore their functions within each innovation system. As a result the thesis provides new materials that may be of value for researchers, policy makers and industry decision makers. Researchers outside the field will be able to reduce their knowledge gap, especially in developing countries such as Sri Lanka. Researchers and industry practitioners can gain knowledge of the availability of facilities, effectiveness, know-how and training opportunities of modern communication channels used in Australia. The results and lessons learned from the survey and interviews undertaken for this study may provide useful input to innovation diffusion in agriculture, ensuring a greater efficiency in using IT based techniques.

1.4 Development of the issue

Innovation is a process that consists of two major steps, invention and commercialization (Boston Consulting Group, 1991). Basically, diffusion occurs during and after commercialisation. Generally, the first step is carried out and tested by agricultural scientists. The second is usually more expensive than invention and the Boston Consulting Group (1991) found that the diffusion of the technology into the mass market costs around ten times as much as the original invention. Hence, the importance of exploring the potential use of ICTs in supporting the diffusion process.

In addition to land, labour and capital, information on agricultural innovations is crucial to the development of agricultural production. Farmers receive information about innovations from a variety of sources, including their relatives, peer groups, suppliers and/or extension agents. Despite their recognized contribution to yield increases and income growth, public extension services face important challenges in the areas of cost effectiveness, relevance, accountability, governance and sustainability (Eponou, 1993).

In agriculture, innovation dissemination is a collaborative activity which involves a set of actors, activities, organisations and institutions. They interact with each other in order to gain, develop and exchange various kinds of knowledge, information and other resources (Freeman, 1987; Nelson, 1993; Metcalfe, 1995; and Edquist, 1997). Therefore, to understand how innovation takes place, it is necessary to study the innovation system in agriculture. This study employs an agricultural innovation systems (AIS) approach to identify the agents involved in knowledge creation and dissemination in agriculture.

Today, agribusinesses have an opportunity to choose whether they seek assistance, depending on the complexity of the innovation and stage of adoption. They can gather information from their suppliers and customers, peer groups or extension specialists, or go it alone with the information on the internet. By the same token, inventors have an opportunity to disseminate information by developing websites which can include multi – media interactive facilities (peer discussion potential), pictures, voice, text, video and

downloadable documents. However, one study conducted to analyse the content of Australian websites for farmers found that there have been wide gaps in the information on the internet, particularly technical information (innovations), market and price information, and local/regional information (Groves and Rin, 1999).

The most important feature of the internet as a communication channel is that, if needed, an agribusiness can by-pass extension specialists and opinion leaders, and directly seek information on an innovation. Public extension workers have to cover a large number of agribusinesses in a given time, and they operate as a service. Therefore some agribusinesses have to wait a considerable time to receive the information required, if dependent upon extension services alone. To maintain a public extension service is a costly activity, and to produce manually operated extension programs and campaigns costs governments a considerable amount of time and funds. As farming is a seasonal activity, most crop and animal farmers need time-sensitive information. For instance, if an agribusiness needs information about a particular pesticide for his/her crop, it has to contact the extension specialist or research organisation during business hours, but if the business has access to the internet it is possible to obtain the information 24 hours a day, seven days a week.

However, to obtain information via the internet, farmers need to have access to a computer with relevant software installed, a telephone or broadband connection, a network provider and the know-how to both use ICTs effectively and the 'information literacy' required to search for, find and appraise information. It is widely recognized that research scientists and extension specialists have access and knowledge on how to use the internet. Most farmers in Australia have access and knowledge on how to use the internet (ABS, 2000), but the majority of Sri Lankan farmers do not.

Early research showed that the combination of mass media and interpersonal communication channels is the most effective way of reaching people and informing them about innovations as they play complementary, rather than competing roles in the dissemination of innovations (Rogers and Shumaker, 1971) and should be combined to produce a communication channel yielding maximum results. Such complementary may also be important in the case of IT and the internet.

On these grounds, this study may make a useful contribution since it attempts to address some issues that have not been dealt with in the past, especially the issue of disseminating innovation through a communication channel combining the mass media and interpersonal components of computer distance technology. Information technology and the internet can be used as a type of mass media channel as well as an interpersonal channel. Mass media, especially via the internet, could play an important role in development by conveying useful information and changing attitudes. And, while it is acknowledged that almost all research organisations in Australia and Sri Lanka are maintaining websites for information dissemination purposes, rather than the more conventional channels like extension networks, television and radio programs, printed materials etc., it is not well known that IT and the internet can be used for the same purpose in a cost effective manner.

1.5 Objectives of the study

A number of studies have investigated how the internet affects and impacts agribusiness in Australia. However, no study has been conducted to investigate how agricultural innovations can be diffused using IT. The principle objective of this research is to study and document innovation systems in agriculture with special emphasis on the role of information technology in the diffusion of innovation. More specifically, the study aims to achieve the following:

- to understand the process of innovation diffusion in agriculture and the place that information technology (IT) might play within it;
- to document the agricultural innovation systems in Australia and Sri Lanka, and the role that IT plays within those systems;
- to analyse, within the limitations of the available information, the role of IT in the diffusion of agricultural innovations in Australia and Sri Lanka;
- to compare, again within the context of limited information, the role of IT in innovation diffusion in agriculture in the two countries,
- to draw out any lessons for Sri Lanka emerging from this comparative analysis; and
- to make suggestions to improve the use of IT in promoting the diffusion of agricultural innovations in Sri Lanka.

1.6 Data sources and survey design

As previously noted these issues have not so far been the subject of detailed study. As a result the available data sources are extremely limited, and financial resources were not available for this study to undertake major new data collections, such as a stratified random sample of actors in the agricultural innovation system in Australia and Sri Lanka.[2] Given the perceived importance of the issue, however, the thesis has been prepared on basis of the available information (in particular, statistical data available from national and international agencies, and reports and other studies on specific issues from researchers in the public and private sectors), supplemented by case studies and by a survey of (and for Sri Lanka interviews with) key officials in agricultural innovation and research agencies in the two countries. The process of this survey collection is outlined below.

Desktop research was done to identify stakeholders who play a role in innovation systems in agribusiness in Australia. This was done by available secondary sources (relevant RIRDC reports, AIAST journals and conference proceedings, CSIRO journals and reports, etc.) and website searches using search engines. This step is necessary to document agricultural innovation system in Australia (second specific objective of the thesis) and identify actors who are traditionally regarded as innovation diffusion agents in AIS in Australia.

We identified more than 150 actors who are directly involved in innovation diffusion in agriculture in Australia, both in state and in private sectors. Then we identified sample of actors (n = 50) predominantly state-owned organisations and universities. Then a structured survey questionnaire was sent to a sample (who were identified by the above step) by post, to gather information regarding the role that IT plays within those systems (players). This method is vital to achieve the latter part of the second specific objective of the thesis.

[2] The Australian Bureau of Statistics has undertaken a number of surveys on innovation within the Australian economy (refs), but these have not covered the agricultural sector.

In Sri Lanka, the same task was done by searching the SLAAS website and relevant conference proceedings. Further, desktop research was done to identify stakeholders who play a role in the innovation system in Sri Lanka. This was done by available web-based resources and searching two major agricultural university library resources. A similar sample (n = 30) was identified and the method of data collection was by interview.

In addition, case studies of each country were sourced and documented to strengthen the argument of the role of IT in diffusion of agricultural innovations in Australia and Sri Lanka (third specific objective of the thesis).

In order to obtain parameters of the agricultural sector, data collected by the ABS and the Department of Census and Statistics (DCS) in Sri Lanka was sourced and utilized.

Design of an appropriate procedure for the selection of a sample is vitally important for the success of any sample survey. Two of the most important considerations in setting out the sample plan, interview schedule and survey method are:

- proper representation of the population by sample; and
- technical feasibility with respect to cost and time constraints.

Often the two desirable properties of good sample representativeness and time and cost factors are at odds with each other – forcing a compromise between precision and practicability. As we shall see in the conceptual framework in Chapter 2, there are a large number of actors involved in agricultural innovation dissemination as a system. In addition, we are comparing two counties, so that we have to cover a large area of potential respondents. Hence, the number of actors and their characteristics regarding innovation diffusion for which data must be collected for this study had cost and time implications. For this reason, a random sample of the entire AIS in each country, though ideal from the representativeness point of view, was not feasible. A structured sample was selected which included R&D organisations as well as agricultural universities predominantly in the public sector (i.e. those who were traditionally considered to be primary actors in innovation diffusion in agriculture). Due to distance and cost factors a

postal survey was conducted in Australia. However, in Sri Lanka, due to the low cost of travel as well as language issues, data collection was by interview.

The entire data collection in Sri Lanka was carried out in two phases. In the first phase, personal interviews were conducted, employing a structured questionnaire (see Appendix 1) similar to that used for the Australia postal survey, among selected respondents from all over Sri Lanka. These respondents were directly responsible for innovation dissemination for the organisation/centre employing them, for example, extension officer, communications officer or research scientist, etc.[3] The questionnaire was designed to ascertain the main innovation activities of the organisation and the sample consisted of 30 respondents (ten universities, eight government departments, six R&D corporations and four private organisations), as well as expert opinion about selected aspects on innovation dissemination in agriculture.

In the second phase, a selected, sample of organisations/centres and research institutes was first identified in 2004, and an explanatory letter and structured questionnaire was distributed by post to 50 R&D organisations including agricultural universities. Approximately six weeks after mailing the first questionnaire, a follow-up letter was mailed to non-respondents. Selected respondents were directly responsible for innovation diffusion activities in their organisation/centre, for example, extension personnel, communications officer or research scientist, etc. In Australia, 7 completed follow-up questionnaires were returned to the author. A sample of the questionnaire can be found in Appendix 1 and in Australia, in total 15 organisations (seven government departments, four universities and four R&D corporations) responded to the survey. This represents a response rate of 30 per cent. A number of limitations were faced during the data collection stage, and they are summarized in Appendix 2.

The questionnaire was organized into 2 major parts. Part 1 concerned the main innovation activities of the organisation and Part 2 sought to gather information on the channels presently used to disseminate agricultural innovations, and especially to determine the role of IT in the diffusion of innovations. Part 1 of the questionnaire was

[3] The cost of conducting the survey and interviews was covered by the CSES at Victoria University in Melbourne.

similar in format to Temel et al.'s (2001b) questionnaire for an agricultural innovation study in Azerbaijan. Most of the interviews were voice recorded (with the prior permission of interviewee) to avoid human errors of translating and misinterpretation due to varying language usages in Sri Lanka. Findings are examined in chapters 3, 4, 5 and 6.

Due to the highly qualitative nature of the questions and relatively small sample numbers both in the survey and interviews, statistical analysis such as cross tabulations or t-tests would not give meaningful results. Therefore, the author did not use statistical analysis to explore the statistical significance, if any, of differences between countries or to differentiate the respondents and corresponding responses. In other words, we did not explore whether there is any relationship between responses and corresponding respondents in the three major respondent categories (government departments, universities and R&D corporations). Finally, we are not claiming our samples (interview and survey) represented the AIS populations in each country.

1.7 Outline of the thesis

This thesis consists of eight chapters. An outline of the thesis structure is given in Table 1.1. The present chapter introduces the research topic and discusses the background and rationale for the research. Background information on innovation in agriculture, development of the issues and objectives of the study and sample design and data collection are also presented.

Table 1.1 Chapters, topic and page numbers

Chapter	Topic	Page
1	Introduction	1-12
2	The Diffusion of Innovation in Agribusiness: Conceptual Framework	13-35
3	Innovation Systems in Agribusiness in Australia	36-60
4	Innovation Systems in Agribusiness in Sri Lanka	61-84
5	Role of IT in Diffusion of Innovations to the Farm Level within the Australian Agribusiness Systems	85-110
6	Role of IT in Diffusion of Innovations to the Farm Level Within the Sri Lankan Agribusiness Systems	111-142
7	Comparison Between Innovation Systems in Australia and Sri Lankan Agribusiness Systems with Special Emphasis of IT	143-165
8	Conclusion	166-181

Chapter 2 focuses on the details of the conceptual framework, supported by a literature review. It also provides important information on the historical transition from a linear view to a systems approach to agricultural innovation, and notes four schools of thought relevant to innovation diffusion in agriculture.

Chapter 3 examines the agribusiness innovation system in Australia. It starts with a brief introduction followed by an overview of Australia, Australian agriculture and a description of the innovation system. The latter part of the chapter analyzes the empirical results of the study.

Chapter 4 examines the agribusiness innovation system in Sri Lanka. It starts with a brief introduction followed by an overview of Sri Lanka, Sri Lankan agriculture and a description of the innovation system. The latter part of this chapter also analyzes the empirical results of the study.

Chapter 5 seeks to explore the role of IT in the dissemination of innovations to the farm level within the Australian agribusiness system. IT begins with a brief introduction, followed by discussion of the role of information technology in the context of the Australian economy, the internet and agricultural technology transfer. Furthermore, this chapter presents two case studies providing evidence on how IT contributes to innovation diffusion in agriculture, followed by the main results of the empirical study. It also tries to identify associations between agricultural extension and IT, and ends with a brief conclusion.

Chapter 6 explores the role of IT in dissemination of innovations to the farm level within the Sri Lankan agribusiness systems. This chapter begins with a brief introduction on information technology in the context of the Sri Lankan economy and the Sri Lankan farmer. Furthermore, this chapter also tries to identify associations between agricultural extension and IT, and presents an analysis of empirical results. The chapter also closes with a brief conclusion.

Chapter 7 compares the agribusiness innovation systems in Australia and Sri Lanka, and discusses the role of IT in the dissemination of innovations to the farm level in Australia and Sri Lanka, respectively. It also explores all the identified innovation diffusion models of agriculture and proposes an IT-dissemination model.

Finally in Chapter 8, the findings of the study and major policy implications are discussed together with an agenda for further research.

1.8 Conclusion

This opening chapter set out the objectives of the study, along with the sample design and justification for undertaking this study. The following chapters will further develop the conceptual framework for this work and empirically investigate the agricultural innovation systems in Australia and Sri Lanka with special reference to information technology.

CHAPTER 2

THE DIFFUSION OF INNOVATION IN AGRIBUSINESS: A CONCEPTUAL FRAMEWORK

2.1 Introduction

This chapter develops the conceptual framework within which the investigation will be set. The main elements of that framework are: innovation and diffusion in the context of innovation systems; tacit and codified knowledge; stages in diffusion; the social context of innovation; the role of local networks; contacts and linkages and the potential role of IT in innovation diffusion in agriculture.

The chapter focuses on three aspects of the conceptual framework namely: innovation (in and of itself) and the diffusion of innovation, and the application of these concepts to agribusiness/agriculture. Hence, we explore the concept of a national innovation system; definitions of the agricultural innovation system; identification of its components and key players; and the concept of the richness and reach of diffusion, which may be enabled by the internet. Further, this chapter identifies various dimensions of a systems approach to innovation diffusion and how it our understanding of it has evolved from the linear approach.

The conceptual framework, presented here will be employed to analyse major actors in the agricultural innovation systems in Australia and Sri Lanka – as presented in chapters 3 and 4. Finally, this chapter reflects on the complexity of linkages between actors in the AIS.

2.2 What is innovation?

Innovation can be defined in many ways depending on which school of thought one is considering and/or the individual who defined it. Definitions of innovation have also

evolved over time. A few representative definitions of innovation, with their corresponding school of thought and how this study defines agricultural innovation are briefly described in this section.

Innovation, as a process, is linked to learning processes and to the information and knowledge management capability that actors and agents have (Lopez, 2004). On the other hand the nature and the form of generated innovations depend on several factors and causes, they do not emerge in a vacuum and their ultimate configuration is not linear. For a single firm, innovation can be defined as applying ideas new to the firm in products, processes, services, organisation, management or marketing (Bryant, 1998). This definition can be applied to agribusinesses as they operate as a single firm or business unit.

Hall (1986) suggests that innovations take two forms: product innovations and process innovations. The former involve the creation of new products or changes in the specification of existing goods and services sold in the market, either as products for final consumer demand or as products used as intermediate inputs within the supply chain. Process innovations involve changes in the way in which inputs are used in any given process of R&D, production, distribution and marketing. On the farm, innovations are mainly process innovations, whereas product innovation occurs primarily among suppliers of agricultural chemicals and equipment, etc.

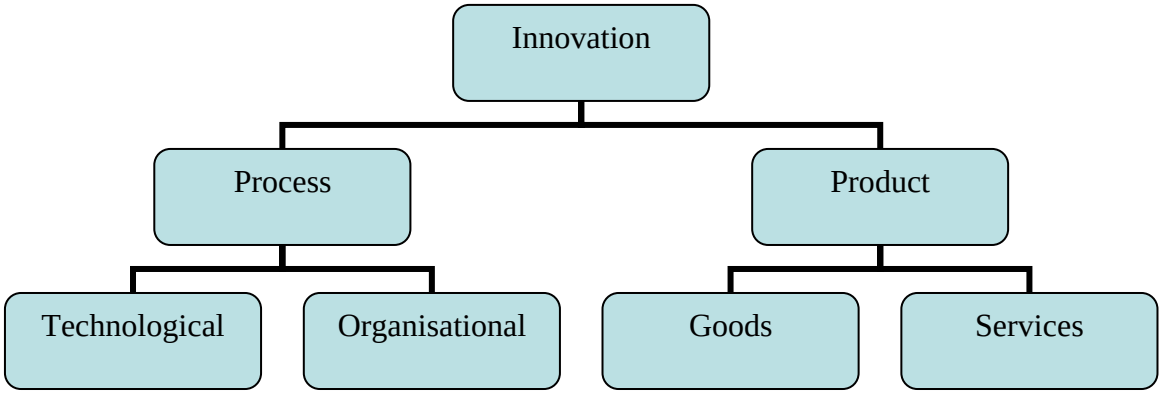
Piana (2003) goes beyond this two way classification, argues that innovation can be classified into three major categories:

1) product innovation (e.g. new goods or services put on sale);
2) process innovation, which changes the way a given good or service is produced within the firm or across a supply chain; and
3) behavioural innovation, when an organisational routine is replaced with a new one.

Quite often, the innovation turns out to be a mix of all three ‘pure’ categories, as in the case of the introduction of a new product that requires new productive competences and changes in the organisation (Piana, 2003).

In 1997, Edquist defined innovation as a new creation of economic significance normally carried out by firms or sometimes individuals. It may be completely new, but is more often new combinations of existing elements. The diagram (Figure 2.1) shows the taxonomy of innovation, including its heterogeneous nature and complexity.

Figure 2.1 Taxonomy of innovation



Source: Edquist (2001).

Within this framework, agricultural innovation can be differentiated into three main categories as follows.

1. Product innovation – items such as pesticides, new seed varieties, new types of animal feed, treatments and veterinary medicines, etc. For these sorts of products commercialization of the research results is done by industry (mainly in areas like the chemicals industry), and typically involves large multinational firms. As a result, information about the new product is driven from the firms in the form of product marketing, and is not transferred directly from the researcher to the farmer. The driver is the producer (e.g. Monsanto) and the link is more likely to be the local distributor/retailer or agricultural supplier.
2. Process innovation – processes relating to new/improved ways of tilling and planting, new breeding and feeding practices, and new ways of tending (e.g. application of pesticides or animal feed, etc.). These may be related to the use of new products. The links between research and farming practices in these

processes are more direct, but diffuse and learning based, involving family, community and extension/information. It is also localized and conditional.

3. Event responses – there may be a third area of innovation relating to responses to unusual events, which happen occasionally, so there is less knowledge about what to do from experience at the farm level. Examples might be plagues (mice, locusts, etc.), diseases (avian flu, foot and mouth, etc.), fire, flood, etc. Again the links between research and farming practices in these processes are likely to be more direct, but diffuse, involving family and community, but possibly with more reliance on extension/information (i.e. drawing on wider experience). The existence of some mandatory regulatory actions might themselves bring about innovation, for instance in a situation where a new animal husbandry regime is to be followed in response to and/or for the prevention a disease or threat of disease.

The analysis of economic and technical change in agriculture shows that innovation is a complex economic and social phenomenon. Indeed, innovation is inherently a social process, both within firms and in a broader sense. Tacit knowledge that has not in fact been codified, and knowledge that is very difficult to codify, play a major role in innovation (Sheehan, 2005). This implies there are great benefits for firms in fostering linkages with other firms and organisations that can pass on such tacit knowledge (Sheehan, 2005).

According to Rogers (1995), innovation is an idea, practice or object that is perceived as new by an individual or other unit of adoption. He defines diffusion as the process by which an innovation is communicated through certain channels over time among the members of social systems. Tornatzky (1990) has defined innovation as ‘the situationally new development and introduction of knowledge-derived tools, artefacts, and devices by which people extend and interact with their environment’ (p91). Some authors restrict the term ‘diffusion’ to the spontaneous, unplanned spread of new ideas, and use the concept of ‘dissemination’ (the term that is used in this thesis) for diffusion that is directed and managed. However, there is no simple pipeline from invention to application.

According to Piana (2003) innovation is a pervasive phenomenon, whose effects are often ambivalent (i.e. leading simultaneously in opposite directions, depending on the goals of the innovator, the technological opportunities as well as social constraints). In particular, innovation can exert an impact on the following variables:

- fulfilment of regulatory requirements (e.g. about environmental protection);
- costs (mainly if process innovation);
- the use of inputs (e.g. energy savings);
- the required skills of manpower (in the directions of standardisation/ simplification, reduction or empowerment);
- the employment structure, thus the relative weight of social groups;
- productivity;
- the quality of the produced goods/services;
- sales, since new needs could be matched to the new goods/services;
- product differentiation;
- variety of the goods/services available to both consumer and business user;
- patterns of consumption;
- exports, when new goods are desired abroad and there are no adequate substitutes;
- the number of firms operating in the market, which increases if innovation is due to young start-up firms, or reduces if incumbents dominate the innovation trajectory, forming a barrier to entry; and
- profitability, potentially both through lower costs than competitors and higher quality (Piana, 2003, p5).

Some effects are based on the asymmetry between the innovator and his/her competitors, while others may depend on the large-scale diffusion of the innovation. Because innovation has such a multidimensional nature this study uses the innovation systems approach, rather than the more simplistic ‘pipeline’ approach. In other words, an innovation is largely the result of a complex set of relationships between agents who produce, distribute, and apply various kinds of knowledge applications, and this set of relationship is known as the innovation system.

2.3 Agricultural innovation and schools of thoughts about diffusion

Diffusion is the process by which an innovation is disseminated through certain communication channels over time among the members of a social system (Rogers, 1995). Time is also involved in the innovation-decision process.

There is a large body of literature on the nature and process of innovation. This has been developed, both empirically and theoretically, in sociology, communication studies, economics and recently information technology. Economists have an applied interest in innovation and have tended to focus on the process. Therefore, this section outlines a short review of the literature on information technology, sociology, communication and economics giving their different perspectives on innovation.

2.3.1 Economics discipline perspective

The innovation process involves both creating new knowledge and drawing on the knowledge pool to generate new products and processes. The process can be divided into three parts:

- invention – devising new product or service;
- commercialisation – actually introducing the invention to the market for the first time; and
- diffusion – subsequent production and consumption of the invention through the economy.

Evolutionary innovation theory (Metcalfe, 1995) has introduced biological concepts (mutation, selection and adoption) to describe the innovation diffusion process. When information about new technology becomes available, the firm or farmer selects it and applies it. In this scenario technology/innovation is a factor of production. Innovative farmers adopt new technology first, and the trickle down effect/imitation spreads the innovation to the other categories of farmers – early adopters, late adopters and laggards, respectively.

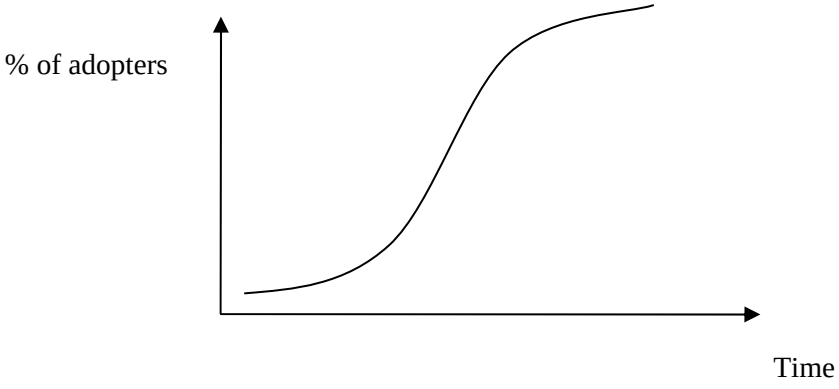
2.3.2 Sociology discipline perspective

According to Rogers (1995) an innovation is an idea, practice or object that is perceived as new by an individual or other unit (e.g. organisation). The characteristics of an innovation, perceived by the individual or member of the social systems, determine the rate of adoption. There are five such attributes of innovations: relative advantage, compatibility, trialability, complexity and observability, respectively (Rogers, 1995). Innovations that are perceived by individuals as having greater relative advantage (may be measured in economic terms, prestige, convenience and satisfaction), compatibility (consistent with values, past experience and needs), trialability (may be experimented with on a limited basis), observability (results of an innovation are visible), and less complexity will be adopted more rapidly (Rogers, 1995).

This theory emphasizes a very important dimension, the concept of time. The selection of the right timing to commence technology dissemination and the use of time as a unit to measure the rate of adoption throughout the whole process are two important implications from this theory (Wong and Romm, 2004). Therefore it is imperative to use time-effective communication channels when approaching potential adopters.

The relationship between time and percentage of adopters can be visualised as follows (see Figure 2.2). By increasing the number of adopters in a given time it is possible to shift the diffusion curve towards the left side. It is possible to shift the curve by increasing awareness and interest in the innovation-decision processes of the potential adopters and/or approaching them in large numbers (Sheehan, 2005).

Figure 2.2 S-shaped diffusion curve



Source: Rogers (1995).

The innovation-decision process is a process through which an individual or an organisation passes from first awareness of an innovation to the decision to adopt or reject the innovation. Diffusion theory considers two steps in the diffusion process. First, based on farmers' needs, research organisations select the most appropriate form of innovation. Second, based on the first choice, research organisations select the most appropriate channel to maximize the number of farmers who will adopt the new technology within a particular time period.

Selection of the right channel is influenced by the size of the target population. The more farmers are exposed to the innovation, the higher the chance that these farmers will adopt it (Wong and Romm, 2004).

2.3.3 Communication discipline perspective

Many models have been postulated as to how innovations are diffused among adopters. However, Rogers and Shumaker (1971) present a practical model that brings out the limitations of the communication element of the agricultural innovation-diffusion process. Diffusion is a special type of communication in which messages are conveyed about the innovation. The newness means that some degree of uncertainty is involved in diffusion.

This pre-internet study points to just two types of communication channels involved in the diffusion process:

1) mass media channels (e.g. television, radio, newspapers, etc.); and
2) interpersonal channels (e.g. extension specialist, supplier, opinion leader, etc.).

An individual or an organisation can reduce uncertainty by obtaining information. Hence, the innovation-decision process is an information seeking and information processing activity–to gain understanding of the economic advantages and disadvantages of a particular innovation and to reduce the uncertainty of adoption.

This study has not sought to measure social systems variables and the characteristics of innovations which determine the process of knowledge and persuasion stages of

innovation-adoption. Rather it tries to identify whether IT may be an important communication channel.

2.3.4 Information technology discipline perspective

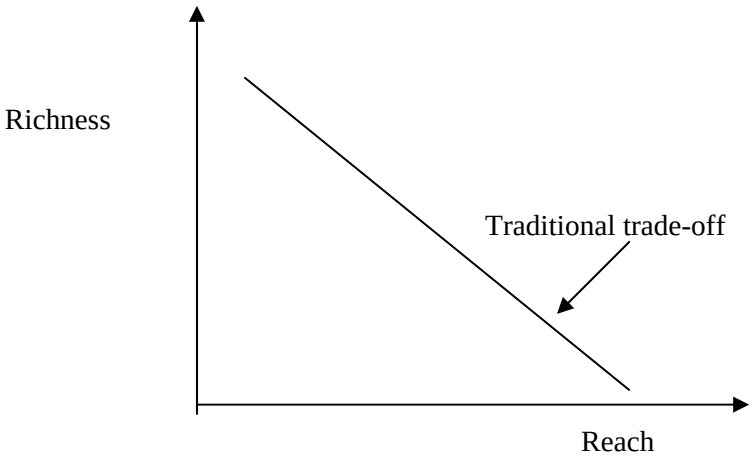
Information technology (IT) is defined in many ways. In the OECD the term refers to 'technologies used in the collection, processing and transmission of information'. It is through these technologies that the world is becoming connected by the internet and is undergoing digital convergence. That is television, personal computers, telephones, movies, textbooks, newspapers and much more are converging on the internet (Long and Long, 2001).

IT can be used to disseminate innovations using a variety of forms. It can also facilitate feedback using e-mail, bulletin boards, video conferencing, and chat rooms. Therefore, adopters can seek information using the internet as a tool, relevant to their stage of adoption, and feedback their experience to other potential users and to researchers. As such, IT may better fit the real world innovation processes revealed by the innovation systems perspective, than the traditional channels.

2.4 Richness, reach and the stages of diffusion

Before the introduction of IT and the internet, it was possible to share extremely rich information with a very small number of people or less rich information with a large number, but it was impossible to share simultaneously as much richness and reach as one would like. Evans and Wurster (2000) depicted this trade-off at the heart of the old economics of information in Figure 2.3 below.

Figure 2.3 Traditional trade-off between richness and reach



Source: Evans and Wurster (2000)

The definitions of richness and reach are presented in the following Box 2.1.

Box 2.1 Definitions of richness and reach

Reach is easy to understand. It simply refers to the number of people – at home or at-work – exchanging information.

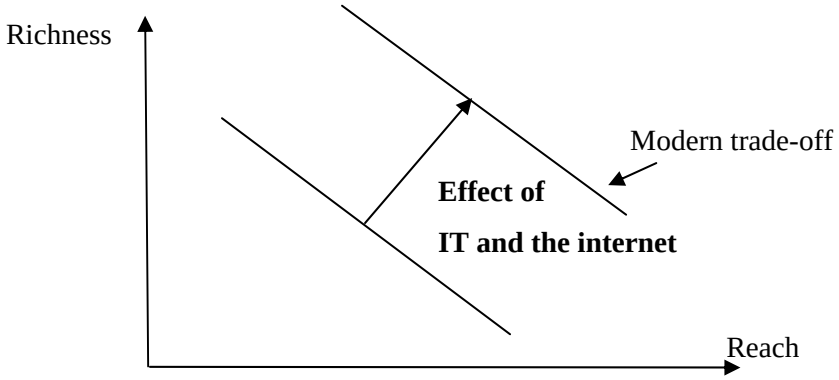
Richness of information is a bit more complex to define. It concerns six aspects of information:

- Bandwidth or the amount of information that can be moved from sender to receiver within a given time. Stock quotes are narrowband, a feature film is broadband.
- The degree to which the information can be customized. Advertisement on television is far less customized than a personal sales pitch, but reaches many more people.
- Interactivity. Dialogue is possible for a small group but to reach millions the message must be a monologue.
- Reliability. Information may be more reliable when exchanged among a small group of trusted individuals, but less so when it circulates among a large group of strangers.
- Security. Managers share highly sensitive business information only in closed-door meetings but they will disseminate less sensitive information to a wider audience.
- Currency. On Wall Street, where seconds count, a few market makers have instantaneous quotes, a larger group of financial institutions receives quotes with a three to fifteen minute delay and most retail investors receive quotes with at least a 15 minutes delay.

Source: Evans and Wurster (2000).

After the introduction of IT and the internet, it has become possible to shift the traditional trade-off between richness and reach as upward, depicted in Figure 2.4.

Figure 2.4 Modern trade-off between richness and reach

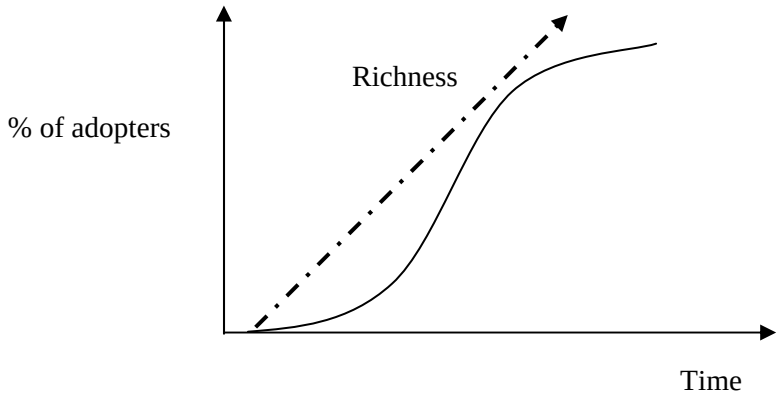


According to Evans and Wurster (2000) communicating rich information has required proximity or dedicated channels, and only a limited number of people can access the information. Conversely, communicating information to a large audience has required compromises in the quality and/or richness of that information. However, IT and the internet enable greater richness and reach simultaneously.

According to Rogers (1995) the S-shaped diffusion curve (see Section 2.3.2) can be enlarged to include a third dimension (in addition to percentage of adopters and time), namely richness of the material diffused with time as shown in Figure 2.5. Figure 2.5 is an amended version of Roger's S-shaped diffusion curve.

With respect to the concept of richness and reach (see Section 2.4), there is an increasing trend of richness of information over time. Therefore according to Figure 2.5, we can see an increasing trend in the percentage of adopters and richness of information, simultaneously over time. As a result, a larger number of adopters can get rich information of innovations without compromising quality using IT as a diffusion tool. The relationship of the percentage of adopters, richness of material and time is illustrated in Figure 2.5 below.

Figure 2.5 S-shaped diffusion curve and richness as a third dimension



In agriculture, adoption of innovation is a mental as well as physical process, which according to Rogers (1995) occurs in five stages namely: (1) awareness; (2) interest; (3) evaluation; (4) trial; and (5) repeated use or rejection. To follow these five steps takes some time. How long depends on the nature of the innovation and for instance how difficult it is to get important information regarding the innovation. If we can shorten the time involved in each step we can accelerate adoption. For example, IT can help to make the awareness and interest stages more accessible to a larger number of potential adopters, supplying rich information in a relatively short period of time.

In reality, innovation diffusion in agriculture is a social process, in which interaction between farmers and researchers involves social links. Therefore, the transfer of knowledge is not just a matter of wires, computers and the internet, but occurs in a much broader social context with numerous players. Those players can be categorised as system players (see Chapter 3) and social players (i.e. community leaders, opinion leaders, religious leaders, innovative farmers, etc.). These social players have a remarkable influence on innovation diffusion and their attitudes may hinder the diffusion in some instances. For instance, during training sessions or demonstrations they exchange concerns as well as ideas.

Players in the agricultural innovation system and traditional farmers have tacit (non-codified) knowledge which also plays a vital role in adoption. When selecting the proper diffusion channel, diffusion partners should consider the potential importance of this tacit knowledge and what role it plays. It is easy to diffuse information in the form of codified knowledge via the internet, but there are limitations to the diffusion of tacit

knowledge because of the social factors involved, and IT and the internet alone are unable to diffuse innovation in agriculture. IT may well be a complementary tool rather than a stand-alone substitute.

Local networks play an important role in diffusion, acting as contacts and linkages in the innovation diffusion process, reflecting both the systematic and social nature of innovation. For instance, in Sri Lanka, paddy farmers grow rice as a group activity. They initiate ploughing and seeding together, sharing irrigation water. Finally, they harvest together. So if we want to successfully introduce a new paddy variety, all farmers in that field should trial the new variety. Hence, the extension worker has to travel to the local area before the start of ploughing to meet with local leaders, including opinion leaders and innovative farmers, and encourage them to adopt the new variety on a small scale, reducing the risk of large scale failure, and building up trust in the adoption of the innovation.

The diffusion process is embedded in a broader (national and international) innovation system, so rather than being just local or regional, is influenced by the various players in the system and by the effectiveness of the system as a whole. IT and the internet, may provide a vehicle to reach beyond the local/regional level to the national and international level. As they have the ability to overcome the barriers of time and distance in innovation diffusion. Feedback facilities, particularly those which are interactive such as email and video-conferencing together with other facilities, including DVDs, CD-ROMs and the ability to connect to media like TV, have been and can be valuable to mechanisms of diffusion.

2.5 Linear approach

The analysis of technical change in agriculture shows that innovation is a complex economic and social phenomenon. To understand how it actually occurs, researchers in the early years developed a simple model, where the actors in innovation-diffusion are identified and ordered in a linear fashion. This approach proposes a ‘technology’ flow from researcher to end-user, like water flowing through a pipeline from tank to tap. According to this view, agricultural research is the only active force driving the

innovation to farmers, while extension services provide the necessary linkage facility between them. Here innovation is the result of a process that follows a sequence of steps, namely: research, diffusion and adoption. The linear model is the foundation for the transfer of technology concept of research and extension, and many researchers and extension agents still use it. The following diagram (Figure 2.6) displays the linear approach to technology transfer. Primarily there are three assumptions in the linear model:

1) research organisations are the major source of new knowledge;
2) hierarchical, linear relationships exist between the different actors representing technology invention, diffusion and adoption respectively; and
3) farmers are the passive recipients of diffusion activity and are not involved in the invention stage.

Figure 2.6 Technology pipeline

According to the linear approach, agricultural innovation is only driven by research and farmers are passive receivers, while extension acts as a link between researchers and farmers. Information flow is one-way (as shown in the diagram). The origin of the technology is the research centre, and farmers adopt the preconceived innovation. Thus innovation is seen as being linear and unidirectional.

The linear model, which is operational in a large percentage of national research and transfer systems in developing countries, has the following characteristics (Eponou, 1993).

- Knowledge generation, transfer and use are sequential, without any interaction of feedback loops.
- There is a science-practice continuum. The sequence is basic research, applied research, adaptive research, action by subject matter specialists, extension and application by farmers. The institutions of the systems are organized accordingly. There is no need for synergy, and there is a clear division of labour.

Research generates technology. Technology transfer delivers technology to farmers. Farmers use the technology.

- There is no collective responsibility for the outcome of joint effort, and research does not necessarily see the generation of practical technologies as the required output of its efforts.

2.6 Systems approach

Our empirical investigation discussed in Chapter 4 found that depending on the context of innovation, the systems approach described in this section is also operating in Sri Lanka. Therefore it is equally applicable to developed and developing countries.

After the seminal work by Freeman (1987), Lundvall (1992) and Nelson (1993), the systems approach to innovation emerged and has been refined for more than decade. According to Edquist (1997), the first person to use the expression 'national innovation system' in published form was Christopher Freeman. However, Freeman (1995) cites the first person to use the term was Bengt-Ake Lundvell.

Ingelstam (2001) specifies a system consisting of two kinds of entities – namely the components which constitute a system, and the relationships between those components. It is possible to identify the boundaries of the system and normally a system operates in its own environment. Thinking about innovation from a systems perspective highlights the important factors that impact on how innovation actually occurs in the economy (Ingelstam, 2001) as listed below.

1. Collaboration: Firms do not innovate in isolation, but in interaction with other organisations, both onshore and offshore.
2. Creativity: Innovation involves creativity. There is no such thing as a general method that produces innovation. It can be unexpected and in response to opportunities that arise in the specific environment.
3. Tacit knowledge: Personal experience and informal, unwritten aspects of knowledge are as valuable for innovation as formal, written knowledge.

4. Geography: Despite the advances in communication technology, sharing knowledge, skills and experience is simply easier when the participants in a learning network are in the same place.
5. Demand: The sophistication and requirements of purchasers (which includes governments and other businesses as well as household consumers) play an important role in stimulating innovation.
6. Evolution: Innovation processes take time, sometimes decades. Therefore, a long-term perspective is important.
7. Cross-sectoral: Innovation occurs in all parts of the economy, not just in high-technology sectors. Bringing together businesses in different sectors (e.g. IT and agriculture) can also be important.

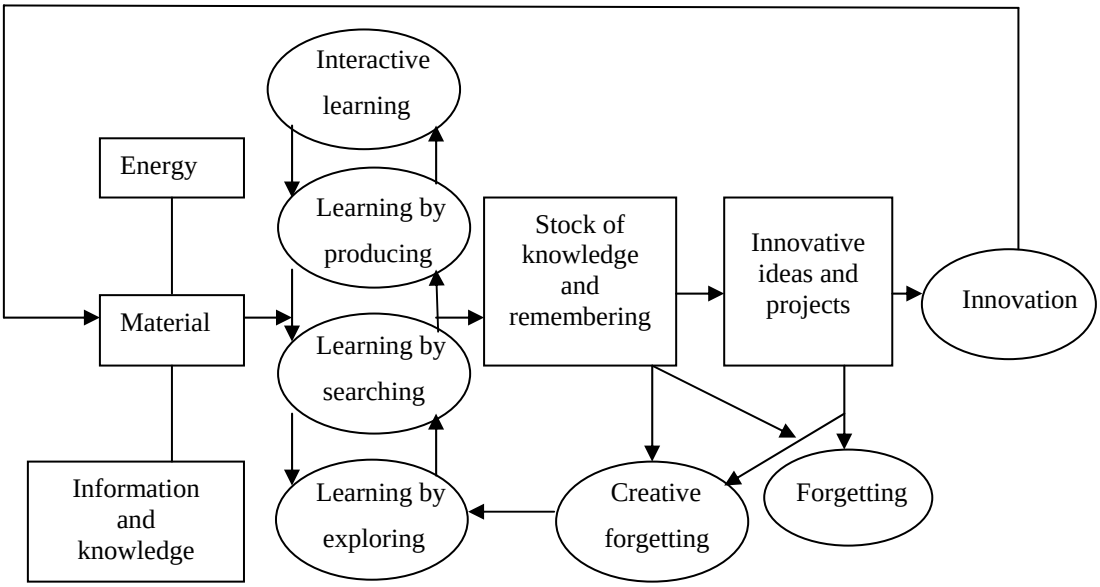
Edquist (1997) defined a system of innovation as including 'all important economic, social, political, organisational, and other factors that influence the development, diffusion and use of innovations' (p. 14). According to Edquist (2001), the systems approach is about the determinants of innovations and not about their consequences in terms of growth, quantity of employment, working conditions, etc.

This innovation systems (IS) approach is a holistic approach that has emerged and become well established during the past decade. It is now widely used in the academic context as a conceptual framework for innovation studies. It is also a useful tool to study not only industrial innovations, but also agricultural innovations in the economy. In fact, the systems approach is crucial in identifying economic, social, political, organisational, institutional and other factors involved in the activities or functions of a particular innovation system. These activities or functions are conducted by a set of agents that interact to achieve a common goal through the exchange of information and by learning from each other.

Social systems theory emphasises the social character of innovation, and innovation is recognised as a continuous learning process that evolves in cycles of feedback loops between technology users/farmers and technology providers. This process can start at any point, for instance, a practical farming problem, a research idea, a market opportunity or a development project supporting a local initiative. The systems approach leads to studying the interaction between the agents involved in light of

understanding innovation as a learning process (see Figure 2.7). There are technical, organisational and institutional innovations which can refer to production, services or other activities (Cook and Memedovic, 2003).

Figure 2.7 The chain flow model: Learning, knowledge, information and innovation



Source: Lopez (2004).

The reality of agricultural innovation is that it involves a more diverse set of agents than conventionally acknowledged by the linear approach. As a result, innovation requires a different set of functions, the most important ones being technology invention, communication and the adaptation of new ideas into current practice. Every function is important and agents or stakeholders need to collaborate in order to achieve innovation. This collaboration can best be analysed in terms of social systems theory.

Recent thinking sees innovation in agriculture as an economic and social process, and the result of the cooperation of farmers, private firms, government research organisations, NGOs, technical specialists and other suppliers of complementary products and services. Each of these actors can initiate an innovation, and interaction between them is best described in terms of a social network or innovation system (Edquist, 1997).

The systems approach thus differs from the linear approach, which assumes innovation always develops as a result of research being transferred via extension to adoption. In the systems view, the potential innovation takes centre stage and we ask who needs to contribute what, so that the innovation can be brought to fruition. Nevertheless the innovation systems approach is not without its limitations, which Edquist (2001) identified as follows.

1. The systems approach does not help to identify the determinants of innovation.
2. The systems approach partly neglects other kinds of learning processes than those leading to innovations in a direct and immediate way.
3. The systems approach largely neglects individual learning in the form of education.

Even so, it provides a useful basis for analyzing the role of IT in agricultural innovation.

2.7 The concept of a 'national' innovation system

Due to the complex nature of linkages between a large number of firms that are spread over a large geographical area, it is necessary to subdivide the innovation systems using an acceptable procedure – based on the critical nature of linkages and relationships which develop between the different stakeholders as they come together to achieve their common goal of innovation, within the economy.

Early thinkers in this field identified different levels of an innovation system. On the basis of size of a firm one level is the micro level, concerning diverse linkages in which an individual firm is involved. The second level is the meso level, concerning the way in which firms cluster together with particularly intense linkages, and the cluster itself has broader linkages in the wider economy. The third is at the level of the national innovation systems, the macro level, the unique pattern of institutions, organisations and linkages between them, which characterises a particular national or regional economy. Finally, these linkages might be addressed at the international level, studying the ways in which the organisations of various national economies interact in the creation, production and distribution of good and services (Sheehan, 2005).

A substantial number of researchers have studied and helped to define national innovation systems (NIS). Those definitions are listed in chronological order as follows:

> …the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify, and diffuse new technologies. (Freeman, 1987, p. 1)

> …the elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge and are either located within or rooted inside the borders of a nation state. (Lundvall, 1992, p. 12)

> …a set of institutions whose interactions determine the innovative performance of firms. (Nelson, 1993, p. 5)

> …set of institutions which jointly and individually contribute to the development and diffusion of new technologies. (Metcalfe, 1995, p. 4)

> …underlines the point that the innovative performance of an economy depends not only on how the individual institutions perform in isolation, but on how they interact with each other as elements of a collective system of knowledge creation and use. (Smith, 1996, p. 6).

In this study we will make use of the concept of a national innovation system as it applies to the case of agriculture, but it is important to remember that, especially within a regionally diverse nation, there are likely to be distinct but inter-related innovation systems operating in particular geographical areas.

2.9 The agricultural innovation system (AIS)

The agricultural innovation system (AIS) is a sub-set of the national innovation system. In this thesis we focus on the AIS in Australia and Sri Lanka with special emphasis on its systematic nature and on identifying the actors involved. A number of scholars have

studied agricultural innovation systems and tried to map and analyse them. We draw on two recent definitions from the literature.

Temel et al. (2001b) defined the agricultural innovation system as a:

> …set of agents that jointly and/or individually contribute to the development, diffusion, and use of agriculture-related new technologies, and that directly and/or indirectly influence the process of technological change in agriculture. (p. 6)

Chairatana (2000) defined agricultural innovation systems as:

> …the interactive activity and relationship between agro and non-agro sectors, which composes of supporters, influenced institutions and producers to learn, exchange, and transfer the knowledge and needs to generate the novelty to the market and growth. (p. 12)

When analyzing the context of the above definitions, it is clear that agricultural innovation diffusion is a collective activity with inter-dependence between various factors. However, these definitions did not identify who the agents/actors are, and what sort of functions they perform in terms of the development and diffusion of technology. This study fills the gap by identifying the actors involved in an agricultural innovation system in terms of their function in Australia, and compares the result with that of Sri Lanka. In chapters 5 and 6 we attempt to address the issue of how IT and the internet facilitate the exchange of information and resources among actors within the systems.

2.9.1 Key players in the agricultural innovation system

Chairatana (2000) identified the following key players in an agricultural innovation system:

- farmers/agribusinesses;
- farming related industry (fertilizer, agro-chemical and agro-machinery industry);
- food processing industry;
- non-food processing industry (non-perishable products industry – furniture, office suppliers, pharmaceutical industry, etc.);

- agro-related and support industry (banking, consultancy sector, future markets, auction house, supermarket, department store chain, transportation and logistics, telecommunications and other mechanisms);
- universities and research organisations/institutions;
- government;
- influential institutions (NGOs, the World Bank, FAO, UNESCO, Chamber of Commerce, co-operations, industrial associations and mass media); and
- consumers.

These players are all considered to be important in innovation dissemination in agricultural innovation systems in each country. Based on this literature we identified and named eleven types of actors with respect to what function they perform in AIS; they are listed in chapters 3 and 4.

There is a bewildering array of theoretical models used as bases to explain innovation diffusion in agriculture. Such theories have greatly influenced the nature of diffusion in agriculture, yet many studies have failed to take into account the theoretical considerations central to valid interpretation of their research efforts. The following outline is limited to those models most widely represented in the literature.

2.10 Innovation diffusion models in agriculture

2.10.1 Introduction

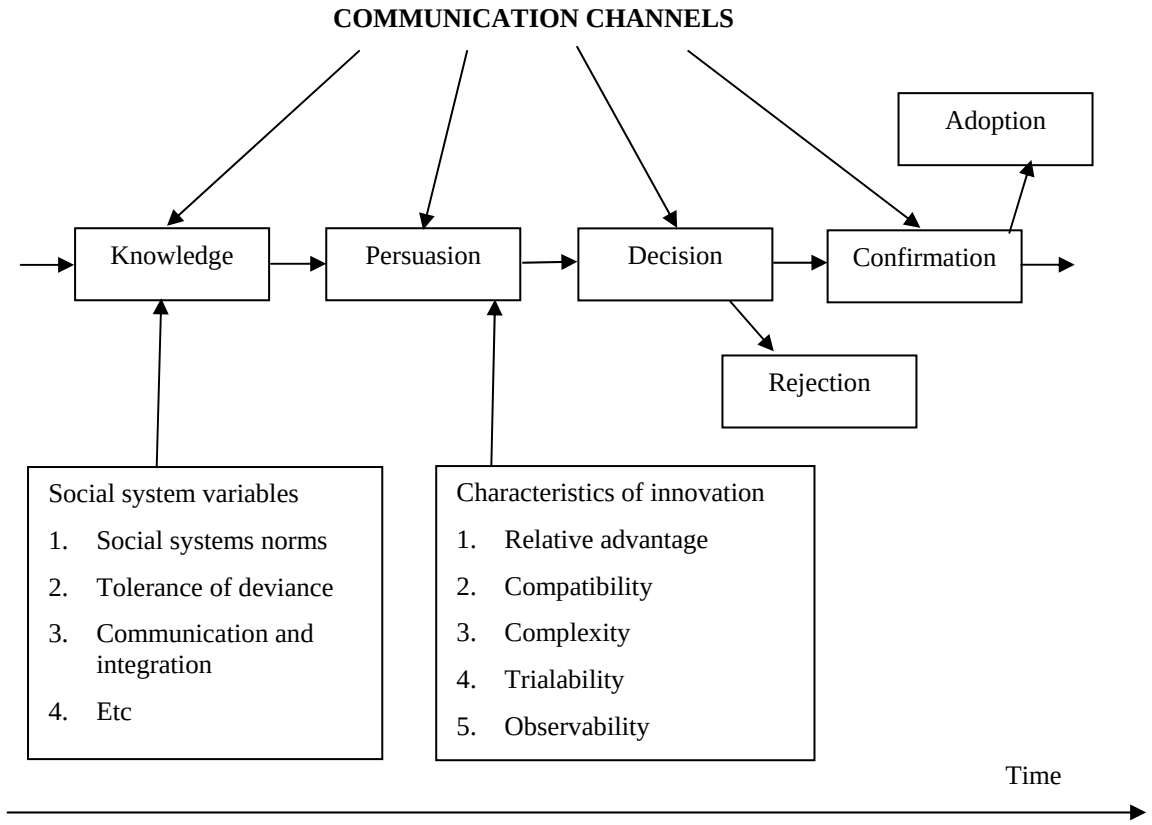
The development of a future networked society implies significant changes in the use of information technology (IT) in agriculture. Farmers' hitherto modest use of IT is economically based, with development of farming methods and application of cheaper externally produced inputs being more efficient ways to reduce farming costs. But this situation will change, as restrictions on chemicals and certain production practices of information technology will become more important. This is due to a need for a higher precision in the use of chemicals and in the care of farm animals, and also due to demands for food documentation. These restrictions and demands will be enforced by governments and by the food industry. Farmers will want IT applications that support the operational aspects of farming (i.e. real-time decision support on high bandwidth

internet connections). Email and chat applications enriched by photos, videos and sound can become important elements in a revived agricultural extension service in the future.

2.10.2 Rogers and Shumaker model

The oldest type of diffusion model, based on communication channels, can be valuable in identifying four stages of the innovation decision-making process illustrated below. This model was postulated by Rogers and Shumaker in 1971. The four stages of the innovation decision process (model) can be illustrated as shown in Figure 8.1.

Figure 2.8 Rogers and Shumaker innovation diffusion model



Source: Rogers and Shumaker (1971).

The above model is a very simple linear one that helps to understand innovation diffusion, but many scholars criticized it for its operationalisation limitations.

2.10.3 Rogers model

One of the most influential models in the area of diffusion of agricultural innovations was published by Rogers (1995), who identified a number of factors which influenced the likelihood of adoption, with the most important being the perceived attributes of innovation. He also included factors relating to the nature of the innovation decision, communication channels, and nature of the social system and the extent of extension workers promotional effort.

Communication channels are the means by which information is transmitted to or within the social system. These communicational channels are divided into two main types namely: mass media channels including radio, TV, newspapers, etc. and interpersonal channels including face-to-face linkages between two or more members of the social system. Time determines the rate of adoption or the relative speed with which it is adopted by the members of the social system. In the present context the social system consists of actors in the AIS that share a common culture, including potential adopters of the innovation (i.e. basically farmers).

Therefore according to this model the rate of adoption is a function of the nature of the innovation, channels of communication, time and the social system. Extension/sales effort can come under the social system or be included as a separate parameter.

2.11 Conclusion

This study recognizes that dissemination of innovations in agriculture is a systematic activity/process, rather than a linear activity, as early scholars thought. This chapter has developed the conceptual framework within which the investigation will be set. The main elements of this framework are summarised below.

When employing the suitable method(s), especially in selecting the channel or number of channels to diffuse agricultural innovation, it is vital to take into consideration not only the factors affecting diffusion, but also the different types of agricultural innovations differentiated in this chapter.

This chapter analyses and documents the transition from the linear approach to the systems approach, which can be used to and identify the major actors in the agricultural innovation systems with respect to the functions they perform.

Information can certainly be valuable. For instance lawyers and accountants make their living by dispensing it, while newspapers sell it. To make information saleable or valuable to its purpose it is vital to reach large numbers of potential customers without distorting its quality/richness. Information of many kinds can be used in production processes, and information about agricultural innovations is an example. IT and the internet have the ability to reach a large number of potential customers without compromising the quality/richness of the information. Furthermore, IT and the internet can disseminate information in various forms, including text, audio-visual, down-loadable and up-loadable files, movies, etc., giving information diffusion partners several options to inform potential customers about their products. Compared to traditional information diffusion methods, such as written material, faxes, newspapers, telephones, face-to-face meetings, etc., the internet is both faster and enables interactive communication, such as e-mail, video-conferencing, etc.

Innovation is defined as applying ideas new to the context in products, processes, services, organisation, management or marketing. Key features of innovation thus are that knowledge or ideas are used which are new to the specific context in which they are applied (although they might be well known elsewhere) and that these ideas might cover many different aspects of business or social operations.

The diffusion of innovation is the process by which a particular innovation is disseminated among the members of a social system. In considering diffusion, reach (the extent to which the innovation disseminated), richness (the complexity and subtlety of the ideas disseminated) and the time taken to achieve a given level of dissemination, are all relevant. The three-dimensional representation of reach and richness over time is referred to as the diffusion curve.

Innovation and diffusion do not follow a simple linear model, but take place in the context of innovation systems, with many different players participating and interacting in complex ways to help or hinder the development and use of new ideas.

The knowledge disseminated in innovation diffusion in not just codified knowledge, but includes important elements of tacit knowledge. Especially in agriculture, it is about more than knowing in theory what to do, but also about knowing in practice how and when to do it, and about being motivated to do it.

It is possible to distinguish a number of common stages in many processes of innovation diffusion: awareness, interest, evaluation, first trial and repeated use or rejection. IT may play a role in any of these stages.

Because innovation is a systematic process and these systems are social systems, innovation inevitably takes place within a particular social context, and this social context may impact heavily on the diffusion process. For example, commitment to traditional practices and the role of community leaders in seeking to reinforce or change these practices may be of critical importance.

In agriculture, diffusion of innovation to the farm gate is critical, so that networks (both social and technological), contacts and linkages at the local level impacting on the individual farmer are very important.

It is possible that IT, the internet and IT applications can influence the shape of the diffusion curve for agricultural innovations, increasing both richness and reach achieved in a given time, and perhaps also reducing both cost and uncertainty associated with the diffusion. But the extent to which this is possible will be influenced by many factors, including: the nature and effectiveness of the innovation system in agriculture; the extent to which tacit knowledge is relevant and to which methods are developed to disseminate it by digital means; the nature of the social forces at work; and the extent to which local networks, contacts and linkages are facilitated through IT.

Finally, the efficiency of diffusion can be measured by the percentage of adopters in a given time, or the shape of the diffusion curve depicted in this chapter. If we can shift the curve left we can achieve greater diffusion efficiency. Therefore, it is useful to use advanced technologies like IT and the internet to reach the maximum possible number potential adopters, to make them aware of an innovation and communicate information about it, so as to encourage them to try and adopt it.

CHAPTER 3

THE INNOVATION SYSTEM IN AGRIBUSINESS IN AUSTRALIA

3.1 Introduction

This chapter is intended to document briefly the Australian agricultural sector, its major trends, major farming systems and its innovation system, to provide a background for the subsequent analysis of the diffusion of innovation within that innovation system. Who are the major stakeholders/actors in the agricultural innovation system (AIS) in Australia? What are the major roles of those actors? What are the major characteristics of Australian agriculture? This chapter addresses these questions by undertaking an empirical review of the AIS in Australia. Section 3.2 presents an overview of Australia, including an Australian agricultural map. Sections 3.3 and 3.4 explore Australian agriculture and the Australian AIS. Section 3.5 presents the results of a survey that was undertaken to investigate various innovation-related activities in selected research and development organisations in Australia and the views of experts those organisations. Section 3.6 identifies some of the major driving forces of innovation in Australia, and Section 3.7 presents some conclusions.

With reference to the conceptual framework described in Chapter 2, the innovation system in agribusiness involves the collaboration of various actors who perform specific functions in the innovation-dissemination process; the innovation systems approach provides the necessary framework to explore the linkages between stakeholders in agricultural innovation-diffusion. These actors belong to various companies, organisations, institutes, corporations, agencies or centres, which can be classified as private, public or NGO/semi-public depending on the nature of their funding sources and whether they operate as a non-profit service or a profit-oriented enterprise. These actors can be categorized, depending on the role they perform in the innovation system, as policy makers, education providers, finance/credit providers, research organisations, input suppliers, extension and information providers, farmers and farm organisations,

logistics providers, processing companies, storage facilities providers, marketing companies, and consumers.

When collaborating and interacting with each other in the development, diffusion and use of new technologies, these actors have to achieve a number of goals and meet a number of requirements. These collaborative links have been shown to increase the cost-effectiveness of diffusion, to make better use of scarce resources and to increase incentives for the commercialization of new technology (Metcalfe et al., 2005). Therefore, the aim of this chapter is to investigate and describe the main innovation-related activities in the innovation system in agribusiness in Australia.

As noted in Chapter 2, a structured survey was conducted to gather data from Australian research organisations/centres and universities. Drawing on these survey results, this chapter gives an overview of the identified components of the AIS in Australia and how they interact with the research components. More specifically, it identifies the collaborative organisations that gain, develop and exchange various kinds of knowledge, information and other resources in the pursuit of innovation; how innovation activities are funded; and what some of the constraints on innovative activities are. It also attempts to identify the kinds of innovation activities undertaken by the organisation or centre surveyed, and the goals of their innovation-related activities. Finally, we try to identify how the organisation or centre gets funding for their innovation activities and the organisational/institutional constraints or incentives for their innovation activities.

There are numerous private and public funding agencies supporting agricultural innovation activities in Australia. The Federal Government and State Governments provide a considerable amount of funding, especially to public research organisations and universities in Australia. For example, the Federal Government funded New Industries Development Program (NIDP) supports innovation in agribusiness in Australia. This program promotes innovation by providing financial assistance to firms that produce innovative goods or services for the agricultural sector. There are two kinds of grants offered by NIDP as listed below.

1. Pilot Commercialization Projects: Applicants need to show the project is innovative, market driven and sustainable. Pilot Commercialization Projects

funding is provided on a matched dollar for dollar basis with the applicant, to a NIDP contribution of between $30,000 and $100,000.

2. In-Market Experience Scholarships: These enable emerging managers to gain first hand experience in specific areas of business management and new markets. Recipients develop their own program of in-market visits, research and selected courses suited to their needs. NIDP contribution is up to a maximum of $30,000 (Department of Agriculture, Fisheries and Forestry, 2004).

Further, NIDP developed a range of IT tools (CD-ROMs) as interactive learning material that helps small to medium agribusinesses improve their skills and build their competitive edge. Two examples of these CD-ROMs are an agribusiness marketing interactive CD, and forming and managing supply chains in agribusiness. These CDs provide practical guidance, exercises and a library facility to novice users, with stories of successful businesses. Two NIDP funded innovations have been identified and documented as case studies in the latter part of Chapter 5.

Identified AIS components that have direct linkages with research components in Australia are summarized in text form, and the types of innovation-related activities, goals of innovation-related activities, organisational/institutional constraints and incentives, and funding sources of innovative activities are summarized in table form, and are described in the text.

3.2 Overview: Australia

Australia is the smallest of the continents and the world's largest island. It is a compact landmass measuring approximately 3,900 km from east to west and about 3,220 km from north to south at its widest and largest points. The total land area in Australia is 7,617,266 sq km (762 million ha). About one-third of the continent is classified as arid (receiving less than 250 mm average annual rainfall) and another third as semi-arid (250 to 500 mm). However, Australia's northern, eastern, south-eastern and south-western areas, with climates ranging from tropical to temperate and Mediterranean-style, usually receive regular rainfall. These areas have become the major agricultural regions (Jayasuriya, 2005).

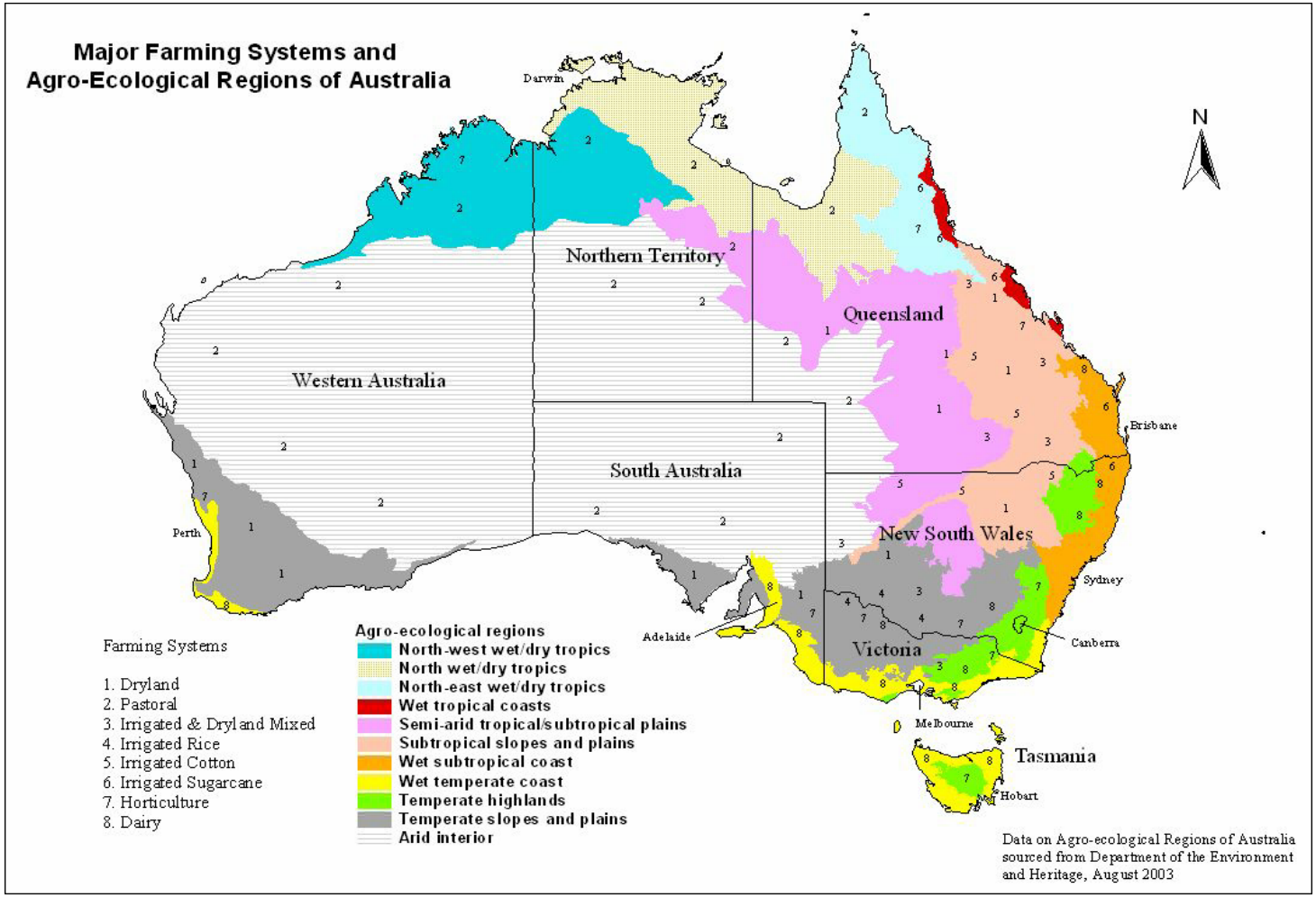
Australia is a multi-ethnic, multi-religious country comprised of a diverse and rich culture. The majority of its people are of European heritage, making up 92 per cent of the country's estimated 20 million population. The other ethnic groups that are part of the country's social fabric are Asians (7%) and Native Australians (Aborigines) (1%) (ABS, 2005). Figure 3.1 illustrates the major agricultural production of Australia. It also indicates the geographically widely spread nature of agricultural activities in Australia, the diversity of the agro-ecological regions in the country and the range of farming systems in operation.

The Federal Government is responsible for major issues that affect the whole country, such as taxation, security, etc. and the eight State Governments in Victoria, New South Wales, South Australia, Tasmania, Queensland, Northern Territory, Western Australia and Australian Capital Territory look after state-wide issues.

3.3 Australian agriculture

Australia has advanced in 200 years from a land largely without widespread, systematic agriculture to one of the world's leading producers and exporters of food, livestock and natural fibre (Reid, 1990). This achievement has taken place in the face of harsh climatic and environmental conditions which necessitated the development of highly specialised agricultural systems, skills and technology. Australian agriculture is generally based on extensive cropping and pastoral activities. While it no longer contributes a large share to GDP (average around 3% in recent years) it utilises a large proportion of natural resources, accounting for 70 per cent of water consumption and almost 60 per cent of Australia's land area (Trewin, 2007).

Figure 3.1 Australian major farming systems and agro-ecological regions



Source: Jayasuriya (2005).

Australia's gross value of farm production is $29.5 billion (4-6% of GDP) with an export value of $25 billion (2003-04). Around 375,000 people (4% national work force) were employed in the rural farm sector. In 2003-04, agriculture accounted for around 5 per cent of Australia's investment effort and employed a similar proportion of Australian's net stock of capital. It directly accounted for around 22 per cent of Australia's total goods and service exports (Productivity Commission, 2005).

Australian farms range in size from small hobby and horticultural properties to large grazing and cropping farms:

- in 2003-04 farms under 50 hectares accounted for around 20 per cent of farms (25,400);
- 33 per cent of farms were sized between 100 and 499 hectares;
- farms over 2500 hectares accounted for 11 per cent of all farms;
- the median estimated value of operations of all Australian farms was $109,000;
- around 17 per cent of farms (21,600) had an income below $22,500, while around 11 per cent (14,100) had an median estimated value of operations of more than $500,000; and
- 99 per cent of Australian farms are family owned and operated (Productivity Commission, 2005).

Over the decade 1995-2005, Australia's total land use on farms has not changed significantly. However, the number of establishments engaged in agricultural activity fell 11.7 per cent over 1995-2005 (see Table 3.1), but the area of establishments by only 3.9 per cent. Total land use fell 1.8 per cent. This can be explained by a process of consolidation of agricultural holdings, as small farms are taken over by larger farms or several small farms are consolidated to form a bigger, more viable unit.

Table 3.1 Land use on farms in Australia, 1995-2005

	1995	**2000**	**2005**	**Per cent change (1995-2005)**
Number of establishments engaged in agricultural activity (a) ('000)	147.1	146.4	129.9	-11.7
Total area of establishments (M ha)	463.3	455.5	445.1	-3.9
Area of crops (M ha)	17.0	23.8	26.7	57.1
Total area of Australian land use (M ha)	**480.3**	**479.3**	**471.8**	**-1.8**

Note: (a) Count of establishments with estimated value of agricultural operations of $5,000 or more.
Source: ABS (2006).

Australian agriculture has undergone much change over the last few decades. Key drivers have been shifts in consumer demand, changes in government policies, technological advances and innovation, emerging environmental concerns and a trend decline in the sector's terms of trade. According to Productivity Commission (2005), Australian agriculture has become increasingly export oriented over the last two decades, with around 22 per cent of production now exported (see Table 3.7). Exports have also become more diverse, with less reliance on traditional commodities, such as wool, and more on processed products, such as wine, cheese and seafood.

The agricultural workforce has a number of distinctive features, including a high proportion of self-employed, family and casual workers; long job tenure; and a relatively older workforce with relatively low education levels and employee wages. Performance within the sector has been mixed. Over the last three decades the cropping industry recorded the highest productivity gains, and the sheep and sheep-beef industries the lowest (Productivity Commission, 2005).

The agricultural sector contributes only 2.9 per cent of GDP in Australia (see Table 3.2). It is quite small compared to other sectors. However, the AIS in Australia involves a significant portion of the manufacturing and services sectors so that agriculture's contribution to the broader economy is important. This involvement is shown in Table 3.7.

Table 3.2 Sectoral comparison of GDP, Australia, 2005, per cent

Sector	GDP (%)
Agriculture	2.9
Industry	23.8
Services	73.3

Source: ABS (2007).

The agricultural sector is an important source of employment in rural and regional Australia. Table 3.3 indicates the distribution of the agricultural (food production) workforce among seven activities of food production in Australia in 2004-05. It is clear that grain, sheep and beef cattle farming absorbed the largest share (133,300 out of 312,250 or 42.7%) of employees. Poultry farming represents the least number of employees.

Table 3.3 Employment in agricultural food production in Australia, 2004-05

Activity	No.
Horticulture and fruit growing	81,650
Grain, sheep and beef cattle farming	133,300
Dairy cattle farming	21,550
Poultry farming	9,375
Other livestock farming	10,250
Other crop growing	15,950
Agriculture not fully defined	40,175
All agriculture	**312,250**

Source: Department of Agriculture, Fisheries and Forestry (2005).

The broader measure of agricultural employment – number of people employed in the agriculture and services to agricultural industries – declined from 2002 to 2006 (Table 3.4). The significant reduction in the workforce in 2003 was largely the result of the drought experienced over Australia during that period, which severely affected the agricultural sector (Trewin, 2007).

Table 3.4 Employment in agriculture industries and services, 2002-06

	Males ('000)	Females ('000)	Persons ('000)
2002	287.6	133.6	412.2
2003	239.8	110.0	349.8
2004	236.5	109.2	345.7
2005	227.0	109.8	336.8
2006	224.1	106.8	330.9

Source: Trewin (2007).

3.3.1 Major farming systems in Australia

Australia's agricultural businesses are mainly engaged in cattle farming, dairy cattle farming, sheep farming or grain growing, or a mixture of two or more of these activities (Trewin, 2007). In recent years, the most valuable commodities produced by Australian farmers have been beef and veal, wheat, milk, wool, vegetables, fruit and nuts, and lamb and mutton. Much of this produce is exported contributing significantly to global markets. The main customers of Australian agricultural commodities are Japan, US, China, South Korea, and the Middle East (Trewin, 2007).

Jayasuriya (2005) identified and categorized the major farming systems in Australia, which are summarized in Table 3.5 below. Those farming systems consist not only of crop farming, but also animal husbandry and forestry.

Table 3.5 Major farming systems in Australia

Farming system	Land area/ % of country	Farm families/ people employed	Enterprises
Dryland	15% of the country	33,200 families	Wheat, sorghum, sunflower, wool, meat, beef
Pastoral	45% of the country	Not available	Beef, mutton, wool
Irrigated and dryland mixed	Not available	Not available	Maize, sorghum, soybeans, canola, wheat, barley, oats, pastures, sheep, cattle
Irrigated rice	155,000 ha	2,000 families	Rice, cereals, sheep
Irrigated cotton	459,300 ha	1,300 families	Cotton lint and seed, other crops, sheep, cattle grazing
Irrigated sugarcane	419,000 ha	6,900 growers. 23,000 employed	Sugarcane, raw sugar, by products molasses, bagasse and fibre
Horticulture	Annual vegetables and perennial fruit 136,500 ha each and wine grapes 128,000 ha	93,000 employed across 13,865 properties 4,500 wine grape growers	Annual vegetables and perennial citrus, nuts, pome fruit, stone fruit, tropical fruit, berry fruit, banana, wine and table grapes, cut flowers
Dairy	305 million ha	13,900 farms employ 50,000 directly, another 50,000 provide related services	Fresh milk, manufactured dairy products
Poultry, swine and goat	Not available	Poultry 1850 farms, swine 3600 farms and goat 2400 farms	Broiler meat, eggs, pig meat, milk, skin

Source: Jayasuriya (2005).

These major farming systems in Australia are noted in order to quantify the percentage of the country each farming system represents, the number of farm families employed and what they grow. This information again shows the diversity of Australia's agriculture.

Table 3.6 describes the number of farming enterprises engaged in agricultural food production activities in Australia from 2000 to 2004. It identifies 17 main activities and gives trends for main activities during the period. Even though the table reflects decreasing numbers of each activity from to 2004, the total extent of land area (769.2 million hectares) of such activities did not decrease correspondently, again indicating farm suggesting amalgamation or the taking over of small farms by large farms during the period (ABS, 2006).

Table 3.6 Number of enterprises engaged in agricultural food production in Australia

Main activity	2000-01	2001-02	2002-03	2003-04	Per cent change (2000-2004)
1. Grape growing	6115	6081	5714	5836	-4.5
2. Apple and pear growing	969	860	836	897	-7.4
3. Stone fruit growing	1000	984	1096	1030	3
4. Other fruit	4495	4344	4382	4098	-8.8
5. Vegetables	4480	4303	3930	3819	-14.7
6. Grain growing	15682	15297	11411	14189	-9.5
7. Grain-sheep/beef cattle farming	15384	15197	16662	15856	3
8. Sheep-beef cattle farming	7993	7421	9009	7803	-2.3
9. Sheep farming	9925	10767	10803	9981	0.6
10. Beef cattle farming	21169	19245	24195	23769	12.3
11. Dairy cattle farming	12605	10999	10709	10178	-19.2
12. Poultry farming (meat)	782	773	717	709	-9.3
13. Poultry farming (eggs)	463	481	457	344	-25.7
14. Pig farming	1052	1061	921	808	-23.2
15. Deer farming	88	49	194	5	-94.3
16. Sugar cane farming	4743	4747	4762	4538	-4.3
17. Cotton farming	996	697	520	562	-43.6
Total	**107941**	**103306**	**106278**	**104422**	**-3.3**

Source: Department of Agriculture, Fisheries and Forestry (2005).

3.3.2 Linkages with the broader economy

According to the most recent national input-output tables (see Table 3.7), Australian agricultural producers consumed $8.9 billion in inputs during 1998-99, of which $8.1 billion were supplied domestically and $778 million worth of products were imported (ABS, 2002). Table 3.7 identifies the main suppliers and the main customers of agriculture in Australia. Services to agriculture were the largest individual category of domestically produced input supplies, costing $1,226 million in 1998-99. Other significant inputs to agricultural producers included, medicinal and pharmaceutical

products ($1.3 billion), road and rail transport ($835 million) and basic chemicals ($800 million).

Agricultural equipment is a major input, but most is imported, so innovation linkages to local stakeholders were likely to be limited. Further, Australian farmers are buying embedded technology, chemicals, fertilizers and pesticides, etc., produced by international manufacturing companies and not developed specifically for Australian use and conditions.

On the demand side, the first three food processing components (meat and meat products, dairy products and other food products) account for $5,720 million, $2,871 million and $1,715 million, respectively. Household consumption was $3,803 million during 1998-99. These shares suggest important demand-side linkages.

Innovation linkages also arise from wine and spirits, textiles, woven fabrics, flour products and cereal products and vegetables, with demands for quality, purity, packaging and handling, etc. The other interesting group of consumers are accommodation, cafes and restaurants and recreational providers who are likely to be small in terms of market size, but are very demanding customers for high quality produce.

Table 3.7 Australia's agricultural producers supply chain, 1998-99

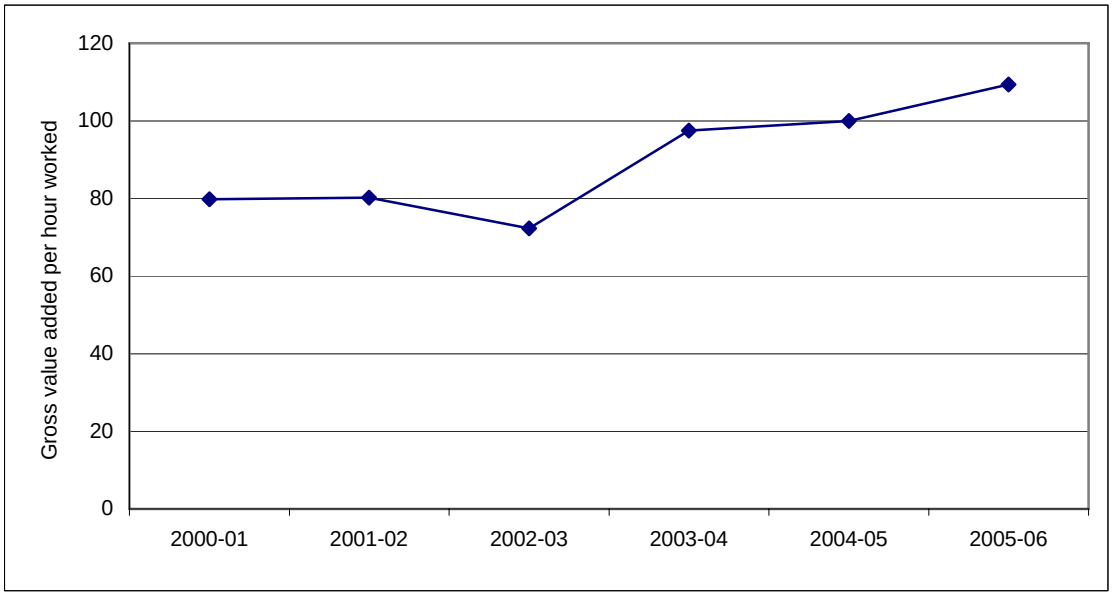
Suppliers & supplies	**Agricultural producers**	**Market & consumers**
Supply $8,911m	Agriculture $30,428	Consumption $30,428m
Domestic supply $8,133m	Domestic production $28,900m	Intermediate (business) use $18,428m
Medicinal and pharmaceutical products, pesticides $1,275		Meat and meat products $5,720m
Services to agriculture, hunting and trapping $1,226m		Services to agriculture, hunting and trapping $1,201m
Other food products $654m		Other food products $1,715m
Basic chemicals $799m		Wine and sprits $988m
Agricultural machinery $126m		Textile fibbers, yarns and woven fabrics $886m
Wholesale trade $733m		Dairy products $1,715m
Road and rail transport $835m		Flour mill products and cereal foods $684m
Banking $496m		Beer and malt $250m
Legal, accounting, and business management services $461m		Fruit and vegetable products $549m
Water supply, sewerage and drainage services $395m		Accommodation, cafes and restaurants $472m
Services to transport and storage $340m		Sport, gambling and recreational services $427m
Petroleum and coal products $362m		Retail trade $176m
Other $431m		Bakery products $36m
		Other $1,715m
Imported inputs $778m		**Final demand $12,000m**
		Household consumption $3,803m
		Private capital expenditure $1,287m
		Inventories $368m
		Exports $6,542m

Source: ABS (2002).

3.3 3 Productivity trends in Australian agriculture

The following Figure 3.2 indicates the labour productivity trend in three major agricultural industries in Australia.

Figure 3.2 Labour productivity in agriculture, fishing and forestry industries, Australia, 2000-06



Source: Productivity Commission, 2004.

Australian labour productivity in agriculture, forestry and fishing industry has been growing rapidly since 2000-01. This reflects that Australia has an effective AIS and that diffusion of innovations is very efficient in terms of technology use.

3.3.4 Conclusion

This section briefly reviews features of Australian agriculture that are relevant to understanding the agricultural innovation system, and the role of IT within it. The main conclusions are as follows.

- Australian agriculture is very diverse, both regionally (very widely spread), in terms of products and climatic conditions, and in terms of the scale of firms (individual small farmers and big corporations); hence the innovation needs are very diverse.
- It has extensive input-out links with the domestic economy, and imports much equipment (each might be a source of innovation).
- A high proportion of Australia's agricultural production is exported, so that it well linked into international markets and to global processes for innovation.
- A strong process of consolidation has been occurring for some time, with the average farm size increasing (this improves the prospects for innovation).

- There is a strong government role in supporting innovation in agriculture, at both the Federal and State level.
- Productivity has been increasing strongly, suggesting that the innovation system is working fairly well.

3.4 Actors in the innovation system in agribusiness in Australia

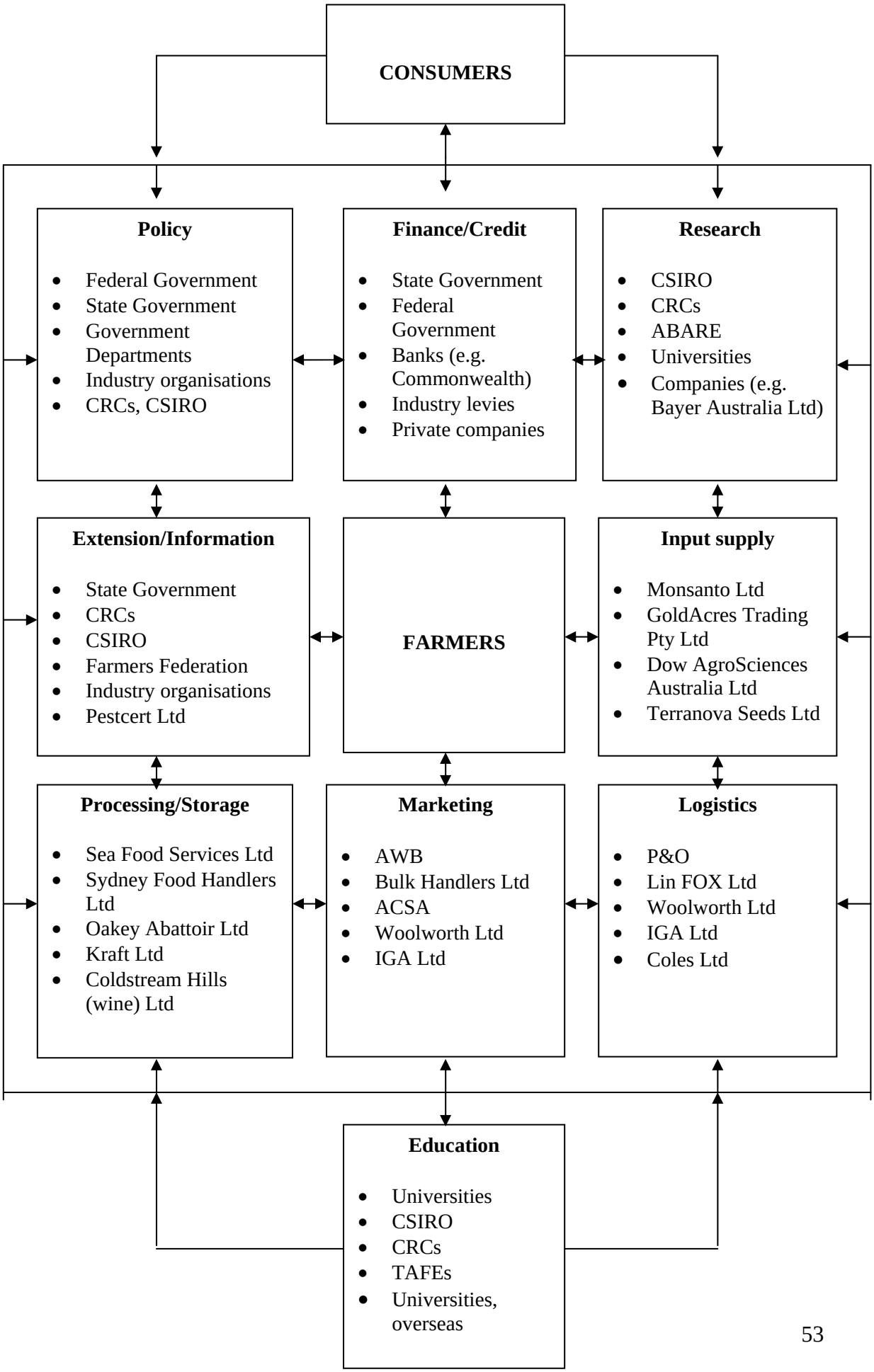
This section reviews briefly the eleven groups of actors in the AIS in Australia. While not an extensive analysis of this AIS, it brings out both the depth and complexity of the innovation system and how the many different players interact to address the distinct feature outlined above. It also emphasises the strong but different role of both the public and private sector in the AIS.

Innovation in agribusiness is imperative to stay competitive in the ever-changing world marketing conditions and to take advantage of increasing globalisation and changing trade agreements between countries. Research has found that the rate of increasing input prices for farming is growing faster than the rate of output price increase. One-way to overcome this is to enhance the productivity of the farming businesses. In other words, actors in the AIS in Australia have to enhance their ability to innovate.

Other research has been undertaken (Mahajan and Peterson, 1985) to determine the linkages among the actors in the innovation diffusion process and has documented that the weakest link is the ‘last mile’ to the farmers (i.e. Extension and Information). Therefore, this study focuses primarily on that part of the system.

Examples of public and private organisations/companies who perform a specific role in the innovation system in Australia are listed in the following text boxes. Figure 3.3 depicts the major players in the AIS in Australia. It also helps to identify some major contributors in each broad category. The left-right arrows indicate that information and resources flow both ways, also described as inflows and feedback loops.

Figure 3.3 Systems diagram of selected actors of AIS in Australia



3.4.1 Policy component

In Australia, the Commonwealth and eight State Governments make policy decisions related to agricultural issues. The Federal Government in with consultation with relevant State Governments, formulates policies that affect the whole of Australia, for instance, water policy (e.g. management of the Murray-Darling River basin) and trade policies. Apart from the above, government bodies, farmer organizations (e.g. Australian Farmers Federation) and industry levies also play an important role, lobbying about the issues that affect them. Government departments (Departments of Primary Industries in each state) are responsible for formulating policies for each state, corporate research centres (CRCs) (play a policy development role in their corresponding research areas) and the commonwealth scientific and industrial research organisation and (CSIRO) also contributes to policy making.

Agricultural policies are vital to shape the agricultural sector in Australia, taking into account all factors that affect agricultural production. Those factors include, research funding issues, pricing issues, import/export and taxation issues, subsidies and drought assistance to farmers, etc.

3.4.2 Finance and credit component

The major banks (state owned and privately owned) are major providers of finance and credit in Australia. State and Federal Governments provide some direct assistance and a lot of indirect financial assistance to agriculture. Other than banks and governments, industry levies also provide finance for farmers as well as research in Australia. The recently introduced Federal Government funded New Industries Development Program provides finance for innovative agricultural industries in Australia. Farmers can also obtain loans from banks for their farming activities. A number of large equipment suppliers (e.g. Ford, General Motors, Holden, CaseIH Pty Ltd, etc.) offer financing for the purchase of major items of equipment, such as trucks, tractors and other farm machinery, and offer various payment options like three-months, six-months or one-year repayment terms.

3.4.3 Research component

Australia has a well-developed research component, dealing with almost all growing crops and rearing animals. CRCs, the CSIRO, ABARE and universities (Australian National University, University of Melbourne, Latrobe University, etc.) play a major role. However, state departments of agriculture research laboratories and private organisations (e.g. Bayer Australia, Botanical Resources, etc.) also do research and development in their specialised areas. Furthermore, the CRCs and other organisations collaborate with each other, sharing information, knowledge and resources in order to find answers to existing problems and to innovate.

Table 3.8 Leading public R&D institutions in Australia, 2006

Name of Institution	Scientists	Total funding over grant period (A$ million)*
Australian Biosecurity CRC for Emerging Infectious Diseases	45	67.5
Australian Sheep Industry CRC	43	84.6
Cotton Catchment Communities CRC		140.7
CRC for an Internationally Competitive Pork Industry	101	79.7
CRC for Beef Genetic Technologies	200	154.4
CRC for Innovative Dairy Products	59	121.3
CRC for Innovative Grain Food Products	58	89.5
CRC for National Plant Biosecurity	35	97.6
CRC for Sugar Industry Innovation through Biotechnology	32	69.4
CRC for Sustainable Aquaculture of Finfish	42	80.0
CRC for the Australian Poultry Industries	55	71.4
CRC for Tropical Plant Protection	32	78.3
CRC for Value Added Wheat	46	69.9
CRC for Viticulture	50	80.6
Molecular Plant Breeding CRC	57	80.1
CSIRO – Division of Animal Production	83	151.3
CSIRO – Division of Aquaculture	n/a	n/a
CSIRO – Division of Crops	n/a	n/a
CSIRO – Division of Farm Management	n/a	n/a
CSIRO – Division of Food	n/a	n/a
CSIRO – Division of Pastures	n/a	n/a

Note: Funding over grant period is seven years.
Sources: CSIRO (2007a, 2007b) and division list is from http://www.csiro.au/science/animalproducts.html .

In Australia, the CSIRO and a number of CRCs are responsible for specific areas of research and they cover specialized areas of research. They are basically government-funded by the Federal and State Governments. Some private research organisations

operate on a fee-for-service basis. However, one can find a research component in almost every actor in the Australian AIS. Government-owned centres, such as CRCs and the CSIRO are bigger in size and employ more staff than the majority of private research organisations. Almost all big research organisations have their own extension network to diffuse information to end-users. All research organisations maintain websites and provide useful information to users. Chapter 4 presents more detail on the channels of innovation dissemination.

3.4.4 Extension and information component

State government departments, CRCs, the CSIRO and universities are engaged in extension and information diffusion activities in Australia. However, private extension organisations (such as Pestcert Ltd., McDonald Australia Ltd., etc.), farming systems groups, farmers federations and growers associations also play a major role in extension and information dissemination activities in Australia.

All the CRCs and the departments of primary industries have their own extension networks. They also collaborate with other actors in the AIS in order to disseminate their findings effectively. These organizations employ face-to-face techniques, group techniques, mass media and IT for information diffusion purposes.

3.4.5 Input supply component

The input supply component consists of private businesses, both nationally and internationally owned. Many of the larger suppliers have their own laboratories and sales staff. They also import technologies, such as new improved seed varieties, more advanced machinery and so on, from the overseas parent and other independent companies and introduce them to farmers through sales campaigns. Monsanto and Dove Agrochemicals are prominent examples of privately-owned enterprises interested in the farming sector in Australia. They specialize in agro-chemicals (growth stimulators, herbicides and pesticides, etc.), seed grains, machinery and fertilizers.

3.4.6 Processing and marketing component

Private companies dominate the food processing and marketing industry in Australia. Most prominent private processing companies are owned by national and/or international interests. Examples of processing and marketing companies are listed in Figure 3.4. Kraft, Sanitarium, Sea Food Services and Sydney Food Handlers are some examples of processing companies in Australia. Bulk Handlers, Food Manufactures, the Australian Cotton Shippers Association, AWB, etc. are examples of the marketing component of the AIS in Australia. The Australian Wheat Board still acts as a single desk for marketing Australian wheat to overseas buyers, although there has been a trend away from marketing cooperatives as their activities have been put onto a more de-regulated footing (e.g. Milk Marketing Board, Egg Marketing Board, etc.).

3.5 Survey results

This section reports on evidence about innovation activity collected from a small, non-random sample of organisations involved in Australian agriculture (described in Section 1.6). It was found that, for these organisations: there was a focus on technology development and diffusion; that their innovation activities spanned a wide range of new products and process activities; that they were heavily dependent on government funding because private sources of funding played only a small some part; and that a range of diverse factors, including funding and staff issues and cultural norms, constrained their innovation activities.

An empirical investigation was conducted to find the interactions between primary innovators (research organisations and university research centres) and other actors in the AIS using a structured questionnaire. The findings of the survey are summarised below.

In the initial phase of this study a demographic analysis of R&D organisations indicated that the sample comprised a fairly homogenous group. This study has undertaken an empirical investigation into 50 identified research organisations/centres in Australia, which include a number of universities, using a structured survey conducted to determine:

- the kinds of innovation-related activities of the organisation;
- the goals of innovation-related activities of the organisation;
- which of the listed behaviours of the organisation is also shaped by organisational/institutional constraints and/or incentives for innovation; and
- how does the organisation get funding for your innovation activities.

3.5.1 Types of innovation-related activities

The survey results show that organisations participating in the survey have conducted all (11) types of innovation-related activities in Australia, in varying degrees. Most organisations conducted more than one innovation-related activity. As a result responses do not total 100 per cent.

Table 3.9 indicates those activities in descending order. Almost all organisations surveyed were involved in technology development (93%); and more than half of the organisations were involved in technology dissemination (67%), training (60%) and demonstration (53%). Further, the survey revealed that technology evaluation, integration, use, policy, introduction/selling, acquisition and financing represented less than half of the innovation-related activities of these organisations. These activities are also conducted by other organisations, such as state governments and private companies. This suggests that technology development and dissemination are among the major innovation-related activities.

Table 3.9 Types of innovation-related activities of the organisation, Australia

No.	Types	(%)
1	Technology development	93
2	Technology dissemination	67
3	Technology training	60
4	Technology demonstration	53
5	Technology evaluation	47
6	Technology integration	33
7	Technology use	27
8	Technology policy	27
9	Technology introduction/selling	20
10	Technology acquisition (local/international)	20
11	Technology financing	13

Source: Author survey (2005).

3.5.2 Goals of innovation-related activities

Table 3.10 reveals the responses relating to the goals of innovation-related activities. Respondents could select more than one option, therefore the responses do not total to 100 per cent. Over 50 per cent of organisations indicated that their goals of innovation-related activities were to provide knowledge and information (87%), introduce new products and services (80%), increase commodity quality (80%), production (73%), reduced environmental damage (67%) and increase market opportunities (60%). This suggests that the most prominent goals of the innovation-related activities of the organisations surveyed relate to information flows and product and process innovation.

Table 3.10 Goals of innovation-related activities of the organisation, Australia

No.	Goals	(%)
1	Provide knowledge and information	87
2	Introduce new products or processes	80
3	Increase commodity quality	80
4	Increase commodity production	73
5	Reduce environmental damage	67
6	Increase market opportunities	60
7	Improve production flexibility	47
8	Reduce labour costs	33
9	Generate own income	33
10	Fulfil regulation or standards	33
11	Reduce material costs	27
12	Reduce energy consumption	27

Source: Author survey (2005).

3.5.3 Funding sources

Table 3.11 shows responses relating to funding sources for innovation activities in research organisations in Australia. Respondents could select more than one option, therefore the responses do not total to 100 per cent.

Looking at the funding sources for innovation activities of surveyed organisations, reveals a mix of funding. However, most of the funding (more than 80%) was derived from the Federal Government and funding bodies/agencies. This suggests that most agricultural research and development funding comes from public sources for the surveyed organisations surveyed. The reason was that almost all organisations surveyed

are owned by Federal or State Governments. State Governments funded relatively less (13%) for agricultural R&D.

Table 3.11 Funding source for innovation activities, Australia

No.	Funding source	(%)
1	Federal Government	87
2	Funding bodies/agencies	80
3	Collaborative contracts	67
4	Competitive grants	60
5	Non-competitive grants	40
6	Industry levies	27
7	Patents and copyright	20
8	Awards and prices	20
9	Own resources	20
10	State government	13
11	International donor assistance	7
12	Loans and credits	0

Source: Author survey (2005).

3.5.4 Constraints and incentives for innovation

Finally, Table 3.12 indicates responses relating to how behaviours are shaped by organisational/institutional constrains and/or incentives for innovation. Respondents could select more than one option, therefore the responses do not total to 100 per cent.

The majority of respondents (53%) indicated that other issues such as funding, staff, equipment, environment and government policy issues affected innovation in their organisations more than the other behaviours listed. The identified behaviours of the organisations were affected by less than 33 per cent of identified constraints and/or incentives for innovation. The most commonly cited constraint to innovation was difficulty in obtaining funding, followed by deficiency of skilled staff and equipment.

Table 3.12 Incentives or constraints have most affect on the innovation behaviour of organisations, Australia

No.	Behaviour of organisation	Percentage (%)
1	Other*	53
2	Cultural norms	33
3	Laws	20
4	Health regulations	20
5	Social rules	20
6	Technical standards	13

Note: * Other issues include funding, staff, equipment, environmental, government policy issues, etc.
Source: Author survey (2005).

3.6 Driving forces of innovation in Australia

Agriculture continues to change in response to many influences, such as market forces, the need for more integrated paddock to plate/user organisation, and increasing input costs in Australia. This study found that about 22 per cent of agricultural products were exported in 1998-99 (ABS, 2002). Direct exports (22.6%) and the total value of rural exports, which is greater than the gross value of production incorporates a good deal of non-agriculture value added. Clearly a high proportion of Australia's agricultural production gets exported, one way or another. Hence international consumers and their suppliers (intermediaries) are a major force driving quality and competitive products from Australia, especially wine, dairy, wool, wheat and meat products. Other major forces within the AIS in Australia are consumer demand for: quality products and low prices; tolerant varieties for drought, pest and diseases; cost effective processes; methods to prevent post harvest losses; etc.

When comparing world labour costs in agriculture, Australian costs are higher than most countries in the developing world. Therefore, to compete in the world market, Australian agriculture needs to innovate. This can be achieved by using improved and/or genetically modified varieties, using sophisticated methods of irrigation, employing modern technologies like remote sensing, computer-aided irrigation, etc.; and depends on effective collaboration among actors in the AIS to innovate and produce high quality products. The extent of agricultural R&D is one important element in this system. Furthermore, in the domestic market there are a lot of innovation linkages on

the demand side, from wine, cereals, fruits, milk and vegetables, to improve quality, purity, handling and packaging, etc.

3.7 Conclusion

AISs in Australia are a complex system with many players interacting and contributing to the overall outcome. In this chapter we identified 11 actors (major players) in terms of their function within the Australian agricultural innovation system. They are policy makers, education providers, finance/credit providers, research organisations, input suppliers, extension and information providers, farmers and farm organisations, logistics providers, processing companies, storage facilities providers, marketing companies, and consumers. These actors are inter-linked with each other in order to share knowledge, information and resources and to meet the requirement to innovate. A systems approach was utilized to identify the systematic nature of the collaborative links of the above actors.

The present study found that almost all input supply, processing/storage, marketing and logistics components of the AIS in Australia are done by the private sector companies, however some private companies are also involved in research and providing finance/credit to R&D activities. Clearly, the private sector plays a major role in the AIS in Australia. Furthermore, public sector involvement is also identified in other components of the AIS.

Even though the Australian agricultural sector contributes a relatively small percentage (3.6% in 2005) to the economy, the AIS in Australia involves a significant portion of the manufacturing and services sectors. Analysing the Australian agricultural producers supply chain in year 1998-99, it is possible to conclude that 22.6 per cent of the agricultural production was exported. On the supply side, most inputs were produced domestically.

Australian agriculture is very diverse and dispersed, closely linked into world markets and heavily dependent on sustained innovation to remain competitive and survive in difficult market conditions. This need for continuous innovation has given rise to a

complex innovation system, with a wide variety of public and private sector involvement in the development and dissemination of innovation to producers. Within this system there appears to be a strong focus on technology development and diffusion, and online training.

Australia has 17 identified farming activities which spread over nine major farming systems (see Table 3.6). As a result it is vital to have an effective communication system to diffuse innovations. The AIS in Australia is very effective in terms of using leading edge technologies, producing highly competitive products for the world market, and inventing and quickly diffusing innovations from R&D centres and corporations to end users. Expenditure for R&D in agricultural, veterinary and environmental science research was A$1198.5 million in 2002-03 (ABS, 2003).

Surveyed organisations indicated that in the major types of innovation-related activities are technology development (93%), technology diffusion (67%), technology training (60%) and technology demonstration (53%). The survey also revealed that major goals (80% or more) of innovation-related activities were to provide knowledge and information, introduce new products and processes, and increase commodity quality, with most of funding coming from the Federal Government and funding bodies for these activities. Finally the survey indicated that the major constraints for innovation can be categorised under funding, staff, equipment, and environmental and government policy issues. Therefore, it is vital to address the above issues to enhance innovation-related activities in the AIS in Australia in general, and surveyed organisations in particular.

Overall, given the rapid growth in productivity in agriculture and the continued competitiveness of Australian agriculture, the Australian AIS appears to be operating reasonably effectively.

CHAPTER 4

THE INNOVATION SYSTEM IN AGRIBUSINESS IN SRI LANKA

4.1. Introduction

National economies are increasingly becoming knowledge driven, including those found in developing countries such as Sri Lanka, where agriculture is the most important sector. To meet ever increasing domestic food requirements and to stay competitive in world markets requires a continuous process of innovation. Many innovations have come about through communication and sharing existing knowledge and information (Ranjit et al., 2006). This chapter contains an overview of Sri Lankan agriculture, followed by a discussion of the agricultural innovation system in Sri Lanka.

Unlike Australia, Sri Lanka is a small tropical country classified as one of the developing countries of the world. However, there are similarities between the innovation systems when it comes to identifying actors who perform specific roles in agricultural innovation. Those actors include policy makers, education providers, finance/credit providers, research organisations, input suppliers, extension and information providers, farmers and farm organisations, logistics providers, processing companies, storage facilities providers, marketing companies, and consumers. However, Sri Lankan innovators are highly reliant on foreign bodies such as the Food and Agricultural Organisation (FAO), Asian Development Bank (ADB) and overseas NGOs for their activities.

4.2. Overview: Sri Lanka

Sri Lanka is a small island separated from the southern tip of India by the Palk Straits, 32 km wide at its narrowest point (see Figure 4.1). It is a strategic location in the Indian Ocean, on the major air and sea routes between Europe and the Far East, which is

advantageous to the country's positioning as a global logistics hub. According to the Annual Report of the Central Bank of Sri Lanka (2003), the country's population was just over 19 million in 2006 and the total land area of the country is 62,705km² (excluding inland waters). Over the past three years the population growth rate of 1.1 per cent per annum has shown no significant changes. In 2006, the population density of the country reached 314 persons per km². The rural, urban and estate sectors represent 72.2 per cent, 21.5 per cent and 6.3 per cent of the available land, respectively (Central Bank of Sri Lanka, 2006).

Figure 4.1 Map of Sri Lanka

Source: Google, Images, www.google.com (2006).

Sri Lanka is a multi-ethnic, multi-religious country comprised of a diverse and rich culture. The Sinhalese, the majority community, make up 74 per cent of the country's population (Central Bank of Sri Lanka, 2006). The other ethnic groups that are part of the country's social fabric are the Sri Lankan Tamils (12.6%), Indian Tamils (5.5%), Moors (7.1%) and other minorities (0.8%) including Malays and Burghers. All of these groups have their own identity, customs and traditions. The official languages of Sri Lanka are Sinhala and Tamil, Sinhala being the language of the majority of the population. Tamil is used widely in the northern and eastern parts of the country.

English is widely spoken and understood in the urban centres and is the most common language of business and commerce.

The country has a bi-modal rainfall pattern under the influence of north-east and south-west monsoons. The north-east monsoon is from October to February and the south-west monsoon is from April to August. These two monsoonal rains create two major cultivation seasons called Yala and Maha. Sri Lanka is divided into three major agro-ecological zones based on the annual rainfall received, as follows:

1. Dry Zone	Annual rainfall below 1,900 mm
2. Intermediate Zone	Annual rainfall 1,900-2,500 mm
3. Wet Zone	Annual rainfall above 2,500 mm

The Dry Zone, which covers about 63 per cent of the land, mainly produces rice and other field crops and supports rain fed or irrigated agriculture. The wet zone, which covers about 23 per cent of the total land area, is mainly the plantation sector with tea, rubber and coconut. Elevations reach up to about 2,000 metres with topography varying from flat through undulating to steep. The range is often represented within a relatively small area. Soils are rich in their variability, but not necessarily in their fertility. Superimposed on these physical attributes is a strong culture and tradition encompassing the rural agricultural sector (Ariyaratne, 2000).

In 1977, Sri Lanka abandoned its import substitution trade policy in favour of market-oriented trade. Sri Lanka's most dynamic sectors are now food processing, textiles and apparel, food and beverages, telecommunications, insurance and banking. The country's economy grew by 6.0 per cent in 2005 (Central Bank of Sri Lanka, 2006). This moderately high growth was supported by the open market policy, a strong export performance and favourable weather conditions.

Since independence in 1948, Sri Lanka has had to contend with severe adverse developments, including civil unrest, a brain drain, and inconsistency of foreign investments due to poor conditions and unstable governments. Slow progress has been recorded with respect to rural development in general, and agriculture in particular, and poverty remains widespread.

Agricultural innovation is one means to help the agricultural sector get out of this vicious circle and become a greater contributor to wealth creation and employment. Sri Lanka has the potential to become an agro-industrial economy in the region of Southeast Asia. Despite this potential, agricultural performance is low and the current socioeconomic conditions put the country among the more heavily indebted countries. In addition, the country is experiencing on-going civil unrest since 1989. More recently (26 December 2004) Sri Lanka was adversely affected by the Tsunami disaster.

4.3. Sri Lankan agriculture

Growing crops has been the main economic activity in Sri Lanka for more than 2,500 years. Therefore the country's economy depends to a large extent on agricultural production. The agricultural production exhibits a dualistic nature, with a plantation sector and a rural sector. In fact, Sri Lankan agricultural production mostly rests on small-scale farmers. According to Central Bank of Sri Lanka (2003) the small holding sector accounts for more than 90 per cent of the total number of holdings. The plantation sector devotes its main efforts to earning export income, while the rural (peasant) sector mainly concentrates on growing the nation's staple foods: rice, fruits and vegetables (Central Bank of Sri Lanka, 2003).

In 2003, about 34 per cent of the total population was engaged directly in agriculture or related activities, such as livestock, fisheries, mining and quarrying (Central Bank of Sri Lanka, 2006). The agricultural sector earned US$965 million in 2003 (Central Bank of Sri Lanka, 2003). The three plantation crops contributed 84 per cent of agricultural exports in 2003 – tea 71 per cent, coconut 9 per cent and rubber 4 per cent. Other agricultural exports, including by cinnamon, cloves and un-manufactured tobacco, contributed the remaining 16 per cent (Central Bank of Sri Lanka, 2003).

Table 4.1 Sectoral comparison of GDP, Sri Lanka, 2005, per cent

Sector	GDP (%)
Agriculture	17.2
Industry	27.0
Services	55.8

Source: Central Bank of Sri Lanka (2006).

As shown in Table 4.1, in 2005 the agricultural sector accounted for 17.2 per cent of GDP while the industry and services sectors provided 27.0 per cent and 55.8 per cent respectively. As a result, the agriculture sector plays a major role in the country's economy, although services is not the largest sector (Central Bank of Sri Lanka, 2006).

Box 4.1 Type, vernacular names and scientific names of Sri Lankan crops

No.	Type crop	Vernacular name	Scientific name
1	Field crops	Chilli	*Capsicum annum*
2		Potato	*Solanum indicum*
3		Groundnut	*Arachis hypogaea*
4		Soybean,	*Glycine max*
5		Green gram	*Cicer arietinum*
6		Black gram	*Vigna mungo*
7		Maize	*Zea mays*
8		Onions	*Allium cepa*
9		Cowpea	*Vigna unguiculata*
1	Vegetables	Tomato	*Solanum lycopersicum*
2		Cabbage	*Brassica oleracea*
3		Leeks	*Allium ampeloprasum*
4		Beans	*Phaseolus Sp.*
5		Beetroot	*Beta vulgaris*
6		Carrot	*Daucus carota*
7		Cucumber	*Cucumis sativus*
1	Fruit crops	Banana	*Musa Sp.*
2		Papaya	*Carica papaya*
3		Mangos	*Mangifera indica*
4		Water melons	*Citrullus lanatus*
5		Jack fruit	*Artocarpus heterophyllus*
6		Oranges	*Citrus sinensis*
7		Cherries	*Prunus serotina*
8		Rambuttan	*Euphoria longana*
1	Nuts	Peanuts	*Arachis hypogaea*
2		Cashew nuts	*Anacardium occidentale*
3		Betel nuts	*Areca catechu*
1	Export agriculture crops	Tobacco	*Nicotiana tabacum*
2		Gherkin	*Cucumis sativus*
3		Arecanut	(same as betel nuts)
4		Tea	*Camellia sinensis*
5		Coconut	*Cocos nucifera*
1	Spices	Cinnamon	*Cinnamomum verum*
2		Pepper	*Piper nigrum*
3		Clove	*Syzygium aromaticum*
4		Cardamom	*Elettaria cardamomum*
5		Cocoa	*Theobroma cacao*
6		Coffee	*Coffea arabica*
7		Rubber	*Heviea brasilensis*

In Sri Lanka, agriculture consists of rice, other field crops, vegetables, fruit crops, forestry, plantation crops, spices, fisheries and livestock sectors and the newly emerged

floriculture and organic agriculture. Some examples of crops which represent the above groups are presented the following Box 4.1 above.

As previously noted, in Sri Lankan agriculture two distinct sectors can be observed. One is the plantation sector with tea, rubber and coconut production for export, and the other is the field crop sector which is dominated by rice cultivation for subsistence. The plantation sector can be further subdivided on the basis of management structure and land size. Large plantations, normally greater than 4 ha, are managed by companies, while small lands, normally less than 4 ha, are mainly managed by individual farmers and are collectively known as the small-holding sector (Wijeratne, 1998).

Sri Lanka's main food crop is rice, which is a staple food in the diet of the population. Therefore, it is given special emphasis by the central government with significant investments in rice-related research and development. The central government has a number of rice research and development institutes (see Table 4.8) devoted to improving regional specific rice plants. Despite this investment, yields tend to have stagnated, for while there has been a 20.4 per cent increase in rice production over 2001-05 (see Table 4.2) this is largely accounted for by the 17.4 per cent increase in area cropped over the same time (Table 4.4), implying an increase in yield over the period of only 2.6 per cent. While the area used for paddy and the achieved yield vary each year, in part reflecting seasonal conditions, there is no evidence of a significant upward trend in yields. As has been noted by Ranaweera (2002), the cost of production of paddy increased significantly in recent years affecting the profitability of production and incomes to farmers. Moreover, a cumulative effect of lack of new technologies and inefficient management practices further contributed to stagnating yields, low productivity and decreasing framer incomes. Increasing demand and stagnating yields, together with increasing production costs in the nations' staple food rice, demonstrate how critical innovation and diffusion strategies are among farmers. They also highlight the importance of collaborating with other rice growing countries and their rice research and development institutes such as the International Rice Research Institute (IRRI) in the Philippines.

Table 4.2 Production, land use and yield of key crops in Sri Lanka, 2001-2005

Item	2001	2002	2003	2004	2005	Total per cent change 2001-2005
Production						
1. Paddy ('000 ton)	2,695	2,860	3,071	2,628	3,246	20.4
2. Tea (million kgs)	295	310	303	308	317	7.5
3. Rubber (million kgs)	86	91	92	95	104	20.9
Land use ('000 ha)						
1. Paddy	798	852	983	779	937	17.4
2. Tea	180	189	188	211	222	23.3
3. Rubber	157	157	129	115	116	-26.1
Yield						
1. Paddy (ton per ha)	3.38	3.36	3.12	3.37	3.46	2.6
2. Tea (thousand kgs per ha)	1.64	1.64	1.61	1.46	1.43	-12.9
3. Rubber (thousand kgs per ha)	0.55	0.58	0.71	0.83	0.90	63.7

Source: Central Bank of Sri Lanka (2006).

This reflects R&D efforts towards yield increase with tea crops (7.5%) and increase in land use (23.3%) in the same period. This is a strong evidence for introducing higher yielding tea varieties or innovation in tea crops and rice crops.

In the Sri Lankan agricultural sector, products do not face the same competitive climate as those of industry, and production is not dependent on the availability of competitive products (Unamboowe, 1984). However, they heavily depend on weather, pests and diseases. The following Table 4.3 indicates that Sri Lanka imports rice and sugar, despite the fact that imports represent a deficit in local production. It also reflects the need for innovation in these crops to match the demand.

Table 4.3 Sri Lanka's agricultural imports and exports, 2005, US$ million

Item	Imports	Item	Exports
Rice	16	Tea	810
Flour	32	Rubber	47
Sugar	132	Coconut	113
Milk and milk products	133	Minor agricultural crops	183
Fertilizer	135		

Source: Central Bank of Sri Lanka (2006).

Table 4.4 shows agricultural land use in selected crops in Sri Lanka during the period 2001 to 2005. Total land area being used is rising, including land planted to paddy, but land planted to rubber is falling. This table also indicates 20 types of field crops grown in Sri Lanka. Apparently, for paddy it shows rising land use and production but little change in yields, therefore there is an innovation problem in paddy R&D efforts.

Table 4.4 Agricultural land use in selected field crops in Sri Lanka, 2001-05

	Agricultural land use ('000 ha)					Per cent change
	2001	**2002**	**2003**	**2004**	**2005**	**2001-2005**
1. Cocoa	6.5	6.6	6.6	1.8	1.8	-72.3
2. Cinnamon	25.1	25.3	25.4	25.5	26.1	4.0
3. Cardamom	4.7	4.7	4.7	0.4	0.4	-91.5
4. Cloves	10.7	10.7	10.7	10.7	10.7	0.0
5. Pepper	30.8	31.4	32.0	32.4	32.8	6.5
6. Coffee	15.8	15.8	15.9	6.9	6.9	-56.3
7. Manioc	27.1	26.4	26.8	23.1	23.5	-13.3
8. Maize	25.9	24.3	27.2	24.9	28.4	9.6
9. Chillies	17.4	16.4	16.1	13.8	17.3	-0.6
10. Red onions	5.2	5.0	5.0	4.4	5.8	11.5
11. Big onions	2.8	2.7	2.6	3.1	4.5	60.7
12. Potatoes	4.3	6.6	6.3	5.5	5.4	25.6
13. Sesame	6.9	6.5	8.3	7.0	9.6	39.1
14. Sugar Cane	7.6	7.9	8.6	8.2	8.4	10.5
15. Cowpea	11.0	10.3	14.1	9.6	11.3	2.7
16. Green gram	11.2	10.5	12.0	8.6	9.6	-14.3

Source: Department of Census and Statistics (2006).

Table 4.5 above indicates the cultivated extent (ha) of selected field crops grown in Sri Lanka in 1999-2003. It is evident from the table that there has been no significant increase in cultivated land during the period of 1999 to 2003 for almost all crops listed. Some crops such as meneri decreased drastically (43.8%) during the period. In terms of total selected field crops, despite the absence of obvious increasing or decreasing trends of cultivation, extents are high across almost all years indicated.

Table 4.5 Selected field crops and cultivated extent, 1999-2003, ha

Crop	1999	2000	2001	2002	2003	Per cent change (1999-2003)
1. Cinnamon	24570	24670	24570	25360	25360	3.2
2. Coffee	16300	15600	15120	14820	14820	-9.1
3. Cocoa	5640	5430	5030	4850	4850	-14.0
4. Pepper	28230	28440	28470	29100	29100	3.1
5. Cardamom	4110	3920	4040	3840	3840	-6.5
6. Kurakkan	6490	6550	5640	5480	5480	-15.6
7. Maize	28900	28640	25710	23410	23410	-18.9
8. Meneri	160	190	100	90	90	-43.8
9. Sorghum	200	160	70	220	220	10
10. Green gram	15370	12970	11070	11250	11250	-26.8
11. Cowpea	13150	12950	10790	11780	11780	-10.4
12. Dhal	10	-	-	-	-	-

Source: Department of Census and Statistics Sri Lanka (2003).

The agricultural sector in Sri Lanka is vulnerable both socially and economically, due to factors such as the low level of commercialisation; low productivity; weak market orientation; marginal/uneconomic operational holdings due to fragmentation; lack of infrastructure facilities; heavy dependence on rainfall; susceptibility to natural calamities; and dependence of the large percentage of the population on agriculture for their livelihood (Ranaweera, 2002).

Additionally adoption of new technologies has been hindered by farmers' education level. According to Ariyaratne (2000), the majority of farmers possess little education. However, this is changing, with the younger generation entering into the farming sector in Sri Lanka. During the last two decades the number of farmers has decreased from 47 per cent to 34 per cent of the population, and the latest forecasts indicate this will be down to 25 per cent by 2010 (Central Bank of Sri Lanka, 2003). To stabilize this farmer population and motivate the younger generation to join agri-based industries, requires improving farming productivity and profitability. Technology transfer to farmers and motivating them to use it will also playing a key role.

The majority of Sri Lankan farmers are poor and categorized as peasant farmers (Wijeratne, 1998). The profitability of most of their farming enterprises are marginal, thus limiting the opportunities for their family members, especially the youth, to contribute to the human resources base of the country. Financial hardship of the farmers directly affects the competition that has to be faced by rural youth from the industrial

and urban sectors. The strengthening of the economy of farming communities through innovation would undoubtedly provide opportunities to compete with these other sectors.

The pattern of land ownership in Sri Lanka by district level is presented in Table 4.6.

Table 4.6 Ownership structure, small holding sector in Sri Lanka

District	Holdings reporting extent less than or equal to 40 perches of land with agricultural output mainly for home consumption (peasant farmers)			Holdings reporting extent less than or equal to 40 perches of land with agricultural output mainly for sale purposes			Total agricultural holdings		
	Number ('000)	Extent ('000 acres)	Average area/holding ng /acre	Number ('000)	Extent ('000 acres)	Average area/holding	Number ('000)	Extent ('000 acres)	Average area/holding
1. Colombo	143.5	15.4	0.11	27.7	42.5	1.53	171.2	57.9	0.34
2. Gampaha	256.4	31.6	0.12	88.6	139.4	1.57	345.0	171.0	0.50
3. Kalutara	122.9	15.4	0.13	76.8	136.0	1.77	199.8	151.5	0.76
4. Kandy	88.7	13.4	0.15	105.0	148.1	1.41	193.8	161.5	0.83
5. Matale	212	3.5	0.16	65.1	125.2	1.92	86.2	128.7	1.49
6. Nuwara Eliya	17.8	2.1	0.12	46.4	58.3	1.26	64.1	60.4	0.94
7. Galle	87.3	11.3	0.13	106.3	165.4	1.56	193.6	176.7	0.91
8. Matara	61.0,	8.4	0.14	92.2	154.6	1.68	153.2	162.9	1.06
9. Hambantota	26.3	4.9	0.19	88.7	198.8	2.24	115.0	203.7	1.77
10. Jaffna	66.5	9.9	0.15	25.3	31.8	1.25	91.9	41.7	0.45
11. Killinochchi	4.2	0.8	0.20	13.5	36.5	2.71	17.7	37.3	2.11
12. Mannar	9.5	1.1	0.11	5.2	20.7	3.98	14.7	21.7	1.48
13. Vavuniya	8.6	1.3	0.16	12.8	32.2	2.50	21.5	33.5	1.56
14. Mullaitivu	66.3	1.0	0.16	11.8	38.8	3.28	18.2	39.8	2.19
15. Batticaloa	78.9	9.6	0.12	20.5	71.1	3.47	99.4	80.7	0.81
16. Ampara	68.1	8.2	0.12	55.8	169.3	3.03	123.9	177.5	1.43
17. Trincomalee	33.3	4.7	0.14	18.9	50.2	2.66	52.2	54.9	1.05
18. Kurunegala	91.3	15.2	0.17	252.8	526.3	2.08	344.0	541.5	1.57
19. Puttalam	65.5	9.5	0.14	69.2	158.4	2.29	134.7	167.9	1.25
20. Anuradhapura	26.4	4.5	0.17	151.0	355.1	2.35	177.3	395.6	2.23
21. Polonnaruwa	12.4	2.2	0.18	59.1	159.1	2.69	71.5	161.3	2.26
22. Badulla	38.7	5.8	0.15	91.2	152.7	1.68	129.9	158.5	1.22
23. Monaragala	8.6	1.6	0.18	82.7	218.3	2.64	91.3	219.9	2.41
24. Ratnapura	56.6	8.5	0.15	136.1	246.4	1.81	192.7	254.9	1.32
25. Kegalle	77.2	13.0	0.17	84.7	146.0	1.72	161.9	159.0	0.98
Sri Lanka	**1477.3**	**202.9**	**0.14**	**1787.4**	**3581.4**	**2.00**	**3264.7**	**3784**	1.16

Note: Perch is equal to 30.25 square feet.
Source: Department of Census and Statistics (2004).

Approximately 55 per cent of farmers (1,787,370) grew their product for sale purposes, compared to the remaining 45 per cent (202,918) farmers who grew crops mainly for home consumption. The latter are likely to pay less attention when it comes to innovation and can be categorised as late adopters or laggards. Farmers who grow their products for sales purposes are likely to pay much more attention to improving their productively not only by adopting innovations but also by experimenting themselves as innovative farmers. This is both because, as Table 4.6 shows, farmers producing for their own use have much small holdings that those producing for sale (with an average plot size across all of Sri Lanka of only 0.14 perches, just 7 per cent of the average plot size for other farmers) and because they will have no discretionary income from production to devote to innovation.

When the average size of holdings is analyzed, the distribution of holdings seems to be skewed with a large number of them grouping in the lower part of each category. Even within the size category of less than 1 acre (0.4ha), the majority of holdings are less than half an acre (0.2ha).

In Table 4.7, information is reported about agricultural operators and agricultural holdings by districts in Sri Lanka. For administrative purpose, Sri Lanka is divided into 25 districts and these are listed in the Table 4.7. These data show that the highest number of agricultural land ownership is in four districts in descending order, namely: Kurunagala, Ratnapura, Galle and Kandy.

Table 4.7 also indicates that a significant number of farmers (139,445) do not own any land in Sri Lanka. These people are cultivating other peoples' land on a tenure basis, also known as tenure-farmers. The relationship between landowner and tenure farmer is legally protected and continues from generation to generation. The landowner gets about 25 per cent of the total profit of the tenure farmer for his land. Farm ownership undoubtedly affects the incentive for innovation and tenure-ship hinders farmers' ability to innovate. Table 4.7 represents the entire farming population in Sri Lanka while Table 4.6 represents only the small holding sector.

Table 4.7 Agricultural operators (farmers) and agricultural holdings by district

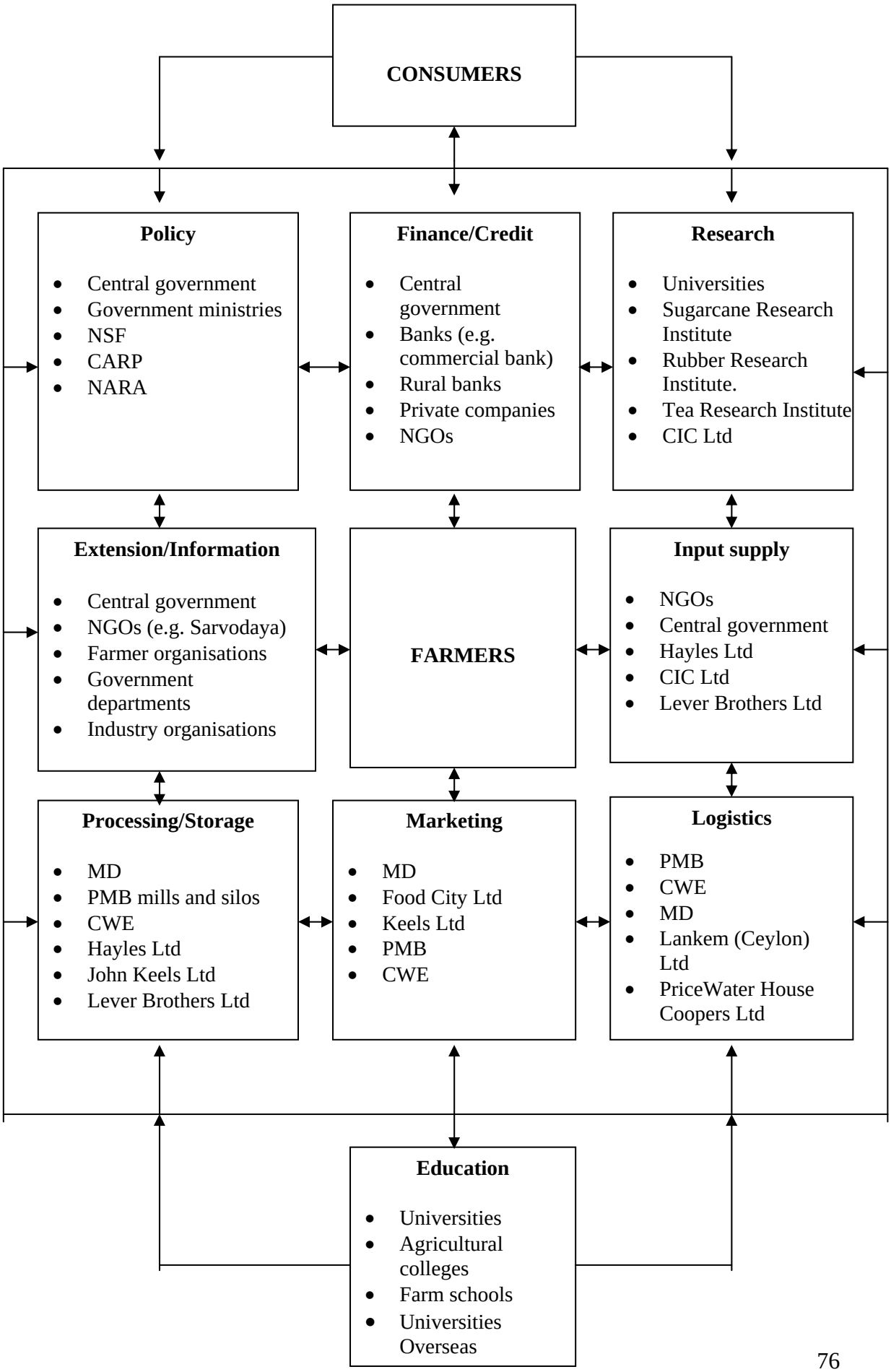
District	Not owning any land	Owning only home garden	Owning home garden and other land	Owning other land only	Total
1. Colombo	1,421	9,522	13,142	2,706	**26,791**
2. Gampaha	4,159	27,739	24,145	32,031	**88,074**
3. Kalutara	3,152	16,489	30,548	25,527	**75,716**
4. Kandy	5,038	22,780	37,311	38,623	**103,752**
5. Matale	4,060	12,018	18,028	29,279	**63,385**
6. Nuwara Eliya	4,681	7,441	15,902	17,555	**45,579**
7. Galle	4,480	14,120	29,520	56,226	**104,346**
8. Matara	6,879	14,081	16,573	53,144	**90,677**
9. Hambantota	9,438	19,106	21,874	36,381	**86,799**
10. Jaffna	2,015	5,848	14,892	2,409	**25,164**
11. Killinochchi	1,677	3,888	5,693	2,233	**13,491**
12. Mannar	1,159	564	2,963	500	**5,186**
13. Vavuniya	946	3,519	5,997	2,297	**12,759**
14. Mullaitivu	3,026	2,002	5,141	1,636	**11,805**
15. Batticaloa	997	2,502	12,713	4,124	**20,336**
16. Ampara	6,698	8,432	33,209	5,443	**53,782**
17. Trincomalee	2,266	5,033	9,295	2,248	**18,842**
18. Kurunegala	14,267	59,922	87,382	86,430	**248,001**
19. Puttalam	7,502	17,498	17,166	24,620	**66,786**
20. Anuradhapura	18,223	43,501	73,980	11,513	**147,217**
21. Polonnaruwa	5,620	13,869	35,805	2,781	**58,075**
22. Badulla	7,119	15,586	29,205	37,487	**89,397**
23. Monaragala	8,993	30,810	34,819	6,366	**80,988**
24. Ratnapura	12,105	27,053	37,843	56,642	**133,643**
25. Kegalle	3,544	24,088	34,606	21,520	**83,758**
Sri Lanka	**139,465**	**407,411**	**647,752**	**559,721**	**1,754,349**

Source: Department of Census and Statistics (2004).

4.4 Components of the innovation system in agribusiness in Sri Lanka

This section attempts to identify the major components and what functions they play in agricultural innovation diffusion in the Sri Lankan agricultural innovation system. It is based on published materials, a comprehensive literature review and a series of interviews conducted in Sri Lanka during 2004. The major actors of the innovation system in agribusiness in Sri Lanka and how those actors link with farmers (and farm organisations) is shown in Figure 4.2 below.

Figure 4.2 Systems diagram of selected actors of the AIS in Sri Lanka



4.4.1 Policy component

Policy making related to agricultural innovation and dissemination is done by the following ministries which are controlled by the central government. Those ministries are: Ministry of Agriculture, Livestock, Land and Irrigation, Ministry of Agricultural Marketing Development, Co-operative Development, Hindu Affairs and Assisting Education and Vocational Training, Ministry of Education, Ministry of Environment and Natural Resources, Ministry of Finance and Planning, Ministry of Fisheries & Aquatic Resources, Ministry of Medium and Small Scale Plantation Industries and Rural Human Resources Development, Ministry of Plantation Industries, and Ministry of Skill Development, Vocational and Technical Education. Each ministry and/or a number of ministries are headed by a cabinet minister who is elected to the Parliament by the general public. The following key units operate under the responsibility of the above cabinet ministers: Central Environmental Authority, Department of Agriculture, Department of Labour, Department of Fisheries, National Science Foundation (NSF), Council for Agricultural Research Policy (CARP), Aquaculture Authority, Department of Higher Education, National Aquatic Research Authority (NARA), Coconut Cultivation Board, Coconut Development Authority, and National Aquatic Research Authority (NASTEC).

The NSF and CARP are major bodies providing funding for most of university agriculture-related research. The other avenues of funding for universities are private businesses and overseas donors. The above organisations have their own libraries and disseminate research findings to other organisations and to the press. The CARP is responsible for formulating agricultural R&D policy and related issues.

Policymakers in the agricultural sector shape the future of the agricultural sector in the country, taking account of all factors that affect agricultural production. Those factors include research funding issues, tariff issues, pricing issues, subsidies to farmers, etc. They also shape the overall the directions of the agricultural innovation system.

4.4.2 Finance and credit component

Banks are major providers of finance and credit in Sri Lanka. They include government-owned banks, such as Peoples Bank, National Development Bank, rural banks, etc. and

private banks, such as Hatton National Bank, Commercial Bank, Selan Bank, etc. Unfortunately these banks required some sort of guarantee (e.g. deed of the land) before they lend money to farmers. As a result, poor peasant farmers cannot get credit from these banks and so rely on local money lenders. These local money lenders normally charge very high interest. As a result, the most poorer farmers barely pay back the amount of money they owe to lenders, and endure a vicious cycle for the rest of their lives.

4.4.3 Research component

The research component is one of the most important components of the innovation systems in agribusiness. Researchers are not only invent, but also disseminate their inventions to interested parties. This component consists of research organisations, universities and centres owned by either government, public companies and private companies or a combination of them.

In the research centres, scientists attempt to find answers to farmers' problems such as, pest outbreaks, diseases, and so on. They normally get to know those problems through extension workers and those linking farmers and research centres. This reverse flow of information is very important and sometimes the only way of getting feedback from peasant farmers in Sri Lanka, due to a variety of factors, such as language differences, physical distances, poor infrastructure, etc. Extension officers work under the Department of Agriculture in Sri Lanka and cater for a very large number of farmers with limited resources. Therefore, the time they spend with individual farmers is low. Moreover, research organisations/centres are responsible for developing more productive materials and methods for farmers as well as providing information to other stakeholders and those who are involved in innovation diffusion and are interested in their findings.

In Sri Lanka, there are numerous research institutes responsible for specific areas of research and they each cover specialized areas of research. Most of them are government owned and funded by the government and overseas funding agencies like FAO, ADB, World Bank, etc. There are a few privately-owned research agencies, which operate on a fee for service basis. When comparing the status of the research

organisations, government research organisations/centres are bigger, employ more staff and have larger overheads than private organisations. NGO-owned and operated research centres, are non-profit oriented and get most of their funding from foreign aid. NGOs are involved in various activities in the farming area, for instance giving financial aid, collecting farm related data, employing their own extension staff, facilitating and diffusing innovations, and sometimes supporting government-owned research organisations and agricultural universities, and making them aware of area specific problems facing farmers. A good example of an NGO in Sri Lanka is Sarvodaya, which operates telecentres all over the country.

Table 4.8 lists the leading agricultural R&D institutions in Sri Lanka. According to a UNESCO science report (2005), despite the importance of biotechnology and modern biological sciences for agriculture, Sri Lanka has not managed to expand these technologies leading institutions over the past decade.

Table 4.8 Leading public R&D institutions, Sri Lanka, 2004

Name of institution	Number of scientists	R&D expenditure (Rs million)*
Horticultural Research & Development Institute	64	0.4
Farm Crops Research & Development Institute	36	34.1
Rice Research and Development Institute	17	23.8
Regional Agricultural Research Centre	13	6.2
Rubber Research Institute	38	100.0
Tea Research Institute	46	154.4
Coconut Research Institute	34	110.0
Sugarcane Research Institute	19	-
Institute of Post Harvest Technology	12	10.2
Hector Kobbekaduwa Agrarian Research Institute	30	48.0
Veterinary Research Institute	29	40.4

Note:*100 Sri Lankan Rupees were equivalent to US$1 in June 2005.
Source: UNESCO (2005).

Almost all research institutes maintain websites and provide useful information to users. Chapter 5 presents more detail on the means (channels) of innovation dissemination.

Other than the above research institutes, agricultural universities also play a vital role in research, involving invention, linking with government, privately and NGO-owned research institutions as well as doing consulting. One of the major roles of university

staff including professors, lecturers and research support staff (research officers, research fellows, research assistants, etc.) is to publish their agricultural inventions in journals, books, reports and most importantly their websites so this information is made available to other stakeholders who are dealing with innovation diffusion activity.

4.4.4 Extension and information component

The technology development and transfer to the farmers engaged in the major sectors in agriculture is undertaken by the government departments and agencies of agriculture, Export Agriculture, Animal Production and Health, Fisheries & Aquatic Resources, and the Department and Plantation Crop Research Institute. The Department of Agriculture, which is the largest organisation catering to food crop production in the country, consists of several research and development institutes. In addition several District Chambers of Commerce and Agriculture located in Colombo and other districts also play an important role for the promotion of innovation systems in agribusiness in Sri Lanka.

The Agriculture Information Service has been providing support through mass media for agricultural development. It is responsible publishing of a wide range of leaflets for farmers and two quarterly journals in the local language for farmers, conducting radio programs in all three languages (English, Sinhalese and Tamil) and producing films on agricultural topics.

The various technology transfer and extension strategies adopted by the Department of Agriculture, include training, mobile training and the field visit systems, and integrated agricultural extension systems. Extensive use of media appears to be somewhat ineffective in providing basic and advanced technology to the farming community, who are becoming more sophisticated and competitive.

4.4.5 Education component

The education component can be categorized as the second most important component of the agricultural innovation systems. This component consists of formal and informal

education activities. Basically formal education is conducted by universities, colleges and schools.

According to the Department of Agriculture, Sri Lankan agricultural education is more than one-hundred years old. The earliest recorded activities were in the 1880s, even before the Department of Agriculture was formally established. At that time the organisation that existed in Peradeniya gave its attention to the investigation of the flora of the country. Subsequently it introduced large numbers of exotics and helped build up a prosperous plantation agriculture. It was then called upon to deal with pests and diseases in those crops. Later, it made experimental investigations into the cultural and manorial requirements of the various crops, began work on the improvement of existing varieties of cultivated crops and took up the development of agricultural education (Gunasena, 2003).

Since peasant cultivation was the ultimate target of such development activities, the Department and the Board of Agriculture then a decision to expand training opportunities for farmers. Thus practical farm schools were set up in the provinces as a result. The earliest schools were established at Labuduwa, Jaffna, Anuradhapura, Wariyapola, Wagolla, Mapalana, Karadian Aru and Horana (Department of Agriculture, 2004).

Agricultural universities train graduates to pursue careers in various organisations and institutes in public, private, semi-government/NGOs. University of Peradeniya and University of Ruhuna are two major universities that conduct agricultural courses leading to degrees and postgraduate qualifications in agriculture. They produce more than 250 graduates per year (Department of Agriculture, 2004).

4.4.6 Input supply component

The input supply component consists of private businesses and NGOs. There are a number of private companies and NGOs operating in Sri Lanka. Basically, private enterprise operates as a business and have their own laboratories and own sales staff. They also import technologies, such as new improved seed varieties, more productive machinery and so on, from the overseas parent companies or otherwise and introduce

them to farmers through sales campaigns. Hayles and CIC are prominent private enterprises interested in the farming sector in Sri Lanka. They specialize in agri-chemicals (growth stimulators, herbicides, pesticides, etc.) seed grains, machinery and fertilizers.

4.4.7 Processing and marketing component

Private companies dominate the food processing and marketing industry in Sri Lanka. The Marketing Department processing plant is the only government owned food-processing facility. However, with respect of rice mills, government and private sectors are equally responsible for processing paddy into rice. The most prominent private processing companies are owned by national or international partners. Examples of processing and marketing companies are listed in Figure 4.2 above.

Figure 4.2 depicts the major players of AIS in Sri Lanka. It also helps to identify some major contributors in each category. The left-right arrows indicate that information and resources flow both ways, also described as inflows and feedback.

4.5 Survey results

For this study we undertook a series of interviews with identified research organisations and universities in Sri Lanka in 2004. Thirty research organisations/centres, including leading agricultural universities, were selected to determine the:

- types of innovation-related activities of the organisation;
- goals of innovation-related activities of the organisation;
- which of the listed behaviours of the organisation is also shaped by organisational/institutional constraints and/or incentives for innovation; and
- how funding was obtained for innovation activities.

4.5.1 Types of innovation-related activities

Table 4.9 indicates the responses for types of innovation-related activities of the organisation in descending order.

Table 4.9 Types of innovation-related activities of the organisation, Sri Lanka

Types	(%)
Technology development	100
Technology training	100
Technology evaluation	93
Technology demonstration	90
Technology integration	83
Technology diffusion	80
Technology introduction/Selling	67
Technology acquisition (local/international)	60
Technology use	57
Technology financing	47
Technology policy	37

Source: Author survey (2004).

Respondents could select more than one option, therefore, the responses do not total to 100 per cent. Organisations that participated in the survey have conducted all (11) kinds of innovation-related activities in Sri Lanka in varying degrees. All organisations surveyed were involved in technology development and technology training activities.

4.5.2 Goals of innovation-related activities

Table 4.10 reveals the results for goals of innovation-related activities of the organisations responding to the survey. Respondents could select more than one option, therefore, the responses do not total to 100 per cent. Almost all organisations surveyed indicated that their goals of innovation-related activities matched the goals of innovation-related activities indicated in the table. Table 4.10 indicates those activities in descending order. This suggests a wide range of goals pursued by the surveyed organisations, with information communication and dissemination uppermost.

Table 4.10 Goals of innovation-related activities of the organisation, Sri Lanka

Goals	(%)
Provide knowledge and information	93
Introduce new products or processes	87
Reduce material costs	80
Generate own income	77
Increase commodity quality	77
Increase market opportunities	73
Reduce labour costs	73
Reduce environmental damage	73
Fulfil regulations or standards	73
Increase commodity production	70
Improve production flexibility	63
Reduce energy consumption	47

Source: Author survey (2004).

4.5.3 Funding sources

Table 4.11 indicates the funding sources of innovation activities in research organisations in Sri Lanka. Respondents could select more than one option, therefore, the responses do not total to 100 per cent.

It is clear that surveyed organisations rely on more than one funding source. A mix of funding bodies provide money to agricultural research and development organisations in Sri Lanka. Those funding sources listed in Table 4.11 in descending order, reveal that funds are equally derived from funding bodies/agencies (87%) and international donor assistance (87%). The next most important funding comes from the central government (63%) and collaborative contracts (63%). This reflects the mix of domestic and international, and private and public entities.

Table 4.11 Funding sources for innovation activities, Sri Lanka

Funding source	(%)
Funding bodies/agencies	87
International donor assistance	87
From central government	63
Collaborative contracts	63
Competitive grants	53
Own resources	40
Patents and copyrights	40
Awards and prices	33
Loans and credits	30
From local government	23
Non-competitive grants	17

Source: Author survey (2004).

4.5.4 Constraints and incentives for innovation

Table 4.12 indicates the answers for the question 'What are the behaviours of your organisation shaped by organisational constrains and/or incentives for innovation?' Respondents could select more than one option, therefore, the responses do not total to 100 per cent.

The majority of respondents indicated that the laws (67%), cultural norms (60%) and social rules (53%) affected to their ability to innovate. For ethical reasons we did not specifically ask what those constraints were.

Table 4.12 Incentives/constraints affecting the innovation behaviour of organisation, Sri Lanka

Behaviour	(%)
Laws	67
Cultural Norms	60
Social Rules	53
Health Regulations	43
Technical Standards	40
Other	40

Source: Author survey (2004).

4.6 Driving forces of innovation in Sri Lanka

Agriculture in Sri Lanka continues to go through changes in response to many influences, such as market forces, increasing input costs and the need to achieve high yields in existing lands (almost all land suitable to cultivation is utilized). In the plantation sector, the competitive world market is the major driving force for high quality and low price products, such as tea, rubber and coconut. Moreover, research institutes focusing on these three products constantly look for high yielding clones and hybrid varieties. However, in the peasant sector, consumer demand for low price products and labour intensive, but highly productive processes, are the major driving forces. Moreover, cost effective inputs, high-yielding varieties and better logistics also play a considerable part in driving innovation within the AIS in Sri Lanka.

Plantations in Sri Lanka are fairly large profitable businesses that are owned either by the government or large multinational companies, or a combination of both. Therefore they can afford to maintain their own research organisations. For instance, the Tea Research Institute looks after all aspects of production and processing of the tea crop. The main objectives of these research institutes are to minimize growing, harvesting and processing costs as well as improve quality, by introducing new varieties and value added products to the consumer. Therefore, these institutes employ agronomists, entomologists, pathologists, soil scientists, extension specialists and so on.

In fact, government policies also help to drive innovation in the agricultural sector in Sri Lanka. For instance, if government wants to stop importing Massoor dhal, then researchers in that sector are encouraged to produce Lanka lentils (Lanka dhal).

4.7 Conclusion

In this chapter we identified 11 actors in terms of their function within the Sri Lankan agricultural innovation system. They are policymakers, education providers, finance/credit providers, research organisations, input suppliers, extension and information providers, farmers and farm organisations, logistics providers, processing companies, storage facilities providers, marketing companies, and consumers. These actors are interlinked with each other in order to share knowledge, information and resources to meet the requirement to innovate. A systems approach was utilized to identify the systematic nature of the collaborative links of the above actors. The study concludes that actors in the AIS are linked to each other for sharing knowledge, information and resources. Some organisations perform more than one role in the AIS in Sri Lanka, such as the central government, marketing department (MD) and universities.

The present study found that a mix of state owned and privately owned actors are involved in the input supply, processing/storage, marketing and logistics components of the AIS in Sri Lanka. However, some private companies in research and NGOs are involved in providing finance/credit and other inputs to R&D activities. As a result, we can conclude that the private sector as well as NGOs play a major role in the AIS in Sri Lanka.

Even though the Sri Lankan agricultural sector contributes a relatively small percentage (17.2% in 2005) to the economy, the AIS in Sri Lanka, involves a significant portion of the industry and services sectors. The Sri Lankan agricultural sector split to two major sectors and small holders have a strong role. It is clear that stagnant or falling productively exists outside the tea production only increased 7.5 per cent from 23 per cent land increase (Table 4.2), rubber and coconut crops. This is a result of strong innovation activity in these major export crops and particularly R&D activities in corresponding research institutes. The nation's staple food rice shows stagnant yields despite the increasing land use.

Sri Lanka has 17 identified farming activities which spread over five major farming systems. As a result it is vital to have an effective communication tool to diffuse innovations. However, due to inefficient extension systems and poor infrastructure, in terms of phone lines and main roads, most of the poorer peasant farmers do not currently receive information on innovations in a timely manner.

Surveyed organisations indicated that the major types of innovation-related activities are technology development (100%), technology training (100%), technology evaluation (93%) and technology demonstration (90%). The survey also revealed that the major goals (80% or more) of innovation-related activities were to provide knowledge and information, introduce new products and processes, and reduce material costs; with most of the funding coming from funding bodies/agencies and international donor assistance. Finally, the survey indicated that the major constraints can be categorised under laws and cultural norms, followed by social rules. Therefore it is vital to address the above issues to enhance innovation-related activities in the AIS in Sri Lanka in general, and surveyed organisations in particular.

CHAPTER 5

ROLE OF INFORMATION TECHNOLOGY IN DIFFUSION OF INNOVATIONS TO THE FARM LEVEL WITHIN THE AUSTRALIAN AGRIBUSINESS SYSTEM

5.1 Introduction

This chapter explores the role information technology IT plays in the diffusion of agricultural innovations to the farm level within the Australian agribusiness systems. It seeks to understand what role IT does and can play within the agricultural sector and what is the opinion of survey respondents about future IT applications to agricultural extension. This chapter reports three case studies describing how IT can facilitate the three types of agricultural innovations identified in Chapter 2.

The focus is on information and communication technology ICT in agriculture in general and in the diffusion of innovations in particular. We draw on R&D data to look at the level and nature of expenditure on agricultural R&D (both R&D in agriculture and agricultural related R&D done in other parts of the AIS), and explore the results of ABS farm use of ICT surveys to examine the use and focus of ICTs in the farming sector in Australia. We look especially at uses of not only computers but also the internet for information and innovation diffusion, together with other relevant farm needs.

With reference to conceptual themes, IT has the potential ability to diffuse rich information about innovations to large numbers of end users in a relatively short time (see Figure 2.6) depicted in Chapter 2. Therefore it is imperative to find quality IT spending data (Figure 5.1) on agriculture and who provides it. In this chapter we rely on data from the Australian Bureau of Statistics (ABS) and from a leading body providing IT data, the World IT and Services Alliance (WITSA). We faced considerable difficulties in finding reliable information, especially data on IT spending on individual

research institutes and industry-specific data, due to limited studies and data collections in this area.

5.2 Information technology and the Australian economy

The following Table 5.1 shows actual ICT spending from 2002 to 2005), together with projections to 2008 in Australia, categorized under four major headings: computer hardware, computer software, computer services and communications. The table shows that over the period 2000-05 overall ICT spending in Australia has grown at 12.0 per cent per annum, with especially rapid growth in computer software and computer services (22.1% and 14.2% per annum respectively), to reach US$46.8 billion in 2005. This represents about 5 per cent of Australian GDP. ICT spending was stagnant over 2000-2002, but almost doubled between 2002 and 2005. The WITSA forecasts suggest a slowing of growth over 2005-08, with total ICT spending growing by 8 per cent per annum to nearly US$60 billion by 2008. This would imply a further modest increase in ICT spending as a share of GDP, with the most rapid growth again in software and services. These numbers need to be interpreted in the light of falling prices for many computing and communication products, so that growth in real ICT spending is likely to be significantly greater than the growth in current price spending shown here.

Table 5.1 Total ICT spending in Australia, US$ billions

	Actual						**Projected**			**Annual change (% pa)**	
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2000-05**	**2005-08**
Computer hardware	5.3	5.2	5.1	6.5	7.8	8.5	9.0	9.3	10.0	5.6	5.6
Computer software	2.1	2.4	2.7	3.6	4.6	5.7	6.6	7.6	8.8	22.1	15.6
Computer services	5.4	5.2	5.6	7.2	8.9	10.5	11.9	13.1	14.6	14.2	11.6
Communications	14.0	11.5	13.4	16.1	19.3	22.1	23.7	24.8	25.6	9.6	5.0
Total ICT spending	**26.6**	**24.2**	**26.7**	**33.3**	**40.5**	**46.8**	**51.2**	**54.8**	**58.9**	**12.0**	**8.0**

Note: 2006 to 2008 forecast.
Source: WITSA (2005).

Table 5.2 Annual per cent change in ICT spending 2000-2004 and 2005-2008

	Actual (% pa) 2000-2005	Forecast (% pa) 2005-2008
Computer hardware	5.6	5.6
Computer software	22.1	15.6
Computer services	14.2	11.6
Communications	9.6	5.0
Total ICT spending	**12.0**	**8.0**

Source: Table 5.1 and author estimates.

Overall strong growth in total ICT spending (11.1 per cent per annum over 2000-04) projected to virtually continue to 2008 (9.8 per cent per annum change over 2004-08), implies a rising share of GDP (overall US$40.5 billion in 2004, rising to US$59 billion by 2008). Especially strongly growth in computer software (21.8 per cent per annum) and services (13.4 per cent per annum), is also projected to continue. Communication spending is the major item but is growing more slowly, both over 2000-04 and in the forecast period of 2006-2008. These numbers need to be interpreted in the light of falling prices for many computing and communication products, so the effects of this increase in ICT spending will be greater.

5.3 Information technology and agribusiness in Australia

There is a strong drive in Australia to make better use of internet based technologies and e-business applications to support supply chain management and integration (Houghton et al., 2005). This section seeks to gather evidence, from three types of sources, of the use of IT in the diffusion of innovation in Australian agriculture. The sources are data on IT or ICT spending in agriculture, data on the use of information technology and the internet in farm businesses and studies reported in the literature.

5.3.1 Data sources on ICT spending in Australian agriculture

Data are available from WITSA on total ICT spending in agriculture in Australia from 2000 to 2005, with projections to 2008 (WITSA, 2005). Several trends are evident in these data. According to WITSA, spending on ICT in Australian agriculture fell by 17 per cent between 2000 and 2002, but since 2002 it has increased strongly, more than doubling between 2002 and 2005 and showing an annual rate of growth over this period

of 30 per cent per annum. This suggests that the agricultural sector has recognized the importance of introducing and using ICT in general, and for information discovery and access activities in particular. But WITSA projects Australian to rise only gradually in current prices over 2005-08, by 4.3 per cent per annum.

Table 5.3 Total ICT spending in agriculture, Australia

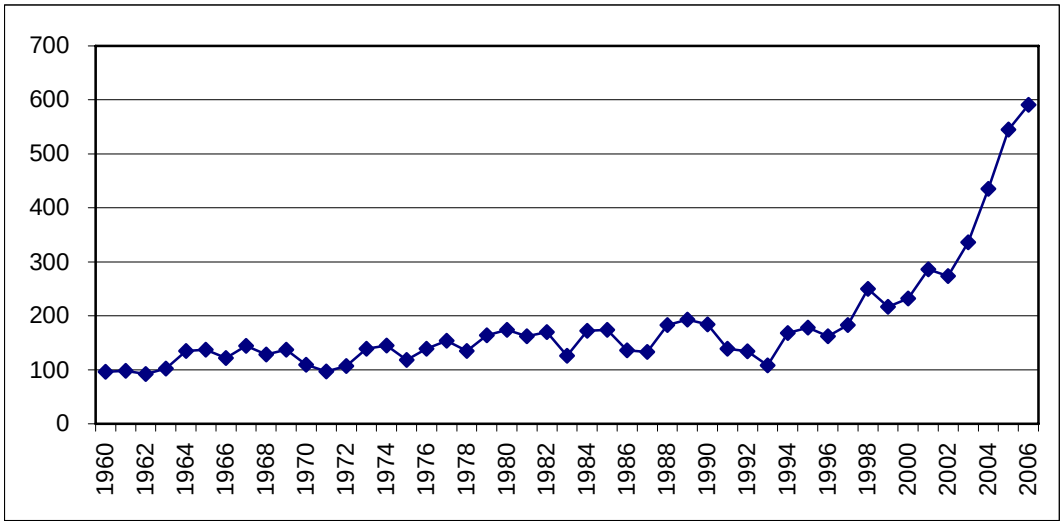
	2000	2001	2002	2003	2004	2005	2000-05	2006	2007	2008	2005-08
							Per cent change pa	Projected			Per cent change pa
ICT spending (US$ m)	92.5	79.3	76.6	106.0	153.6	168.0	12.7	178.8	186.8	190.9	4.3

Note: 2006 to 2008 is projected.
Source: WITSA (2005).

The other source of data for Australia is that from the Australian Bureau of Statistics on information technology gross fixed capital formation in agriculture. This data does not cover all ICT spending, being just related to the capital component, but the data series has the advantage of providing a price index for IT investment. This means that the current price data can be adjusted to take account of overall IT prices, and hence of falling prices for many forms of IT equipment. The resulting data are displayed in Figure 5.1, and show that in real terms IT capital formation in Australian agriculture more than doubled between 2002 and 2006, to reach just on A$600 million (in 2004-05 values) in that year.

These two data sources both show a surge in IT spending in Australian agriculture since 2002, and suggests that Australian farmers and other agribusinesses now have a clear understanding of the benefits that the use of IT might bring to their businesses.

Figure 5.1: Real IT capital formation in agriculture in Australia, $m, chain volume measures with a 2004-05 reference year



Source: ABS cat. no. 5204.0 (2007).

5.3.2 Farm use of IT and the internet

According to the Australian Bureau of Statistics (2005) in 2003-04, 55 per cent of the 130,526 Australian farms with an estimated value of agricultural operations of $50,000 or more used a computer as part of their business operations. This was an increase of 1 percentage point since 2002-03. During 2003-04 an estimated 47 per cent (61,082) of farms in Australia used the Internet as part of their business operations, also increasing by 1 percentage point from 2002-03 (ABS, 2005). The above results reflect the fact that Australian farmers are adopting computers and using the Internet for their farming business. They have realized the importance of IT.

Table 5.3 shows that more than 50 per cent of Australian farmers had already adopted IT facilities for their farming business by 2005-06. These data indicate a willingness to accept IT as a new business tool. In addition the above table indicates differences of computer use between states, for instance, NSW farmers were the highest number of computer users while ACT farmers were the least. Percentage wise ACT is higher than NSW, quantity is higher in NSW because of greater population numbers and size of state. Further it shows strong growth of farmer use in IT in the last couple of years.

Table 5.4 Farm use of the internet for business operations, by state and territory, Australia

State	2003-04			2005-06		
	All farms	Farms using a computer		All farms	Farms using a computer	
	(no.)	(no.)	(%)	(no.)	(no.)	(%)
New South Wales	40,827	18,627	46	40,077	20,266	51
Victoria	32,463	13,320	41	32,357	16,077	50
Queensland	26,785	12,478	47	27,132	14,169	52
South Australia	14,238	7,685	54	14,111	8,686	62
Western Australia	11,877	6,950	59	11,915	8,044	68
Tasmania	3,866	1,771	46	3,877	1,848	48
Northern Territory	382	209	55	380	226	60
Australian Capital Territory	88	43	49	86	47	55
Australia	**130,526**	**61,082**	**47**	**129,934**	**69,362**	**53**

Source: ABS (2006).

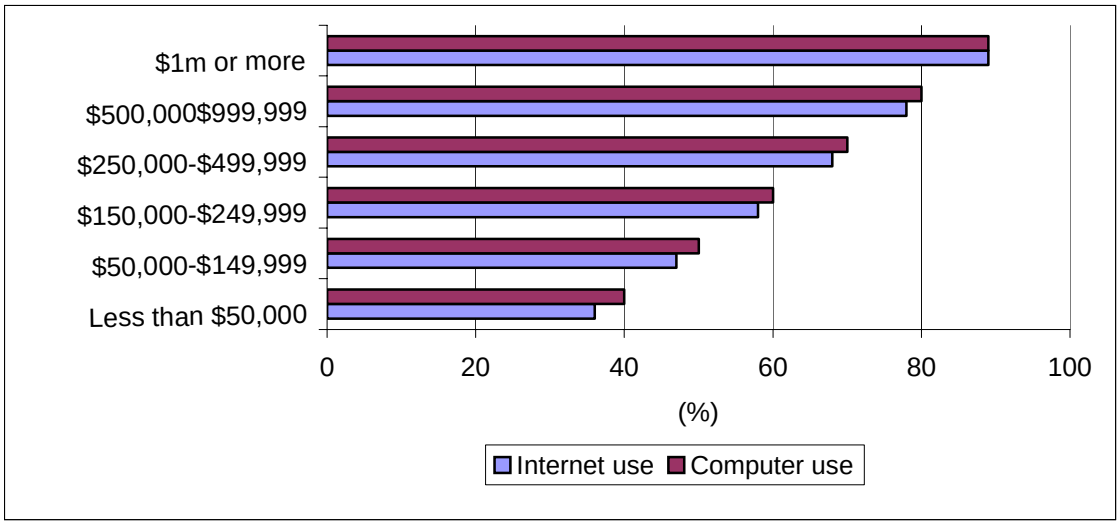
The above shows that more than 50 per cent of Australian farmers had already adopted IT facilities for their farming business by 2005-06. These data indicate a willingness to accept IT as a new business tool. In addition the above table indicates differences of computer use between states, for instance, NSW farmers were the highest number of computer users while ACT farmers were the least. Percentage wise ACT is higher than NSW, quantity is higher in NSW because of greater population numbers and size of state. Further it shows strong growth of farmer use in IT in the last couple of years.

ABS farm surveys reveal that there was a strong positive relationship between farm size, as measured by the estimated value of agricultural operations, and the use of a computer and the internet. The proportion of larger farms using a computer and the internet for business purposes was significantly higher than for small farms (ABS, 2005). It could be assumed the reason is that small farms cannot afford the cost of obtaining IT facilities (cost includes: cost of a computer, maintenance, ongoing internet access charges, etc.) and/or do not see the value of obtaining IT.

According to Taragola and Gelb (2005), the factors limiting the use of ICT by farmers are: inability of farmers to use ICT; no perceived economic or other benefit; difficulty in using/unfriendly; lack of technological infrastructure; cost of technology; not useful information/unrelevant problems; fear of technology; not enough time to spend on

technology; no understanding of the value of ICT; lack of training; better alternatives; personal impediments; and lack of integration with other farm systems.

Figure 5.2 Computer use and internet use on farms, by farm size, 2004-05



Source: ABS (2006).

The survey also reveals that the most common internet activities undertaken by Australian farms in 2003-04 were email (39%), obtaining weather information (35%) and checking the availability or cost of goods or services (29%).

According to Groves and Rin (1999) a significant proportion of farmers in Australia considered that there were wide gaps of information on the internet, particularly, technical information (innovations), market and price information and local/regional information. This has no doubt changed, but there is room to improve these information gaps and educate Australian farmers in information discovery and use.

Table 5.4 lists the internet activities for farm business operations by state and territory during the year 2004-05. It is very clear that farmers used their internet facility primarily for the seven activities listed but seem not to have used it to look for innovations/technical information. This shows that either farmers were unaware of the option of finding relevant technical innovation via internet or they were not confident of the validity of technical information found on the websites.

Table 5.4: Internet activities for farm business operations, by state and territory, Australia, 2004-05

Internet activity	NSW	VIC.	QLD.	SA	WA	TAS.	NT	ACT	Aust.
1. Obtain weather information	38	33	37	45	54	30	47	36	**39**
2. Obtain market information	27	20	26	31	37	20	35	24	**26**
3. Availability or cost of goods and services	30	26	30	35	37	28	37	38	**30**
4. Purchased or ordered goods or services	15	13	16	18	19	16	28	27	**15**
5. Accessed government websites	23	19	26	27	31	22	33	37	**24**
6. Paid bills via the internet	25	23	25	32	39	22	28	35	**27**
7. Email	39	37	42	48	57	37	52	48	**42**
8. Other	3	2	4	3	4	3	6	4	**3**

Source: ABS (2006).

5.3.3 Studies on the use of IT in Australian agriculture

It is widely acknowledged that Australian farmers are generally less educated in terms of formal qualifications relative to the wider community (Bell, 2002). While their education level does not stop them being good businessmen, it could be a barrier to the uptake of new technology. According to Bell (2002), many Australian farmers who are successful in farming business are aware of their need for further education and training. However, their location and the low population density in rural Australia make it difficult for them to attend formal classes in colleges and universities in the capital cities, make it harder to establish formal education facilities and conduct formal classes in rural areas.

Distance education is one option to overcome the above difficulties. Distance education is growing rapidly, with many universities and colleges offering formal degrees as well as short courses delivered via the internet. In a survey of farmers in north-west Victoria it was found that many farmers noted the value of short rather than longer formal courses, but stressed that they must be available at the right time at a convenient place (Bell, 2000). If courses could be held at least substantially on the internet, then the problem with travel or the cost of accommodation can be largely overcome.

Rin and Groves (1996) conducted an early content analysis of 206 websites for Australian farm businesses. They analyzed how accessible sites were, how well the information was presented, the depth of the content, and the future of interactive activities. The 'content' included corporate information, research documents, fact sheets, press releases, newsletters, directories and publication lists. The report concluded that, taken as a whole, Australian websites served agriculture well in terms of farm news, weather and environmental information, and in some industries, technical information. Their study recognised the value of email as an internet application for both information gathering and communication purposes. Other interactive applications, such as news groups, were then used by only a minority of farmers who had an internet connection. This findings support the ABS data presented in Table 5.4.

Further, a significant minority of websites expected to introduce much more interactive mechanisms, such as bulletin boards and mailing lists. Farmers valued the web as the second most important application. They consistently identified a need, in descending order of importance, for: commodity market prices, weather information, information on supplies and financial information. The study also found that a significant proportion of farmers were interested in making online purchases, sales and banking transactions, and the majority of farmers were also willing to do online banking once they were satisfied there was no or very little risk. Of those unwilling to make online purchases, security concerns were the greatest obstacle. This study also revealed that the reasons behind the non-adoption of computers and the internet use in general were: the conservative attitudes of farmers, lack of knowledge on how to use computers, and farmers not being of the 'computer generation'. Finally, Groves and Rin concluded that there is an ongoing need and demand for farmer training in internet use, especially support and training in search techniques (and broader information literacy) and farm business applications. As more and more farmers connect to the internet and communication infrastructure problems are resolved, as content continues to develop, and as the problem of information overload is overcome, the internet clearly has a significant role to play in the future of Australian agriculture.

Hargreaves and McCown (2000) conducted an investigation to find cost-effective interactions via the internet that aided learning and decision making for farmers, their advisors and scientists. These interactions were centred on the potential value of soil

monitoring and cropping systems simulation to learning, planning and decision making in dry-land crop and soil management in Australia. This research demonstrated that the internet has an important role to play in facilitating interaction between farmers and specialists around specific issues where time and/or distance are constraints. It also demonstrated that farmers value online benchmarking, scenario exploration, tactical planning, and yield forecasting.

Farmwide Pty Ltd (2000) reported the existence, nature and scale of unmet demand for online services. Their report provided an estimate of the extent of unmet demand for online services among rural and remote Australians. They also took into account differences in the nature of demand between access and usage in the context of ongoing concerns over the quality of rural telecommunications infrastructure for voice, as well as data.

Simpson (2001) reported that the internet had been seized upon by many as a potential saviour for rural Australia, but it also poses a significant threat, opening communities up to global forces outside their control, with potentially damaging effects. His study also explored both sides of this equation for rural Australia and showcased how many communities and businesses are dealing with the challenges.

Pasqual (1998) suggested that agricultural extension needs to find more effective ways of handling, communicating and using information. It is not enough to collect and store information, extension must also develop more efficient ways of organizing, retrieving and transferring it.

Clark and McCarthy (2001) conducted a project to accelerate the adoption of e-mail/internet services to improve access to quality technical, financial and social information and create global networks for FM500 (project called Farm Management 500) farming families in Australia. Australian farmers can also improve their businesses by bypassing traditional distribution channels on both the supply and marketing side using the internet as an e-commerce communication channel (Rin and Groves, 1999).

Groves (1998) analysed the special information needs of rural businesses and how to substantially improve access to the required online information. He canvassed issues such as developing specialised search engines, more and better training in search techniques, how content providers could help through better design of their pages and supporting a range of regional communication initiatives. These communication needs are dependent on fast operating speeds. According to the report, a significant proportion of Australian farmers expressed considerable frustration at the difficulty of finding information on the internet. Therefore, to overcome frustration Groves recommended the following (1998):

- to create a specialised search engine and provide training in search techniques to farmers;
- to encourage content providers to adopt 'best practice' in terms of the accessibility, navigability and marketing of their web-sites;
- to create a directory of the search pages on sites with site-specific search engines;
- to support regional communication initiatives; and
- to create an Australian agriculture newsgroup.

5.3.4 Conclusion

A number of clear conclusions emerge from this analysis of the limited evidence available about use of IT in Australian agriculture. First, IT spending in Australian agribusinesses has surged since 2002, with IT capital formation in aggregate more than doubling in real terms between 2001-02 and 2005-06. Secondly, both computer and internet use on farms in Australia is strongly related to farm size, with rates of nearly 90 per cent in 2004-05 in farms with annual turnover of $1 million or more, but at only about 40 per cent on small farms. Thirdly, the proportion of farms using the internet for business purposes has risen strongly in recent years (from 46% in 2002-03 to 53% in 2005-06), with more rapid increases in some states. But there is little statistical evidence of widespread use of the internet yet to access information about new technologies and innovations. Finally, a wide range of developments are needed to improve the ability of Australian farmers to use the internet effectively for innovation diffusion.

5.4 The internet and agricultural technology transfer

According to Nielsen (1999), websites have significant advantages, such as 24 hours per day access, contents can be readily revised and updated, the opportunity to use multimedia, and not being limited to own information (i.e. can be linked to other related sites). He suggested that the web should be viewed as simply another tool in our extension communication toolbox. One of the main strengths of the internet and websites are that any farmer can access those sites irrespective of his/her nationality, race, ethnicity, religion and wealth, from anywhere in the world. Websites can be developed using any language and various other electronic multimedia, for example digital images.

> Another dimension of interest in the internet in studying IT innovations has been the determinations of whether the diffusion is occurring as a result of technology push or business pull. Again, due to its complex nature, the internet has been affected by both technology push and business pull. The technology push came first, as the net was developed and browsers followed, which made the innovation accessible to a much wider circle of organisations and people. Once that accessibility was achieved, however, the technology has appeared to diffuse with increasing rapidity. (Prescot and Slyke, 2003, p. 2)

The quality of a web page is mainly dependent on up-to-date content, good presentation, accessible formatting, navigability, connection to search engines and hypertext links to other related websites. Additionally a website's design is vital for its promotion. Other promotional techniques used in Australia include: listing with general and specialised directories, seeking links from other sites and promotion through participation in online discussion. In particular, minimum download times and navigability should be considered when designing a website. The main condition for minimising download times is to minimise the number and size of graphics. Grows (2000) conducted a study of Australian websites, researching their design and accessibility for rural Australia. He found that relevant techniques include the use of descriptive titles, meta-tags, page summaries and positioning of content on pages in order to gain maximum placement in search engines. Websites for some organisations can be used as a primary

communication tool, which provides links to past and present research as well as to their product catalogues.

To minimise the number and size of graphics, in particular, site owners/webmasters should consider the following points:

- whether a background image is needed at all and, if so, how its size can be minimised;
- how image numbers can be reduced by substituting text for images, adopting consistent images throughout a site, and whether some images can simply be dispensed with; and
- how image size can be reduced through choosing the right image format, reducing the height and width of an image, removing unnecessary detail from an image (e.g. backgrounds) and compressing image size as much as possible before loss of quality becomes an issue.

5.4.1 Measuring effectiveness of websites

To assess user demand, most content providers rely on email feedback on their websites and others get an indication by monitoring their hit counters to see how many people view their web pages. Monitoring usage through 'hits' ranges from simple monitoring of hit counts through to more detailed analysis of access and download statistics across different areas of a website.

In early 1997, a questionnaire was dispatched to the content providers of the 206 Australian web sites identified as relevant to Australian farm business. The following Table 5.5 provides some details of 48 respondents who answered the questionnaire and provided information on usage.

Table 5.5 Hits per month and % of respondents who answered the question, Australia

	% of responses
Under 500	43
500 to 2000	3
2000 to 10,000	20
10,000 to 20,000	7
20,000 to 50,000	3
50,000 to 100,000	7
100,000 to 200,000	7
Over 500,000	10

Source: Rin and Groves (1999).

5.4.2 Awareness of potential abuse of technology and remedy

Unlike most commonly used information dissemination methods, IT and the internet have potential threats of abuse. Those threats include:

- computer viruses;
- worms;
- spy ware;
- adware;
- unsolicited emails (SPAM);[4]
- data mining, corruption and theft;
- unauthorized access and amendments;
- pop-up advertisements and other annoyances; and
- technical problems with the internet services provider (such as connection problems, delays and slow speed).

Remedies include:

- anti-virus software;
- anti-spy-ware;
- email filters;
- using passwords;
- pop-up blocks;
- fire-walls; and

[4] Most definitions of spam are based on the email being Unsolicited Bulk Email (UBE). That is, spam is email that is both unsolicited by the recipients and there are many substantively similar emails being sent. Spam is usually also unwanted, commercial and sent by automated means and some definitions include those aspects (http://en.wikipedia.org/wiki/Spam_%28email%29).

- high speed broadband and use of a reliable internet service provider.

5.5 Case studies

The main role of ICTs in innovation dissemination in agriculture is to act as a communication channel between different stakeholders in the agricultural innovation dissemination system, complementing existing channels. Australian extension officers (agronomists, livestock officers, etc.) work closely with researchers to enable the results of research to be communicated to farmers through Agfacts and Agnotes, field days, educational short courses, demonstration plots and trials and on-farm advice. Almost all of them are computer literate and use a variety of IT applications, including the internet, for their day-to-day work requirements. Computers and the internet have variety of features and functions which can be used to produce extension programs. Those functions and features include:

- interactive internet based software (e.g. Microsoft Net Meeting);
- distance learning via internet (e-extension education); and
- websites with down loadable PDF documents and pictures.

The three case studies detailed in boxes 5.1, 5.2 and 5.3 below demonstrate some of the practical ways IT applications can be used in agriculture and in facilitating agricultural extension. Further, these case studies reflect their relevance to the work of extension workers.

Case Study 1: In this case study on the Mouser Software Program, IT plays not only a dissemination role but also the role of analysis tool and model. The Mouser Software is an example of an agricultural event-response innovation.

Case Study 2: The second case study is an example of a process innovation in agriculture in Australia relating to logistics.

Case Study 3: Zynx is an example of product innovation in Australian agriculture.

Box 5.1 Case Study 1 Mouser: An example of event response innovation in Australian agriculture

The main element of the Mouser program is a CD-ROM that contains information for Australian farmers and extension officers on management options available for controlling mice. It was originally designed using a web interface, but producers made a decision early on to provide a stand-alone CD-ROM, rather than an interactive web page or a link to a web page. There are, however, links to various web pages from the CD. They went for the CD-Rom, because a few years ago, only relatively few farmers had good and direct access to the Internet. This is changing, but access to the Internet is still somewhat limited and slow in many areas.

Mice plagues are a major problem in Australia. The purpose of Mouser was to bring together different types of information for use by farmers and extension staff in Australia to assist them in managing the damage caused by mice to crops. It was designed in a user-friendly manner, so that users could go through at their own pace to find out what they wanted on the biology of mice, control techniques, monitoring, etc. Mouser also provides a decision key to assist in suggesting different ways of managing mice.

According to Brown et al. (2003), Mouser is a resource package that provides decision support for the management of house mouse plagues. This knowledge management software is designed for use by growers, grower groups, extension officers and government departments. However, it has been discovered that the Mouser prototype is also being used by librarians and school teachers as a teaching aid and as a source of general information.

The Mouser program was developed by the Cooperative Research Centre (CRC) for Tropical Pest Management and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in 1998. In 2001, the CSIRO released a CD-ROM version called Mouser, which gives farmers access to years of scientific expertise through their home computer. The CD's developer, Peter Brown, wanted farmers to be able to make informed decisions about mouse control using the best and most up-to-date information available. It also includes an economic model and decision key which assist the user in decision making. The producers designed the CD so that it is easy to navigate. There is also a good search engine to find other information. The idea was that there should be little training required to operate the CD (other than basic computer skills, which they assume most farmers and extension staff would already possess).

This initiative came about from contact with Dr Geoff Norton at the Centre for Pest Information Technology Transfer (CPITT). He was developing software for the management of insect pests, and the developers recognised that they had enough information to be able to setup something for house mice. They set about developing a prototype version, then applied for funding through the Bureau of Rural Science, ACIAR and others. A programmer at CPITT wrote the code, and the author with the input from others at CSIRO wrote all the content. The economics module also had input from David Thompson, (Centre for Agricultural and Regional Economics in Armidale), NSW and from Greg Hood. There is currently no ongoing maintenance of the system. It was designed as a stand alone product, but if there is enough support in the future the producers might try to upgrade it. Unfortunately, there are no statistics on use, but so far around 220 copies have been distributed. When the next mouse plague comes along, interest is likely to increase again.

This was the first time such a decision support system had been available for vertebrate pests such as mice, and it is considered a benchmark for this type of product. There are now other products available, particularly a video/DVD on managing mice, but this is from the perspective of how to apply a rodenticide to kill mice (manufactured by a rodenticide bait manufacturer). The Mouser CD is independent of any particular interest, is more interactive, and having the economics module and the decision key makes it is more useful.

Its producers are not sure about the future. They are monitoring how it goes, but it would be up to users to tell them if they want an upgrade or improvement. One idea is to make it available through the web. They have also thought about applying this format to other types of pests, particularly for rodents that cause problems in rice crops in South East Asia. Some work has gone towards this and they have provided information to other people through the International Rice Research Institute.

Source: Brown et al. (2001).

Box 5.2 Case Study 2 Logistics: An example of process innovation in Australian agriculture

With around $26 billion worth of fresh food products are transported around Australia every year, the value of annual losses of such goods through poor handling and accidents, is estimated at close to $1 billion. Temperature is the single most important determinant of perishable food's shelf life, product quality and food safety. According to Goodwin (2006) 4-5% of lost perishables are avoidable wastage.

Designed by Exago Pty Ltd in Australia, it was developed as a monitoring and control systems for food transport systems from shippers/suppliers to receivers/customers (illustrated above) to minimise food transport losses. In moving perishables, climate control is imperative. Therefore, the Melbourne based Exago Company supply chain technologies permit the continual reading of the temperature and location of food products on the move, from farm-gate to food manufacturer or retail counter.

Data Powers Safe Journey is an innovative web-based tracking and monitoring systems for sensitive cargoes. The system starts with consignment monitoring. Radio frequency identification tags are located with the products (e.g. fruits and vegetables) in the boxes or pallets. The temperature of each product is collected from the beginning and tracked along the way, via the internet, with a data capturing device located at the front of the refrigerated trailer. This monitors wired or wireless sensors and readers, and extends to cool store monitoring, checking environments at processing plants, distribution centres, cold store depots and transport inter-changes. As depicted above, this technology combines with data tagging and mapping via global positioning, mobile communications and internet technologies. Clients can obtain data through mobile phone alerts, so it is possible to analyse the condition of the product and take necessary corrective action if required. The system allows for a change of temperature settings when necessary, and at the same time offers security against incidents of theft.

Source: Goodwin (2006).

Box 5.3 Case Study 3 Zynx: An example of a product innovation system in Australian agriculture

KEE Technologies develops and manufactures innovative electronic control solutions for agricultural machinery. KEE has been involved with the emerging 'precision farming' trend since the adoption of global positioning systems (GPS) in agriculture in the mid 1990s, and has developed the ZYNX platform and software to meet the needs of this emerging market. The KEE product range includes interactive control systems for use in harvester monitoring, seeding and spraying. These products are suited to a diverse crop application covering horticulture as well as broad-acre farming.

The recent development of data logging capability in the KEE product range provides farmers with an electronic record of all activities, coupled with the opportunity to preset the control systems to ensure best practice is achieved. Through strategic alliances with three major companies that produce auto steering products, the company can now offer a fully integrated system that can deliver hands-free operation for the operator–the true auto-pilot for the land.

With a range of functions running, Zynx offers farmers better efficiency and greater productivity. For example, it addresses the frustration of farmers who were unable to spray outside daylight hours due to the need for visual navigation - blobs of foam mark previous passes, and farmers needed daylight to see them for the second pass. Now, with the fine calibration and on-board guidance system, farmers can work in the dark if they want to (see Houghton et al., 2005 Department of Agriculture, Fisheries and Forestry, 2003).

Source: Houghton et al. (2005) and Department of Agriculture, Fisheries and Forestry (2003).

5.6 Survey results

5.6.1 Opinions on future IT application to agricultural extension

To canvass opinion regarding future IT applications to agricultural extension, a survey of selected agricultural research organisations was undertaken for this study. A

statement and corresponding Likert opinion scale ranging from Strongly Disagree to Strongly Agree was used.

Fifty questionnaires were mailed and total responses were 15. Results are summarized in Table 5.6 below. Eighty per cent of respondents agreed that IT is an emerging technology that can facilitate the diffusion of agricultural technology, of which 27 per cent strongly agreed with the statement. None of them disagreed with the statement. Ninety-seven per cent of the respondents agreed that almost all researchers in Australia have the ability to use IT for their day-to-day activities. Only 7 per cent of respondents strongly disagreed with the statement that IT can overcome constraints of time and distance, while 86 per cent agreed.

Table 5.6 Opinion of respondents towards future IT applications to agricultural extension

Statement	Percentage (%)				
	Strongly disagree	Disagree	Neither	Agree	Strongly agree
1. IT is an emerging technology that can facilitate diffusion of technology	0	0	20	53	27
2. Almost all researchers have the ability to use IT for their day-to-day activities	0	7	7	20	67
3. Computers are no longer a luxury item for ordinary people	0	13	7	33	47
4. IT can overcome constraints of time and distance on technology transfer	7	0	13	53	33
5. There are plenty of computer training courses for novice users	0	0	27	73	0
6. To find a ISP is not that difficult	0	7	13	33	40
7. Due to competition the cost of ISP and telephone connection charges are decreasing	0	7	40	20	20
8. Portable lap-tops make technology transfer task easier	0	7	20	60	13
9. In future it is possible to use mobile/wireless internet technology	0	0	20	53	27
10. IT channels can replace the existing extension network in the future	13	33	27	27	0

Source: Author survey (2005).

Table 5.6 indicates the answers of respondents in Australia. Twenty-seven per cent of the respondents agreed with the statement that the extension workers' role could be replaced by IT channels in the future. There were mixed responses regarding whether a computer was no longer a luxury item for ordinary Australians, about 13 per cent disagreed. Eighty per cent of respondents agree that there are plenty of computer training courses for novice users. The majority of respondents believe that portable laptops make technology transfer easier, and in the future it will be easier to use mobile/wireless internet technology.

Asked whether IT can facilitate diffusion, no respondents strongly disagreed or disagreed. However, 20 per cent were unsure and 80 per cent respondents supported the statement.

5.6.2 Opinions on future IT use

There were mixed responses to the most controversial statement that IT channels can replace the existing extension network in the future 46 per cent disagreed with the statement and only 27 per cent agreed, another 27 per cent neither agreed nor disagreed. No one strongly agreed with the statement. That means that according to the specialists in the field of innovation diffusion the possibility of replacing the current extension network by IT channels is minimal (only 27 per cent believe) in the near future.

Respondents were also asked an open-ended question: 'from your experience what is the potential for IT as a diffusion channel?'. A range of responses was given, although the total number of responses was small (9). No consistent themes emerged, although the majority supported the central idea. The following were some of the opinions drawn from responses. They represent the qualitative evidence collected in the Australian survey, for which a mail questionnaire was used rather than face-to-face interviews.

IT is another option in a suite of communication channels. Its importance will increase with time. But a range of existing channels will remain relevant. Many people (clients) are not in the habit of accessing the WWW.

IT has very high potential. However, major issues of access and speed outside major metropolitan areas (i.e. regional and remote) are still constrained by network speed.

IT can target end users with timely technical information and data. It can provide broad awareness.

IT has potential for sharing information and creating awareness. It is limited by the fact that users have to go to it.

IT is very useful for general awareness. However it is not good for 'adoption'. For adoption there is a need for a variety of connections.

Potential is moderate, however high in our area of research.

A small to moderate proportion of the audience has access and utilities, but is increasing; one tool in a suite of tools.

Very high potential. In fact as our organisation is slowly moving away from providing extension free of charge. IT should have a very big role/potential in the future.

Generates interest. We also receive initial contacts from private industry who wish to use our services (contracts). Also other researchers in our field use it as a resource. Some farmers would use it, but not many.

IT is only one of many methods we use. We do not rely on IT exclusively or as 1st choice. Our main clients (farmers) prefer to obtain their information from people/personal contacts ahead of written, ahead of electronic. This is slowly changing as younger farmers take over farms. They are more IT savvy.

In conclusion, the majority of respondents who answered believed that IT has potential to diffuse information, but needed to be used with a mix of existing methods to achieve maximum results. Some respondents mentioned present constraints, such as access and connection speed.

5.6.3 Major communication channels used to diffuse information of innovations

The survey revealed that 60 per cent of respondents reported that they used websites for information diffusion very often and only 13 per cent reported rarely using websites (Table 5.7). These results indicate that the majority of respondents still rely on traditional extension networks (73 per cent). It was interesting to see that 93 per cent of respondents reported that they often used radio for their communication. The survey also revealed that the majority of respondents rarely used TV and films/videos. A considerable percentage of respondents still use written materials for information diffusion. This implies that there is the possibility to substitute these written materials by web pages and/or downloadable files in the future. The results in Table 5.7 also reflect that respondents employ all channels in varying frequencies for their diffusion purposes, however they already use websites, very often (third most common).

Table 5.7 Usage of major communication channels to diffuse information of innovations

	(%)		
	Very often	**Often**	**Rarely**
Extension network	73	27	0
TV	0	7	93
Films/videos	0	13	87
Radio	0	93	7
Newspapers	47	40	13
Local newsletters	60	33	7
Bulletins	13	53	20
Websites	60	20	13
CDs/DVDs	13	47	33
Fact sheets	40	47	7
Booklets/leaflets/pamphlets/posters	60	33	0
Research reports	67	27	0
Magazines	13	60	27
Fax	0	20	73
Educational programs	20	33	47
Software	13	13	67
Technical manuals	13	20	60

Source: Author survey (2005).

5.6.4 Presence of an official website

Every organisation interviewed maintained a website. This reflects that every organisation surveyed already recognized the importance of having an official website.

5.6.5 Purpose of the website

When asked what was the purpose of maintaining a website everyone indicated that the provision of useful information to users was one purpose. The other main reason indicated was that their organisation gained publicity through the website (93 per cent) and 80 per cent reported using the website as a vehicle for providing service to clients. Fifty-three per cent of respondents stated that they used their website as a more cost-effective and/or efficient means of communication Table 5.8. This result revealed that organisations are already using their websites for information and diffusion purposes.

Table 5.8 Purpose of the website

	(%)
Provision of useful information for users	100
Publicity for your organisation	93
As a vehicle for providing service to clients	80
As more cost-effective and/or efficient channel of communication	53
Other	20
As means of conducting commercial or financial transactions	13

Source: Author survey (2005).

5.6.6 Target audience of the website

Most of the respondents (87 per cent) indicated that their target audience were farm businesses and their own staff (87 per cent), followed by the general public (73 per cent), professional and technical personnel and other businesses (27 per cent) Table 5.9. This reflects that the surveyed organisations' primary objective for development of a website is to communicate information to farm businesses and among their own staff. However more than 50 per cent of respondents indicated that they also targeted the general public, professional/technical support and other businesses. This suggests that they use the website to broaden their reach.

Table 5.9 Target audiences of an organisation's internet site

	(%)
Farm businesses	87
Own staff (i.e. an intranet)	87
General public	73
Professional/technical support	67
Other businesses	53
Other	27

Source: Author survey (2005).

5.6.7 Reasons to use information technology

The majority of respondents surveyed stated that they used IT because it was providing timely information about an innovation (80 per cent) and was convenient to use (73 per cent), followed by efficient (67 per cent) and easy to manage/edit information (60 per cent), effective (53 per cent), low cost (53 per cent), and can combine with other media (53 per cent) (Table 5.10). Only twenty per cent or less believed that IT and the internet had low overhead and establishment costs, low employee training costs and low maintenance costs. This implies that when using IT and the internet they have to be prepared to bear relatively high establishment and maintenance costs.

Table 5.10 Reasons to use information technology

	(%)
Timely information about an innovation	80
Convenient	73
Efficient	67
Easy to manage/edit information	60
Effective	53
Low cost	53
Can combine with other media such as DVDs, sound video camera, etc.	53
Low overhead and establishment costs	20
Low employee training costs	20
Low maintenance costs	7

Source: Author survey (2005).

5.6.8 Proportion of budget allocated to information dissemination

The proportion of the budget allocated by responding organisations to information dissemination is relatively small. Twenty-seven per cent indicated that it is less than 10 per cent (Table 5.11). Not one responded that they had allocated more than 50 per cent of their budget for information dissemination. This reflects the fact that there were relatively few organisations surveyed that are exclusively involved in information dissemination.

Table 5.11 Proportion of budget allocated to information dissemination

	(%)
<10%	27
10%-20%	53
40%-50%	13
>50%	0

Source: Author survey (2005).

5.6.9 Use of feedback facilities and search engines

Eighty per cent of respondents indicated that their websites contained a hit counter and an email feedback facility. Only 27 per cent said their websites have interactive facilities, such as bulletin boards, forms, etc. (Table 5.12). This suggests that the surveyed organisations wanted to measure and monitor their websites usage.

Table 5.12 Use of feedback facilities

Indicators	(%)
Hit counter	80
Email feedback facility	80
Interactive facilities, such as bulletin boards, forms, etc.	27

Source: Author survey (2005).

5.6.10 Use of search engines

Eighty per cent of respondents stated that they used search engines to find information and only 20 per cent of respondents do not use search engines (Table 5.13).

Table 5.13 Use of search engines

	(%)
Yes	80
No	20

Source: Author survey (2005).

Internet search engines help users find material on a given subject. Agribusinesses and other stakeholders dealing with innovation diffusion can use search engines to find a web address or web link.

5.7 Conclusion

There is an increasing trend in ICT spending in general and in agriculture in particular in Australia. This suggests that the importance of ICT to the economy has been recognized by both industry, the services sector and the agricultural sector. We can see an increase in farm use of computers and the internet, with a positive correlation between farm size and computer and internet use. Computer usage is always a little ahead of internet usage, but the gap is increasingly closing with time. In fact, there is

very limited information available on web-based innovation diffusion particularly in the Australia agribusiness system. However the presentation of three case studies where some IT facilities were used in extension systems demonstrates the potential to use IT as an effective tool of innovation dissemination within AIS in Australia.

Australian Bureau of Statistics surveys of farm use of computers show strong uptake of computers and the use of the internet for communication, including searching for information about the weather, markets and, to a lesser extent, technical information. However there is no evidence about the diffusion of innovation by IT in Australian agriculture despite R&D institutes and universities having web-based communication strategies.

Our own survey revealed that websites were the third most commonly cited category of agricultural innovation communication channels, behind the extension network and research reports.

One hundred per cent of respondents indicated the presence of an official website for their organisation/centre, and that the provision of useful information for users was the major purpose of their website. Their principal target audience was farm businesses and their own staff.

In conclusion, this chapter found that IT is an important diffusion tool in Australia, and expectations are that it will become more so over time.

CHAPTER 6

ROLE OF INFORMATION TECHNOLOGY IN DIFFUSION OF INNOVATIONS TO THE FARM LEVEL WITHIN THE SRI LANKAN AGRIBUSINESS SYSTEM

6.1 Introduction

The development of IT and the internet has changed the way society accesses and processes information (Bell, 2002). It is acknowledged that agricultural scientists and agribusinesses operate in widely dispersed locations and diverse socioeconomic strata throughout Sri Lanka. Therefore, there is a need for a variety of communication channels to get information about innovations out to agribusinesses/farmers. Traditional channels, such as TV, radio and the extension network take a considerable time to disseminate agricultural innovations. Communication delays could be a barrier to the uptake of innovations designed to improve efficiency, sustainability and profitability of farming businesses. The question is, how can these people be reached effectively and efficiently as we move into the information age? The internet may be one possible tool.

Computer-based communication has gained tremendous popularity in recent years, mainly due to its ease-of-use, efficiency, speed and cost-effectiveness. The increase in ease-of-use and efficiency is due to better software, while the increased speed and cost-effectiveness is due mainly to improvements in computer and communications technology and communications services (Adams et al., 1992).

This chapter explores the role IT plays in the diffusion of agricultural innovations to the farm level within the Sri Lankan agribusiness system. It seeks to understand what role IT can play within the agricultural sector as well as what its importance is to the Sri Lankan economy, and finally what the opinion of respondents are towards future IT applications in agricultural extension.

6.2 Information technology and the Sri Lankan economy

The following Table 6.1 indicates some of the key statistics on computer usage in Sri Lanka. It shows that about 10.5 per cent of households nationally possessed a computer in 2003. But this number is increasing year by year, and there is a promising future for IT development in Sri Lanka. However, when comparing urban and rural areas it is clear that urban areas have a household computer density ten times that of the rural sector. It is also clear that, in 2003, only a small proportion of the working age population (less than 3%) could use a computer or the internet on their own.

Table 6.1 Some key statistics on computer literacy, use of home computers and email and internet services, Sri Lanka, 2003

Indicator	%
Computer literacy (percentage of household population in the age group of 5-69 years who can use computers)	9.7
Households having computers (national)	10.5
Households having computers (urban sector)	30.8
Households having computers (rural sector)	3.1
Households having computers (estate sector)	0.3
Percentage of household population in the age group of 5-69 years who can use email on their own	2.8
Percentage of household population in the age group of 5-69 years who can use the internet on their own	2.6

Source: Department of Census and Statistics, Sri Lanka (2004).

Table 6.2 indicates the total information and communication technology spending in Sri Lanka from 2002 to 2008 (2006 to 2008 are forecasts). An increasing trend can be seen in total ICT spending as well as in the components of ICT spending in Sri Lanka. The majority of spending goes to communications, with computer hardware computer services and computer software significantly lower (due, in part, to relatively high communications costs).

There has been fairly good historical growth (8.3%) in IT spending in Sri Lanka, and a higher rate of growth is projected by WITSA over 2005-2008. Very rapid growth in spending on software and services (nearly 30% per annum) is forecast but there has been, and is expected to continue to be, much slower growth in telecommunications spending. This declining share suggests that there is a need for more investment to build up the telecommunication network. Agriculture share is low (2% as opposed to 19 per

cent share of GDP, see chapters 3 and 4), and declining, but higher than in Australia (0.3%).

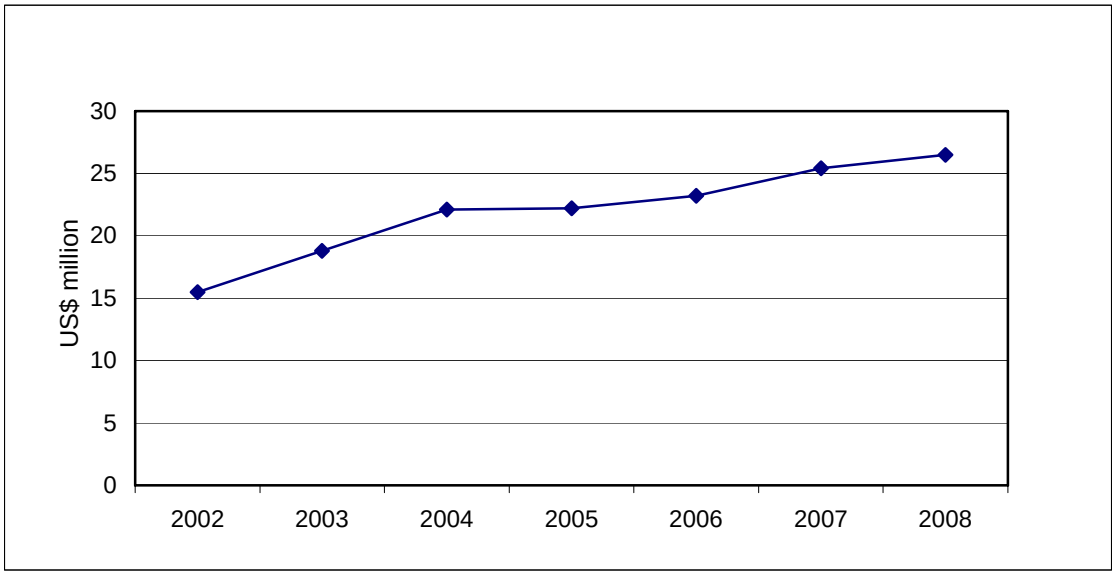
Table 6.2 ICT spending in Sri Lanka, US$ million

ICT Spending	2000	2001	2002	2003	2004	2005	2006	2007	2008
	Actual						Projected		
Computer hardware	91.5	100.4	111.3	133.9	162.1	185.8	211.3	251.0	290.0
Computer software	17.8	21.8	27.3	35.9	49.1	64.8	83.5	110.7	141.0
Computer services	27.5	31.8	41.7	57.3	76.9	101.5	130.8	174.5	224.1
Communications	679.0	619.5	707.5	756.0	833.9	887.9	953.0	1,019.1	1,077.1
Total ICT spending	**815.8**	**773.5**	**887.8**	**983.1**	**1,122.0**	**1,240.0**	**1,378.6**	**1,555.3**	**1,732.1**

Note: 2006 to 2008 forecast. See also Appendix Table A3.3.
Source: WITSA (2005).

Figure 6.1 depicts total ICT spending in the agricultural sector in Sri Lanka from 2002 to 2008. It is clear that there has been an increasing trend of ICT spending in agriculture over 2001-05, although at a rate of growth (6.0% per annum) below that for total ICT spending (8.7%). The projected rate of growth for ICT in agriculture (4.6%) is also well below the rate of all ICT spending. ICT spending in agriculture is only about 2 per cent of total spending, by comparison with agriculture's share of GDP of about 19 per cent. These facts suggests, while the agricultural sector has recognized the importance of introducing and using ICT in general, and innovation related activities in particular, both the level and rate of growth of ICT spending in the sector is low. This is likely to be related to the relatively low level of computer and internet skills in the rural community in Sri Lanka, noted above in Table 6.1 and detailed further in the next section. Given that IT adoption is very low in the rural sector, there is a need for a different approach to cater for farmers. Telecentres or mobile IT facilities may be what is needed to get farmers' attention – poor farmers can have access to telecentres or mobile vans with IT facilities. This approach is discussed in sections 6.3.1 to 6.3.7 of this chapter.

Figure 6.1 Total ICT spending in agriculture in Sri Lanka, US$ million



Note: 2006 to 2008 forecast.
Source: WITSA (2005).

6.3 Rural attitudes and IT capabilities: The Global Knowledge Centre Project survey

6.3.1 Global Knowledge Centre (GKC) Project

The Global Knowledge Centre Project is one of a number of projects implemented under the e-Sri Lanka Initiative. It aims to meet the ICT infrastructure requirements of rural areas in selected districts in the south and north-eastern parts of the country through the establishment of global knowledge centres and the provision of different ICT based services (Priyaratna, 2004a).

The main activities implemented under the Global Knowledge Centre Project include:

- a survey on existing communication shops/cyber cafes;
- selection of potential GKC locations;
- selection of GKC support institutions;
- training of personnel; and
- conducting a survey on the present use of ICT tools, and information and communication needs of various communities (Priyaratna, 2004a).

According to Priyaratna (2004a), the selection process covered two distinct regions namely, the deep-south and the north-east. The districts covered under the deep-south region include, Galle, Matara, Hambantota, Monaragala, Ratnapura and Badulla. The districts covered under the north and east region include: Jaffna, Kilinochchi, Vavuniya, Mullaitivu, Polonnaruwa, Anuradhapura and Trincomalee.

The main objective of the survey was to understand the information and communication needs of the people living in communities in the above districts. Moreover, the specific objectives of the survey were to identify types of services requested by the residents, willingness and ability to pay for the requested services, and patterns of usage of ICT based services (Priyaratna, 2004a).

Two research teams were deployed, one in the south region and another in the north-east region. Both teams had 10 members and one field supervisor each. Before the survey started a one-day training session was organized with each team.

South region

In the south region, the Village Headmans (VHs) that were visited by the research team are summarized in Table 6.3 below. It shows the 6 Districts, 9 District Secretariat Units (DSU), 10 Village Headman (VH) and number of people (population) under each VH. In total, 39 villages were visited, and 1,438 individuals interviewed (Priyaratna, 2004a).

Table 6.3 District, DSU, VU and number of people in the south region, Sri Lanka

District	District Secretariat Units	Village Headmen	Number of people
Badulla	Bandarawela	Bandarawela East	3,954
Badulla	Wlimada	Welimada Town	2,419
Galle	Thawalama	Hiniduma North	2,254
Hambantota	Suriyawewa	Suriyawewa Town	3,948
Hambantota	Tangalle	Danketiya	2,342
Matara	Pasgoda	Urubokka	2,319
Monaragala	Kataragama	Detagamuwa	4,991
Monaragala	Sevanagala	Sevanagala	4,970
Ratnapura	Embilipitiya	Maduwanwela	3,325
Ratnapura	Embilipitiya	Panamura	4,566

Source: Priyaratna (2004a).

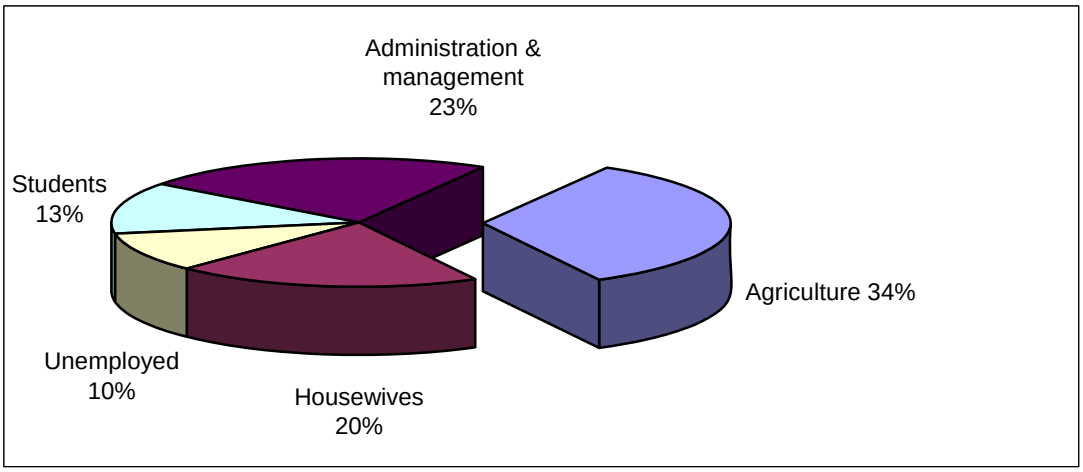
6.3.2 Demographics of respondents

Out of the 1,438 people that were interviewed, 54 per cent were females, and the rest (46%) were males. The Village Headman with the most female and fewest male respondents was Danketiya (with 60% females and 40% males), and the Village Headman that had the least females and most males interviewed was Detagamuwa (with 48% females and 52% males).

Regarding the age breakdown of respondents, the age group that included more respondents was the 31 to 40 years old with 40 per cent of the respondents, followed by the age group of 41 to 50 years old with 40 per cent. The people representing the age group of people 61 years old and over represented the smallest group, with 20 per cent of the respondents.

Figure 6.2 depicts the employment status of survey respondents of the south region. It shows that 34 per cent of the population are employed in the agricultural sector.

Figure 6.2 Employment status, Sri Lanka, south region, 2003



Source: Priyaratna (2004a).

Close to two-thirds of the respondents (64%) reported having between one and ten years of schooling, and the biggest group (35%) had nine to ten years of schooling. Only 1 per cent of the respondents stated that they had no schooling at all. While the level of education in the local language is high, when asked about the level of proficiency in English, only 28 per cent of the respondents considered themselves as literate.

More than half of the respondents (56%) had an average personal monthly income (for the year 2003) of more than Rupees 5,000 (A$70 approximately) and more than one third of respondents (37%) reported having an average family monthly income of Rupees 5,001 to 10,000 (A$70-143 approximately).

6.3.3 Use of telephones

The majority of respondents (85%) reported having used the telephone at least once. Almost one fifth of the females (20%) and one tenth of the males (10%) had never used a phone. The VH that had the fewest number of people that had experience phoning at least once was Panamura (71%), and the VHs with the most people that had experienced using the phone were Bandarawela and Suriyawewa with 93 per cent each (Priyaratna, 2004c).

From the respondents that had used a phone previously, close to two-thirds (63%) reported having used a phone in the last three months. The number of females that had used the phone previously but had not used it in the last three months represented 41 per cent of females interviewed.

Respondents were asked about any suggestions they had in relation to improving the telephone systems in their communities. Close to half of the respondents (43%) stated that they would like to see phone connections being less expensive, followed by phones being closer (27%), more phones (20%), and phones functioning better (10%).

6.3.4 Computer knowledge

Only 2 per cent of the respondents stated that they had used the internet. The VH that had the most respondents reporting to have used the internet was Bandarawela (5%), while in Detagamuwa, Urubokka and Panamura none of the respondents had used the internet. The respondents that had never used the internet stated the main reasons as:

- no need for using the internet (56%);
- don’t know how to use internet (29%);
- internet is not available in the community (12%);
- difficulty with the language of internet (1%); and

- price of connection (1%).

6.3.5 Information and communication needs

Close to one fifth of the respondents (16%) stated that they specifically travel outside of their community to either send or receive information that is of interest to them. More than one third of the people (37%) who travel outside their community for sending or receiving information do so between three and four times a month, while 10 per cent travel more than once a month. The main tools that they use for sending or receiving the information of interest are telephone (50%); newspaper (47%) and fax (1%). The main types of information that respondents send or receive while travelling outside of their communities include personal and family related information (50%), employment information (13%), and information on the political situation in the country (10%) (Priyaratna, 2004c).

When the respondents were asked to state the types of information that is important for their daily activities, they provided the following responses in descending order: agriculture, politics (both national and international), education, entertainment, business and health. This result reflects high demand for agricultural-related information.

North-east region

The VHs that were visited by the research team in the north and east region included a total of 5 Districts, 10 District Secretariat Units, 10 VHs, and 29 villages. In these villages a total of 1,242 individuals were interviewed (Priyaratna, 2004b). Table 6.4 summarises the District, DSU, VH and the total number of people in each VH.

Table 6.5 District, DSU, VH and the number of people in north and east region, Sri Lanka

District	District Secretariat Units	Village Headmen	Number of people
Anuradhapura	Rambewa	Ikkirigollawa	3,609
Jaffna	Jaffna	Reclamation West	4,082
Jaffna	Vadamarachchi	Point Pedro	4,522
Jaffna	Valikamam	Kopay South	2,993
Polonnaruwa	Medirigiriya	New town	2,444
Trincomalee	Kinniya	Maharoof Nagar	3,280
Trincomalee	Mutur	Jaya Nagar	2,628
Trincomalee	Thambalagamam	Mullipothana North	3,817
Trincomalee	Town and Gravets	Manayaveli	4,970
Vauniya	Vavuniya Town	Rambaikkulam	4,207

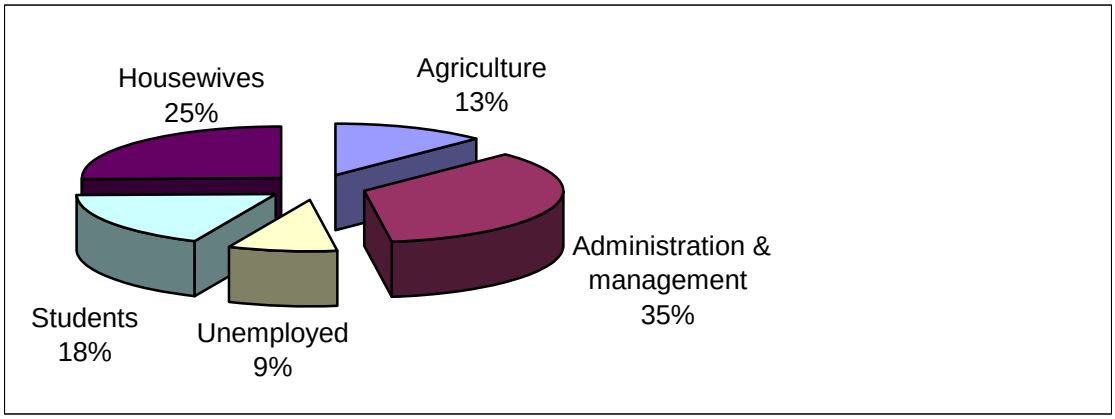
Source: Priyaratna (2004b).

6.3.6 Demographics of respondents

Out of the 1,242 people that were interviewed, 661 or 53 per cent were females, and the rest 47 per cent were males. Regarding the age breakdown, the age group that include the most respondents was 21 to 30 years old with 56 per cent of the respondents, followed by the age group of 31 to 40 years old with 38 per cent. The people representing the age group of people 61 years old and over represented the smallest group with 6 per cent of the respondents. The only age group where the male representation was higher than the female was the age group of 61 years old and over. For the rest of the age groups (13 to 20 years old, 21 to 30 years, 31 to 40 years, 41 to 50 years, 51 to 60 years old) females represented the majority of the respondents (Priyaratna, 2004b).

Figure 6.3 depicts the employment status of survey respondents of the north and east region. As opposed to the south region, in the north and east region only 13 per cent of the population are employed in the agricultural sector. Most people in this region work in administration and management.

Figure 6.3 Employment status, south region, Sri Lanka, north and east region, 2003



Source: Priyaratna (2004b).

Only 2 per cent of the respondents stated that they had no schooling at all. While the level of education in local languages is high, when asked about their level of proficiency in English, 46 per cent of the respondents considered themselves to be literate in English, with the rest (54%) considering themselves illiterate. More than half of the respondents (55%) had an average personal monthly income (for the year 2003) of more

than Rupees 5,000 and more than one third of the respondents (42%) reported having an average family monthly income of Rupees 5,001 to 10,000 (Priyaratna, 2004b).

6.3.7 Use of ICT tools

The majority of the respondents (82%) reported having used the telephone at least once. More than one fifth of the females (22%) had never used a phone, but only 14 per cent of males had never used one.

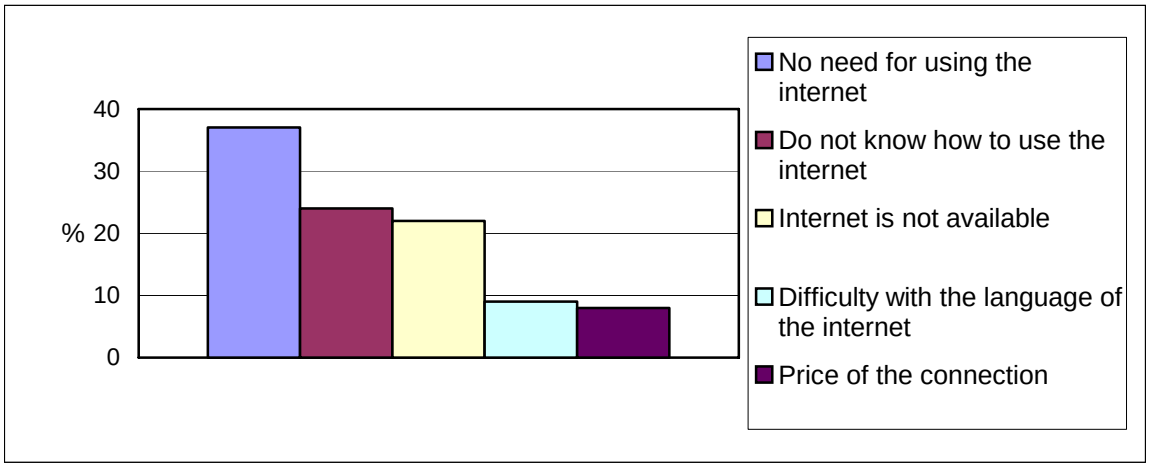
The respondents who reported never using a phone stated that the reasons for not using a phone were: nobody to call (45%); not knowing how to use a phone (14%); lack of phones (18%); phones too far away (11%); and phones too expensive (3%). From the respondents that had used the phone previously, more than two-thirds (71%) reported having used the phone in the last three months. Even in this case, the females that had used the phone previously but had not used it in the last three months represented 35 per cent of the female respondents (Priyaratna, 2004b).

Respondents were asked about any suggestions that they had in relation to improving the telephone systems in their communities. More than one third of respondents (37%) stated that they would like to see phone connections being less expensive, followed by phones functioning better with (24%), phones being closer (20%), and more phones (13%) (Priyaratna, 2004b).

6.3.8 Computer knowledge and use of the internet

Only 6 per cent of the respondents rated their computer knowledge as average or very good. The rest (94%) rated their computer knowledge either below average or as no knowledge at all. More men rated their computer knowledge as average or very good than women. According to Priyaratna (2004b), close to 10 per cent of the respondents stated they had used the internet. The respondents that had never used the internet stated as the main reasons for not using the internet as depicted in Figure 6.4 below.

Figure 6.4 Reasons for not using the internet



Source: Priyaratna (2004b).

As in the case of internet usage, 9 per cent of the respondents had used email. The main reason for not using it were as follows: there is no need for using email (37%); don't know how to use email (26%); the service is not available (22%); price factor (14%); and other (2%). The people that used email stated they used it for educational (34%), social (32%), and business (19%) purposes.

6.3.9 Information and communication needs

More than one third of the respondents (36%) stated that they specifically travel outside of their community to either send or receive information that is of interest to them. More than one third of the people (40%) who travel outside their community for sending or receiving information do so between three and four times a month, while 16 per cent travel more than once a month. The main tools that they use for sending or receiving the information of interest are telephone (51%); newspaper (22%), fax (9%), and internet (6%).

The main types of information that respondents send or receive while travelling outside of their communities included personal and family related information (49%), employment information (8%) and educational information (8%). When the respondents were asked to state the types of information that is important for their daily activities, they provided the following responses; education; entertainment; business; national and international news; market prices; and agriculture (Priyaratna, 2004b). This result reflects the employment pattern depicted in Figure 6.2.

6.3.10 Conclusion

In conclusion, the Global Knowledge Project was considered to be a pilot project implemented to gather information about ICT demand in terms of use of existing telecentre services and ICT needs of rural communities in Sri Lanka. According to the two detailed regional studies that comprise the overall survey, there is very low IT capability and access in the selected rural areas, although there are definite signs of interest in acquiring information for agriculture and a willingness to travel to acquire it. However, information literacy issues were of concern, including such things as how general familiarity with the use of ICTs can help people better access the information they needed.

6.4 Telecommunications and IT infrastructure in rural Sri Lanka

Telephone availability in Sri Lanka is poor with waiting lists into years in some regional and rural areas. Most of the telephone exchanges were installed in the nineteenth century and still use archaic technology, creating congestions at peak hours. The Central Bank of Sri Lanka (2006) estimates that Sri Lanka's phone density is 0.93 per 100 people for a population with huge unmet demand. The state-owned Sri Lanka Telecom, which now has a monopoly on landlines, is unable to expand its network fast enough due to lack of funds. Therefore foreign direct investment is urgently needed to help build the telecommunications infrastructure especially in rural areas (Jayasuriya and John, 2002).

The country has recently started to privatise telecom services in a bid to improve the telecommunication infrastructure and due to significant public investment made in this sector over the last five years, Sri Lanka Telecom started replacing outdated switching systems and cable networks with modern powerful and effective digital switching systems. As a result, the capacity and quality of communications infrastructure has increased sharply.

Sri Lankan farmers are predominantly peasant farmers with relatively low exposure to information technology. The majority cannot afford to buy a computer and do not have

the skills to operate one. Rural internet penetration in Sir Lanka lags behind that of urban areas. This can largely be attributed to poor rural telephone, road and power infrastructure. As a result, people in rural areas of Sri Lanka face numerous barriers to access and adoption of new technologies, such as information technology.

To overcome these barriers the Sri Lankan government and NGOs have launched several development programs to introduce IT into the rural sector, particularly to the farming communities. These programs deliver education, information, services and market opportunities to rural people including farmers. Electronic communications infrastructure is rapidly promoted by the "Vidata Centers" established by Ministry of Science and Technology in almost all the rural areas. These centres also cater for the needs of the rural agribusiness sector to some extent. While collecting Sri Lankan data for this study, the author interviewed two highly credible and reputed organisations responsible [5]for introducing IT into economically disadvantaged farming communities – namely, the government owned Information and Communication Technology Agency (ICTA) Sri Lanka, and Sarvodaya Movement (an NGO). The results are presented in Section 6.5.

The Dialog Broadband Network (DBN) has provided WiMAX (World Interoperability for Microwave Access) Broadband Wireless Access (BWA) services to selected pilot customers in the Hambantota, Matara, Galle, Kurunagala, Anuradhapura and Polonnaruwa districts (Wijewardane, 2007). Amadeus Lanka Pty Ltd., World Vision and Hotels Corporation are among the technology pioneers who have joined Dialog Broadband in the pilot launch of WiMAX services in Sri Lanka.

According to Wijewardane (2007) WiMAX provides broadband internet access across the footprint of the wireless network, enabling anywhere-anytime access to high speed broadband. Further WiMAX is capable of delivering a host of end-user services while optimising the resources of the services provider. A key attribute of WiMAX is its higher 10Mb/s speed. The service is IP based and supports a quality service, which allows the delivery of multimedia services on a single connection which is necessary to

[5] In the absence of detailed official statistics on ICTs in Sri Lanka, these organisations provided information about farm use of IT in Sri Lanka.

facilitate extension activities in Sri Lanka. WiMAX wireless broadband plays a key role in bringing connectivity and information within the reach of everyone, bridging the digital divide in Sri Lanka (Wijewardane, 2007).

6.5 Access to IT in rural Sri Lanka: The development of telecentres

6.5.1 Telecentres

Telecentres are a relatively recent phenomena in Sri Lanka, and are being explored by international and national development agencies in providing access to modern technologies for isolated rural communities who cannot afford to purchase a computer or have skills to use IT. The first telecentres appeared in Europe in the 1980s, where the idea spread quite rapidly, mainly in rural areas of developing countries (Wijesinghe, 2002). They have also been established in isolated rural towns in Brazil, which plans to build several hundred in the next few years. Telecentres provide access to the internet, fax machines, photocopying, telephones, email, electronic networks and library resources. They grant rural audiences better access to information than the local media, such as radio and television. Telecentre venues can be used to facilitate organising virtual village-to-village meetings and tele-training events. Therefore, these centres provide not only single points for sharing global information through the internet, but also disseminate much needed technical information about agricultural innovations along with facilities for video conferences, forums and distance learning (Ariyaratne, 2004).

Some lessons can be drawn from prior experience and are listed below.

- Centres are managed better when the owners have a stake in them. In some projects, donated equipment is lying around unused. The entrepreneurial instinct is a strong force in making a centre effective.
- There is a great demand for telephony, and ICT use can be built up in response, but it takes time, training and local adaptation.
- Simple business models are more likely to be successful than complicated ones. The idea of a multipurpose telecentre is ambitious and without extensive training and support many of the wider aims of telecentres are difficult to accomplish (Benjamin, 2000).

Establishing telecentres in urban or rural areas with some connectivity does not present great difficulties. The lack of broadband telecommunications infrastructure is a major challenge in rural areas, however the situation is changing with such initiatives as the introduction of WiMAX wireless dialog broadband access to selected pilot customers in six districts as described in Section 6.4. Other factors come into play that further raise investment and operating costs in rural areas (humidity, low skills of the client population, and lack of technical facilities and staff to maintain equipment). When selecting a suitable venue for establishing a telecentre, it is vital to choose a place that is not too far from their homes, where farmers normally gather or visit often, such as village fairs, village boutiques, temples, churches, mosques or schools.

6.5.2 Telecentres in Sri Lanka

There are a number of cyber cafes, communication shops, and telecentres across the country and the majority of them are situated in urban and semi-urban areas (Priyaratna, 2004c). In Sri Lanka, existing telecentres have been initiated by the Government, private owners and NGO sponsored owners. According to Ariyaratne (2004), the Sarvodaya movement is a prominent NGO that has established several telecentres.

Telecentres can be used as a common meeting point between farmers and extension workers in Sri Lanka. Extension workers and agricultural instructors can educate farmers about using modern IT facilities located in telecentres. They are important venues of knowledge and technology dissemination for farmers (Ariyawikrama, 2004).

The basic telecentre common in Sri Lanka's urban areas has fairly standard features. It consists of premises stocked with several computer terminals and simple furnishings, consisting of chairs or classroom desks for users and regular desks or tables for the terminals. The principal mode of connectivity is dial-up through normal telephone connections. The main services offered to the public are access to the internet (chatting, emailing and browsing) and the availability of elementary software (word processing, spreadsheets, etc.). Administrative and support staff oversee the use of the machines, collect payment for the services, and provide rudimentary technical support to the users (Ariyaratne, 2004).

According to Priyaratna (2004a), connection to the internet is preferable over a dedicated transmission line or via PSTN-based broadband (e.g. ADSL), but at small telecentres and in small towns the only option may be a dial-up service at low transmission rates (e.g. 28 kbps). While Sri Lanka is fortunate to have a rapidly growing communications network for connectivity nationwide, remote communities are penalized by slower data connections due to the lack of available and affordable broadband connectivity (Ariyarathne, 2004).

6.5.3 NGO-sponsored telecentres

Ariyaratne (2004) stated that Sarvodaya has become a centre for various development activities in Sri Lanka, including ICT-based programs for the poor. Since 1997, seven telecentres have been established by Sarvodaya. Some of these are quite modest, but all have become functional as ICT nodes for community development.

Within the virtual village concept, the potential of ICT is harmonized with the traditions and development of the rural community. Two virtual villages consist of 'tele-huts' established near a 'village-community-bank'/CBO office (a community based organisation), and networked (externally) to the district telecentres. Wireless community networks are used within each village so that the tele-huts can connect to the Village Access Points (VAPs). In the first of the virtual villages opened on 12th of January 2004, the VAPs consist of three 'static' ICT points at a temple, a school and an ayurvedic practitioner, and two 'mobile' ICT points which provide access to women, farmers and entrepreneurs. The community ICT network functions as a supporting mechanism to the on-going community development work (Ariyawickrama, 2004).

The second virtual village was opened on the 12th of March 2004, at Kuda-oya, Nuwara Eliya. Visiting scholars, such as Professors Samaranayake and Weerasinghe, met the local community to see what they thought of the ICTs. Everyone was looking forward to interacting with ICTs like digital cameras and laptop computers. The telehut, which is a local model of a telecentre, will work as the village hub to network with the other 31 telecentres established around Sri Lanka (Ariyarathne, 2004).

The IDRC funded virtual village project was a leading edge research project, with technological and sociological research underway within the three key project partners: the University of Colombo School of Computing, the Agri Business Centre of the University of Peradeniya and the Centre for Women's Research. In this endeavour Sarvodaya is combining its 48 years of community development experience with 9 years of ICT4D experience (Ariyarathne, 2004).

6.5.4 Networking grassroots

According to Ariyarathne (2004), with the advancement of information technology the whole world speaks of the global village and global family. Yet, due to lack of awareness and availability among the Sri Lankan rural community, the benefits of information technology are largely confined only to the urban areas. Hence, the rural community living in remote villages have been deprived of the opportunity to enjoy the positive effects of information technology. However, according to Shakeel et al. (2001), establishing and operating rural telecentres is perceived to be more costly than urban ones. The objectives of the Sarvodaya Information Technology Programme were to link information technology to the community development process, reducing the gap between the rich and the poor in relation to information technology, and providing access to its benefits in the rural community (www.sarvodaya.lk).

On 1 September 2000, the first telecentre that coordinated all the Rural Information Centres of the Ratnapura District was set up as the Ratnapura District Telecentre. The Information Technology Program, implemented under the co-ordination of the Sarvodaya Social Empowerment Division, was linked with projects funded by the Novartis and Nippon foundations, and village level training programmes were launched in 15 districts. Rural Information Centres were started at the village level and telecentres at district level (Ariyarathne, 2004).

The Sarvodaya Information Technology Unit was set up within the Vishva Samadhi Complex at the national headquarters in Moratuwa on 2 April 2001. During the 3-year period from 2001 to 2003, 4 main activities were implemented at all levels of society from the national to grass roots level (coordinated by a group of young volunteers), and were aimed at developing:

- the telecentre programme;
- an IT training programme;
- rural information centres; and
- mobile information technology services.

6.5.5 Government telecentres

The e-Sri Lanka initiative of the Government of Sri Lanka recognizes that an important component of poverty and underdevelopment globally is the lack of access to information (Priyaratna, 2004a). According to Ariyaratne (2004), the e-Sri Lanka initiative is a stakeholder led, multi-donor funded, national development program, launched on 20 November 2002. The project aims to use information and communication technology (ICT) to foster social integration, peace, growth and poverty reduction in Sri Lanka, especially by increasing agricultural production. Currently, e-Sri Lanka is funded by the World Bank and the Government of Sri Lanka (Ariyaratne, 2004).

There is also a commitment for funding by the Japan Social Development Fund (JSDF), the Korean Government, the Swedish International Development Agency (SIDA) and the Canadian International Development Agency (CIDA). The private sector also contributed through their participation in the building of two regional telecommunication networks. This initiative aims to harness the benefits of towards achieving its overall objectives of:

- poverty reduction;
- building peace; and
- socioeconomic development.

The initiative is being implemented through six main program areas in order to achieve these key objectives, namely:

- information infrastructure;
- re-engineering government;
- ICT capacity building;
- ICT investment and private sector development;
- developing an e-Society; and

- technical architecture, standards and security (Priyaratna, 2004).

As has been noted by Priyaratna (2004c), the ICT Information Infrastructure Development Program of the e-Sri Lanka initiative addresses the current ICT connectivity issues in rural areas. The program plans to establish access points known as 'global knowledge centres' (telecentres) in rural areas in order to offer a range of ICT related activities. The Information and Communication Technology Agency of Sri Lanka is the primary government body mandated to implement the e-Sri Lanka initiative (Priyaratna, 2004a). The project is funded by a group of donor agencies through the Government of Sri Lanka.

The goal of the Global Knowledge Centres Project is to set up universal access centres which offer ICT related services in the Grama Niladari (village headman) Divisions. The objectives of the project are:

- to ensure wider access to the internet and to promote the usage of ICT at the grass-roots level;
- reduce the isolation and marginalization of rural communities through connectivity; and
- facilitate dialogue between communities and those who influence them, such as government planners, development agencies, researchers, technical experts, educators and others (Priyaratna, 2004c).

These centres would be equipped with computers and other ICT-related equipment in order to offer community specific services, including the following: phone connection (local and IDD); internet access; email; photocopying; printing; faxing; scanning of documents; computer training and government services.

Barriers to expanding telecentres include: lack of IT background in the communities where the telecentres are located; the high cost of ICT-based services; lack of relevant content; and lack of content in local language (Priyaratna, 2004c).

6.6 Information technology and agricultural extension in Sri Lanka

The primary objective of the extension worker (officer/agent) is not only to make available to the farmers and the industrial entrepreneurs the knowledge which is necessary for the production of goods and services, but also to assist him/her in the effective use of that knowledge (Unamboowe, 1984). The knowledge is available in research organisations, institutes and among individuals. The necessary factor is the establishment of a link between the source and the end user. Extension services provide the link. They also create a feedback to these knowledge generators, because they identify problems through farmers. Unamboowe (1984) reported that transfer of technology means the effective generation, communication and adaptation of the technology to a given environment, which is also influenced by socioeconomic and political conditions.

IT can be an effective tool (see section 5.4) for agricultural extension and communications within the AIS. Extension workers can use IT for their day-to-day work with farmers. For instance they can use lap-top computers for knowledge dissemination purposes. And generally, compared to existing informational channels, farmers can be reached more effectively and efficiently using a web-based approach. Websites can be used as educational sites for farmers and web features, such as email facilities and other interactive facilities like bulletin boards, can be used as feedback channels for farmers, facilitating personalized two-way communication. Websites are an effective tool for transmitting information, and possible uses of the internet for farmers include getting up-to-date information on farm management techniques, innovations, looking for farm-related workshops, gathering information on problems such as insects and diseases, or learning about legislation and taxes that affect them as landowners. They can also communicate directly, asking questions and conveying their concerns to extension officers and researchers.

On the same token actors of the AIS can be used in a web-based approach to cater not only for the needs of farmers but also fulfilling their own needs as actors in the AIS. Invention can happen anywhere in an innovation system. Therefore farmers should have to search the web to find the necessary information for their queries with support from an extension worker or advisor. On the other hand using feedback loops, farmers as well

as other interested actors of the AIS can contact experts and seek answers to their specific questions. As a result, the internet acts as a two-way communication channel linking all actors of the AIS like a cobweb supporting speedy and timely exchange of information, knowledge and resources among actors as described in Chapter 3, 24 hours seven days a week.

Sri Lankan agriculture followed traditional farming methods until the first wave of the Green Revolution in the late 1960s. This revolution gave a sudden boost to the production of major cereals, especially rice in the assured irrigated areas. Profitability of new seed varieties encouraged their diffusion among farmers showing, generally that if a particular practice is profitable, diffuses quickly. There is no limit to innovation, but in the current systems there are information access and communication constraints which severely limit the diffusion of innovation.

This thesis argues that farmers should be able to navigate the entire innovation adoption process by participating in a campaign facilitated through IT and conducted by the extension worker. Using standard techniques, extension workers can produce their campaign material using stand alone software such as (PowerPoint) or web based software (such as, Microsoft NetMeeting) in any language. Therefore, they can overcome language, cultural and literacy barriers to communication by using not only the local language but also using the audio (voice) capabilities of IT. Box 6.1 provides an example of this process.

Box 6.1 Case Study 1 Production of CD-ROMs for extension at Audio Visual Centre, Sri Lanka

The Audio Visual Centre in Gannoruwa, Peradeniya in Sri Lanka has issued 13 informative CD-ROMs containing agricultural information. The officer responsible for diffusion of these CD-ROMs in the Department of Agriculture controlled Audio-Visual Centre in Gannoruwa, described how he developed them to disseminate much needed information not only to farmers, but also as a supporting tool to extension officers. He stated that his PhD also related to producing and disseminating agricultural information using IT applications like CD-ROMs that he gained at an Australian university. There are a number of computers equipped with CD burners/writers and relevant software, scanners, printers, digital cameras, etc. in his office. He employed several staff who had the necessary computer as well as agricultural knowledge to produce the following 13 CD-ROMs.

According to the DOA website, these 13 CDs are titled as follows:

1. Royal Botanical Gardens. Peradeniya Botanical Gardens at the click of a mouse, presents pictures and valuable information on the Royal Botanical Gardens. It is available in English and German and is a memorable souvenir to any visitor and a valuable gift for those who live abroad. The CD takes the viewer on a guided tour of the gardens giving detailed information on interesting places in garden and its flora.
2. Vegetable insect pests. Vegetable insect pests at the click of a mouse. This CD presents information on almost all the insect pests harming vegetables in Sri Lanka, giving the recommended control measures as well. This CD is very useful to anyone interested in getting to know vegetable pests.
3. Overhead Projector. This CD includes information on overhead projector technology, one of the most valuable instructional media. Hence, it is useful to persons who work as trainers.
4. Flip Chart. This is an interactive multimedia CD for low cost flip charts. Flip charts are the most widely used audio-visual aid used by extension workers. This will be useful to all officers who are involved in technology transfer programs, especially for village level extension officers who work under low cost environment.
5. Food Crops: Paddy.
6. Food Crops: Potato.
7. Food Crops: Red Onion.
8. Food Crops: Big Onion.
9. Food Crops: Brinjal.
10. Food Crops: Tomato.
11. Food Crops: Mushrooms.
12. Food Crops: Banana.
13. Anthurium. This CD-ROM includes information regarding varieties, cultivation practices, propagation techniques, pest and disease and post harvest handling of Anthurium.

CD-ROMs 5-12 include technical information regarding the cultivation of these crops. Food processing is also discussed in an interactive format. The technical information is explained through video clips, digital photographs and text.

The key feature of these CDs is that they are in the Sinhala language. They are useful to farmers and extension workers involved in village level technology transfer. They are also useful to the general public and students.

All of these CDs were replicated by sending the master CD to a Singapore based IT company to minimize the cost of replication before distributing to selling points and extension personnel.

Source: http://www.agidep.gov.lk/NEWS/News.htm

6.6.1 Survey results

To canvass opinion regarding future IT applications to agricultural extension, a survey was undertaken for this study. As before, a statement and corresponding opinion ranges from strongly disagree to strongly agree was used. Results are summarized in Table 6.5 below. All respondents agreed that IT is an emerging technology that can facilitate the diffusion of agricultural technology, and of those 57 per cent strongly agreed with the statement. None of them disagreed with the statement.

Sixty per cent of the respondents agreed that the extension workers' role could be replaced by IT channels in the future. Twenty per cent disagreed. There were mixed responses on whether a computer is no longer a luxury item for ordinary Sri Lankans. Thirty three per cent of respondents strongly agreed with the statement that computers were a luxury, while 27 per cent disagreed.

Table 6.5 Opinion of respondents towards future IT applications to agricultural extension, percentage

	Strongly disagree	Disagree	Neither	Agree	Strongly agree
	(%)				
1. IT is an emerging technology that can facilitate diffusion of technology	0	0	0	43	57
2. Almost all researchers have the ability to use IT for their day-to-day activities	0	13	6.7	47	33
3. Computers are no longer a luxury item for ordinary people	6.7	27	0	33	33
4. IT can overcome constraints of time and distance on technology transfer	0	0	6.7	37	57
5. There are plenty of computer training courses for novice users	0	27	0	53	20
6. To find an ISP is not that difficult	6.7	17	23	33	20
7. Due to competition the cost of ISP and telephone connection charges are decreasing	20	37	10	23	3.3
8. Portable lap-tops make technology transfer task easier	0	6.7	6.7	57	27
9. In future it is possible to use mobile/wireless internet technology	3.3	0	17	60	23
10. IT channels can replace the existing extension network in the future	3.3	17	20	33	27

Source: Author survey (2004).

The overwhelming majority of respondents believed that IT can overcome the constraints of time and distance in technology transfer within the farming community. However, the majority disagreed that internet connection charges are decreasing due to competition between internet service providers (ISPs) and between telephone companies. Seventy-three per cent of respondents agreed that there are plenty of computer training courses for novice users. A large majority of respondents believed that portable lap-tops make technology transfer easier and in the future it will be possible to use mobile/wireless internet technology.

6.6.2 Cyber agricultural extension

In January 2004, the Department of Agriculture, established cyber extension units (rural knowledge centres) at all Govijana Kendra with necessary links to research centres, extension offices and training centres as well as private sector organisations. The outcome of this project was the establishment of a quick information exchange mechanism in the agricultural sector of Sri Lanka and the following specific outputs are expected.

- Farmers and farm women are the main target audience of the project. The information network and database will provide an opportunity for them to quickly access agricultural technology and marketing information.
- Researchers would be provided with literature databases and databases for future agricultural research.
- Village level officers (extension workers, agricultural research assistants, Samurdhi officers, etc.) would be provided with an effective distance education mechanism.
- School children who need to write essays about agricultural issues for their curriculum, especially for learning agriculture, would benefit from the information.
- Agriculturists of the entire sector would benefit from the speedy and regularly updated information flow.
- An ideal database would include current field information to assist policy makers/administrators decision making.
- Printed information would be supplied for a nominal fee to run the unit as a self-sustaining project (Department of Agriculture, 2005).

According to Wijesinghe (2002), the sources of information for farmers in the Bibile district in Sri Lanka are identified as other farmers, marketing agents, village fairs, village businessmen, farmer groups, extension services (given here in order of importance). Other sources of information are identified as experience (tacit knowledge), marketing agents and sellers, government extension, television, radio, posters and advertisements in their order of priority.

He identified a potential to establish an IT-based information system in the Bibile district considering its literacy rate (91%), general knowledge of English (21%) and the social attitude of the people surveyed in the district. It is important to recognise Wijesinghe's findings concerning existing information flows in planning the optimal channels to disseminate innovation in the Sri Lankan context. His study also gives an indication of how information flows between farmers and its sources in Sri Lanka.

There are many and varied paths of communication for farmers ranging from folk media and traditional social groupings to radio, video and the internet. Information technology can help overcome barriers of language and literacy, cultural differences and physical isolation. It is a powerful tool, which can be used to inform and educate farmers about new ideas and technical innovations for agricultural and rural development (Wijesinghe, 2002). However to use IT effectively requires:

- awareness of information requirements and the existing knowledge of the farmers;
- understanding the audience, their listening patterns and learning methods, etc.
- recognition of available resources, including telephone lines, electricity, etc.; and
- selection of a suitable innovation dissemination model to build effective communication.

Farmers are scattered all over the country. Therefore, it is a question of reaching these farmers in a cost effective way. It is difficult to reach them individually and the recent phenomenon of telecentres is one of the answers to this question. Farmers can easily gather at rural telecentres located in convenient places, such as close to a village fair, close to a temple/church or close to a village school.

The technology transfer process often begins when farmers raise concerns about an adverse situation or problem that affects their farming, and request a solution from the extension worker. The extension worker sends an email to a specialist in the relevant discipline describing the situation or problem in order to ascertain if the problem has been confronted previously, and to request related references. Then the specialist refers the extension agent to relevant websites or information sources.

If the answer is not found by those resources, the specialist could communicate about the problem with other specialists nationally or internationally through emails, discussion groups, chat and special interest groups (Risdon, 1994). These communications would be done via the internet. Furthermore the specialist could also use popular internet search engines to find information.

One innovative approach may be for research scientist/extension worker to acquire a small van, fill it with the latest IT, including an Internet connection via a portable lap-top, and to take it to where the farmer is. Primary venues of such visits could be village schools, village fairs, village temples, churches or mosques. The van could spend up to a week at each site. During this time farmers could be invited to surf the internet and attend introductions to software packages, which they can use for downloading information on innovations.

6.7 The role of IT in the diffusion of innovations in agriculture

Questionnaire-aided interviews were carried out in Sri Lanka during 2005, meeting 30 respondents. Questions and their responses are provided in the following sections.

6.7.1 Major communication channels used in Sri Lanka to diffuse information about innovations

Table 6.7 below indicates the percentage and frequency of major communication channels used by the interviewed organisations. Twenty-seven per cent of interviewed respondents indicated that they already use websites Very often, 40 per cent indicated Often and 23 per cent Rarely. These results suggest that the interviewed organisations already recognize the importance of a website as a tool for innovation diffusion. It is

interesting to find that CDs and DVDs also played an important role in diffusion, with 47 per cent in the Often category. TV and newspapers were rarely used channels for diffusion. Over 50 per cent of respondents reported that radio and magazines were used often to diffuse information. Table 6.6 reflects that the Sri Lankan organisations interviewed still mostly rely on written materials for diffusion although they represent a relatively lower percentage weight in the Very often category (except magazines). Finally, these results revealed that respondents used a mixture of channels/methods for diffusion.

Table 6.6 Usage of major communication channels to diffuse information about innovation

	Very often	Often	Rarely
	(%)		
Extension network	43	27	20
TV	20	30	40
Films/Videos	20	47	23
Radio	6.7	57	27
Newspapers	13	27	47
Local newsletters	13	30	27
Bulletins	30	13	23
Website	27	40	23
CDs/DVDs	13	47	27
Fact sheets	13	10	37
Booklets/Leaflets/Pamphlets/ Posters	27	23	6.7
Research reports	27	30	17
Magazines	17	57	6.7
Fax	17	23	30
Educational programs	37	17	30
Software	30	3.3	37
Technical manuals	30	30	17
Other	13	0	0

Source: Author survey (2004).

6.7.2 Presence of an official website

Ninety seven per cent of organisations interviewed maintained a website and only 3 per cent did not (see Table 6.7 below). This result suggests that interviewed organisations already recognized the importance of having a website.

Table 6.7 Presence of an official website

	(%)
Yes	97
No	3

Source: Author survey (2004).

6.7.3 Purpose of the website

When asked what was the purpose of maintaining a website, everyone indicated that provision of useful information to users was one reason, 93 per cent indicated that their organisation gained publicity through the website and 73 per cent of respondents stated that they use their website as a more cost-effective and/or efficient communication channel. Fifty-three per cent of respondents indicated that they use their website as a vehicle for providing services to clients.

The results suggest that interviewed organisations are already using their websites for diffusing information, including innovations (see Table 6.8 below).

Table 6.8 Purpose of the website

	(%)
Provision of useful information for users	100
Publicity for the organisation	93
As more cost-effective and/or efficient channel of communication	73
As a vehicle for providing service to clients	53
As means of conducting commercial or financial transactions	17

Source: Author survey (2004).

6.7.4 Target audience for the website

Most of the respondents (83%) indicated that their target audience was professional and technical personnel, and 67 per cent listed their own staff as target audience (Table 6.9. Only 60 per cent indicated that the general public was their target audience. Fewer respondents stated their target audience was farm businesses and other businesses. The reason, of course, is that most of the farmers in Sri Lanka do not have access to the internet and they do not have a computer.

Table 6.9 Target audiences for the website

	(%)
Professional/technical support	83
Their own staff (i.e. an intranet)	67
The general public	60
Other businesses	37
Farm businesses	33
Other	13

Source: Author survey (2004).

6.7.5 Reason to use information technology

Everyone interviewed stated that they used IT because it is an effective and efficient communication method. Ninety three per cent agreed that IT channels convey timely information about innovation, and 97 per cent indicated they found it easy to manage/edit information. Seventy-seven per cent stated that IT is convenient to use. Other reasons were given in Table 6.10 below.

Table 6.10 Reasons to use information technology

	(%)
Effective	100
Efficient	100
Easy to manage/edit information	97
Timely information about an innovation	93
Can combine with other media such as DVDs. sound video camera, etc.	87
Convenient	77
Low cost	67
Low maintenance costs	47
Low employee training costs	43
Low overhead and establishment costs	33

Source: Author survey (2004).

6.7.6 Proportion of budget allocated to information dissemination

The proportion of the budget allocated to information dissemination is relatively small (Table 6.11). Sixty-seven per cent indicated that it is less that 10 per cent. Only a small proportion of respondents stated that they allocate more that 50 per cent of their budget to information dissemination.

Table 6.11 Proportion of budget allocated to information dissemination

	(%)
<10%	67
10%-20%	23
40%- 50%	3.3
>50%	6.7

Source: Author survey (2004).

6.7.7 Use of feedback facilities

Eighty-three per cent of respondents indicated that their websites contained an email feedback facility, while 43 per cent of them stated that their websites had a hit counter (Table 6.12). Only 17 per cent of them said their websites had interactive facilities, such as bulletin boards, forums, etc.

Table 6.12 Use of feedback facilities

Indicators	(%)
Email feedback facility	83
Hit counter	43
Interactive facilities, such as bulletin boards, forums, etc.	17

Source: Author survey (2004).

6.7.8 Link to search engines

Eighty-seven per cent of respondents stated that they use search engines to find information and only 13 per cent of respondents do not use search engines (Table 6.13).

Table 6.13 Search engine usage

	(%)
Yes	87
No	13

Source: Author survey (2004).

6.8 Conclusion

There is an increasing trend in ICT spending in agriculture in Sri Lanka, suggesting that the importance of ICT to the economy has been recognized by both industry and services sectors in general and the agricultural sector in particular. However computer

literacy and IT use is very low in rural Sri Lanka. IT spending nationally has been growing significantly, but spending in the agricultural sector remains very low in spite of growing rapidly parallel to the national total.

There is significant unmet demand for computers with internet access, IT based services and IT education among rural Sri Lankans, despite lack of prior exposure to computers or other aspects of the IT world. However, products and services are not successful unless customized to the specific needs of rural farmers. Farmers stressed the need for websites and IT applications to be developed in their local languages, because English fluency is rare in rural areas in Sri Lanka.

High dial-up access costs have precluded widespread use of the internet in rural Sri Lanka. With the Central Government's increased focus on rural development and its emphasis on transmission of knowledge, information and resources, it is expected that connectivity issues will soon be addressed by Sri Lankan policy makers.

The most important barrier to the establishment of IT and the internet is the lack of understanding of ICT, and consequently there is a lack of cooperation among actors in the AIS in Sri Lanka. To overcome this the government could introduce awareness programs for those involved in diffusion activities.

Two regional surveys show very low IT capability and access in selected rural areas, although there are definite signs of interest in acquiring information for agriculture and a willingness to travel to acquire it. While rural access is limited by hardware issues, recent trends in development of wireless broadband access could change that dramatically over time.

An important development in Sri Lanka is a movement for the creation of large numbers of telecentres combined with wireless broadband which could greatly increase effective access to the role of the extension officer in IT diffusion, rather than replacing it, and case studies show how this is being achieved. Leaders in agricultural innovation in Sri Lanka believe that IT can play an important role in innovation diffusion in agriculture, and are already making extensive use of it.

The case study in this chapter demonstrates that the Department of Agriculture in Sri Lanka, has started to use an IT application (CD-ROM) to disseminate agricultural innovations to farmers.

The survey revealed that websites were the fifth most used channel, together with written material (booklets, leaflets, pamphlets, posters), but behind the extension network, bulletins, technical manuals and software in agricultural innovation dissemination in Sri Lanka.

Ninety-seven per cent of respondents indicated that they maintain an official website. Of those, one hundred per cent indicated that provision of useful information was the purpose of the website. However, farm businesses were not their currently main target audience, because the majority of Sri Lankan farmers do not have access to computers.
All surveyed organizations indicated that reasons for using information technology, such as websites, were as an effective and efficient means of diffusion. Sri Lankan survey respondents did not see websites as a low cost method, in terms of low overhead and establishment, employee training and maintenance.

In conclusion, this chapter revealed that the importance of IT as a dissemination tool will increase with time in Sri Lanka. Except for farmers in the large plantation sector, the majority of Sri Lankan farmers need assistance (e.g. extension worker or telecentre worker) to use the IT facilities provided by the central government and NGOs.

CHAPTER 7

COMPARISON BETWEEN INNOVATION SYSTEMS IN AUSTRALIAN AND SRI LANKAN AGRIBUSINESS WITH SPECIAL EMPHASIS ON INFORMATION TECHNOLOGY

7.1 Introduction

The aim of this chapter is to compare and contrast the agricultural innovation systems of Australia and Sri Lanka, and examine the role of IT in dissemination of innovations to the farm level within Australian and Sri Lankan agribusiness.

The chapter focuses on providing answers to the following four key questions:

1. What are the key similarities/differences between Australia and Sri Lanka in relation to their agricultural innovation systems?
2. What are the key similarities/differences between Australia and Sri Lanka in relation to the use of IT for the diffusion of agricultural innovations?
3. Are there lessons that can be drawn for Sri Lanka from Australia's use of IT in the diffusion of agricultural innovations, or are the two countries/systems too different?

Section 7.2 compares the AISs in Australia and Sri Lanka with special emphasis on the farming sector. Section 7.3 of this chapter compares survey/interview results of types of innovation-related activities, goals of innovation-related activities, behaviours of organisations, constraints or incentives to innovation and funding sources of innovation activities of selected organisations. Section 7.4 compares current approaches and attitudes to possible use of IT for diffusion of innovations in agriculture. ICT usage and expenditure comparison is presented in Section 7.5. The chapter concludes with Section 7.6.

7.2 Comparison of the agricultural innovation system in Australia and Sri Lanka with special emphasis on the farming sector

Sri Lanka is a small island and Australia is the smallest continent in the world. As a result of vastly differing size and the climatic condition, the two countries differ significantly. Australia is predominately a temperate country and Sri Lanka is a tropical country. Therefore, both the scale and the diversity of crops grown and animals reared in each country is different. Australia grows on a very large scale and higher diversity of crops and farm animals than Sri Lanka. However, a part of Australia (state of Queensland) has a tropical environment too. In the light of these facts, the scope and the relevance of the study can be evaluated and the findings of the study placed in proper perspective. In particular crop/animal and product diversity, the land utilization pattern, ownership structure and the characteristics of AIS are discussed in this section.

This study found that there are crop/animal and product similarities and differences between Australia and Sri Lanka. Both countries grow similar fruits (e.g. banana, avocado, guava, jack fruit, lime, durian, grapes, mandarin, strawberry, mango, etc.), similar vegetables (e.g. carrot, beans, leeks, cabbage, beetroot and raddish,) similar nuts (e.g. peanuts), cereals (e.g. rice), natural fibre (e.g. cotton) and similar oil-seed plants (e.g. sunflower). Whereas there are examples of fruits, vegetables, nuts and oil-seed plants grown Australia that are not found in Sir Lanka, and some found in Sri Lanka but not in Australia as shown in the following tables.

Table 7.1 Crops grown in Australia, not found in Sri Lanka

Fruits	Vegetables	Nuts	Oil plants	Grains
Figs	Broccoli	Almonds	Olives	Oats
Peaches	Silver beet	Macadamia	Canola	Barley
Nectarine	Snow peas	Walnuts		Wheat
Duku	Green peas	Hazelnuts		
Custard Apple		Pistachios		

Source: Author's own development. See Appendix Table A4.1 for botanical names.

Table 7.2 Crops grown in Sri Lanka, not found in Australia

Fruits	Vegetables	Nuts	Oil-plants	Grains
Lovi	Mukunuwenna	Betel nuts	Coconut	Kurakkan
Beli	Lotus roots	Kottamba		
Sapota	Murunga			
Anona	Kohila			
Woodapple	Nivithi			

Source: Author's own development. See Appendix Table A4.2 for botanical names.

The sheep industry (wool and mutton) and deer industry is only found in Australia, whereas goat rearing for milk and meat is found in Sir Lanka. When comparing the food processing industry, Australia is far ahead of Sri Lanka in terms of scale, diversity and exports. In Australia, the dairy cattle milk-processing product known as yogurt is popular, and in Sri Lanka buffalo the cattle milk-processing product known as curd is popular. The Australian processed food market is much more highly developed in terms of the number of products, scale of products and export market penetration.

Both in Australia and Sri Lanka we can see a geographical concentration or dispersion of crops and animals. For instance, the Australian wine industry is basically concentrated in certain areas of southern and western Australia and, likewise, the Sri Lankan tea industry is basically concentrated in the high country and certain areas of hilly or mountainous parts of the low country. Moreover, the Australian rice crop, and many of fruit crops grow only in Queensland, due to its tropical weather conditions. The cattle industry, vegetables and seafood industries can be found all over the country, except in the arid regions in Australia, whereas rice cultivation and coconut cultivation can be found all over the country except in the hill country in Sri Lanka. In conclusion, in both countries we can see a geographical concentration of crops as well as dispersion of crops in order to satisfy their climatic requirements.

Sri Lanka has two distinctive agricultural sectors depending on the land use patterns: the plantation sector growing tea, rubber and coconut, and a small holding sector, with rice being the staple food crop, vegetables and fruits. The plantation sector features large scale operations, relative to the subsistence sector, and depends on a hired labour force to cover the production, processing, storage, marketing, packaging and distribution,

mainly to export markets. These plantations are run by large multinational firms, both nationally and internationally owned companies, and the state government.

Comparatively, in Australia, there is no such starkly dualistic nature to land use patterns or specified crops for export. However, depending on water use patterns (i.e. irrigated or rain fed) nine (dryland, pastoral, irrigated and dryland mixed, irrigated rice, irrigated cotton, irrigated sugarcane, horticulture, dairy and poultry, swine and goat) farming systems can be found, covering both crop growing and animal rearing. Similar to Sri Lankan farms, many Australian farms are also run by families using family labour and hired casual labour during harvesting times.

In Sri Lanka, agricultural land can be subdivided into two main categories – the plantation sector, consisting mainly of tea, rubber and coconut and to a lesser extent, spice crops; and the peasant food crops, vegetables and fruits. A considerable proportion of the production from the plantation sector is exported, while almost all the production of the peasant sector is used for local consumption. Whereas, in Australia, land is utilized for 9 major farming systems and 22 per cent of all its agricultural products are exported.

Comparatively, Australian cattle farming (dairy and beef), wine growing and poultry (eggs and meat) contribute to national income much more than their Sri Lankan counterparts. For instance, Sri Lanka imports powdered milk and wine from Australia, whereas, Australia exports powdered milk and wine. However, sea fishing, in terms of number of fishermen employed, is much bigger in Sri Lanka than Australia.

There is comparatively little difference between the actors involved in the AIS in Australia and Sri Lanka. In both countries the actors can be represented by eleven identified categories of actors in terms of their function, namely: policy, education, finance and credit, marketing, input supply, research, extension and information, logistics, processing and storage, farmers and farmer organisations, and consumers. However, there are significant differences in the market size of actors in terms of number of players in each category, their scale of operations and their turnover. The Australian AIS is not just larger, but the scale of commercial activities within it is much

higher than in the Sri Lankan AIS. Nevertheless, the weakest link in the diffusion of information to farmers in both countries is in the ‘last mile’.

With respect to the marketing component of the AIS, both countries have supermarkets and markets. Almost all supermarkets and markets are located in the urban areas of both countries. However, in Sri Lanka, village fairs dominate as a venue for exchanging fruits, vegetables, nuts, grains and farm animal products (eggs, fish and meat) between farmers and consumers. These village fairs are conducted in a place which everyone can access, such as close to a village school, hospital, temple, church or mosque. In contrast, there is a large and sophisticated distribution system in Australia.

The AIS in Australia is very effective in terms of using leading edge technologies, producing highly competitive products to world market and inventing and quickly diffusing innovations from research to end users. Governments and government institutions/organisations play more than one role in the AIS in both countries. However, almost all input supply, processing/storage, marketing and logistics components of the AIS in Australia is done by private sector companies, whereas there is a mix of private companies and state owned actors involved in these activities in Sri Lanka. The most interesting and significant difference in terms of the status of organisational actors involved in both counties, is that only in Sri Lanka are NGOs (national and international) found taking a major role, especially in the input supply and finance/credit supply components of the AIS.

With respect to characteristics of farmers, there are similarities in terms of educational level (they are less educated than the rest of the population), tend to hold more conservative attitudes relating to farm decision making, and are in the habit of learning from peer groups rather than instructors. Similar age and labour use patterns can be seen in both countries. However, with respect to income level and technology use in farming activities, Australian farmers are well ahead of their Sri Lankan counterparts.

When comparing ethnicity and country of origin of the farmers, we can see a marked difference between Sri Lankan and Australian farmers. Basically Sri Lankan farmers are divided into three main ethnic groups: Sinhalese, Tamils and Muslims, whereas Australian farmers reflect a more diverse range of ethnic backgrounds, including those

who come from European and Asian countries (British, Irish, Greek, Italian, Chinese, Vietnamese, Croatian, Serbian, Indian and so on). However Anglo-Saxons represents the majority of family farmers.

Another significant difference can be seen in terms of land ownership patterns between family farms. Some Sri Lankan farmers do not own their farmland, but have a right to cultivate it with legal protection, and a right to share the profit (normally landlords get 25% of the profit). This type of arrangement is not widely seen in Australia.

Comparative analysis suggests that Australian farmers use sophisticated farming practices, such as remote sensing, computer-aided drip irrigation and other agricultural innovations described in Chapter 5 to improve their productivity. Sri Lankan farmers lag far behind in the use of such techniques, except in large plantation estates. Large plantations are able to introduce modern high-tech practices, because of their scale and profitability.

When comparing the integration into global markets, institutions and innovation processes, Australian actors in the AIS have greater capacity than those of the Sri Lankan AIS. Sri Lankan plantations have integrated into global markets, institutions and innovation processes, nevertheless on a much lesser scale (e.g. in tea, rubber, coconut, etc.). Most of the agribusinesses in Sri Lanka are functioning as small and medium scale businesses.

There is significant difference in terms of internet awareness and capacity of farms in both countries, for example, the majority of Sri Lankan peasant farmers do not have computers. While larger businesses in Australia and Sri Lanka have almost reached saturation in terms of computer use, internet access and websites, small farm businesses in Australia are increasingly catching up. In comparison, Sri Lankan farmers have to rely on telecentres that are managed by the government or NGOs as basically non-profit organisations.

In conclusion, Australian Federal and State Governments encourage private sector companies to provide the finances to innovate, via R&D activities, and to build on the capabilities of developing new products, processes and event responses, acquiring

know-how, and gaining competitive advantage in the global market. In comparison, the Sri Lankan agricultural market system is far less developed except in the plantation sector, As a result, many of the major commercial actors that both drive innovation and diffusion (e.g. chemical and seed suppliers, machinery manufacturers and distributors and agents) are not as active in Sri Lanka – leaving a greater innovation and diffusion load on the public sector and traditional extension services.

Moreover, since 1989 Sri Lanka has faced civil unrest/war, with a separatist Tamil Tiger movement fighting for a separate state. Therefore, there are always serious disturbances, particularly in the northeast. This dramatically affects the AIS in Sri Lanka. This separatist war has created a massive flow of refugees to Tamilnadu (India) and internally displaced many people inside Sri Lanka, disturbing their livelihoods of farming, fishing and other business. Such difficulties add greatly to the challenge of economic development.

This section attempts to compare overall AISs in Australia and Sri Lanka with special emphasis on the farming sector. It also found key differences and similarities in crops grown in each country, and differences in key industries. Comparative analysis found that Australia is far ahead of Sri Lanka in terms of scale, diversity and exports. The scale factor is a direct correlation of country size and diversity can be correlated to the seasonal nature of the Australian climate.

The Australian AIS is very effective in terms of using leading edge technologies. Except in the plantation sector, the Sri Lankan AIS lags far behind on using these technologies due to the poor economic conditions of farmers and their small-scale farms.

In conclusion, comparative analysis indicates that significant differences in terms of size, types of industries, products diversity, penetration of international market and similarities with respect to crops grown, farmer demographics and types of actors exist between the AIS in Australia and Sri Lanka. A marked difference can be found in use of computers and the internet. The majority of Sri Lankan farmers neither have a computer nor access to the internet, while the majority of Australian farmers own computers as well as have access to internet facilities. As a result actors in the Sri Lankan AIS use other communication channels indicated in Table 7.7 to approach their end users.

7.3 Comparison of survey/interview results: Types, goals, behaviours and funding sources of innovation-related activities

Thirty organizations we interviewed in Sri Lanka: ten universities, eight government departments, six R&D corporations and four private/ (NGOs) organizations. In Australia, the survey sample consisted of: four universities, seven government departments and four R&D corporations. The response rate was 30 per cent in Australia and Sri Lanka

.

It should be noted that in this analysis we compare opinions of surveyed and interviewed organizations/institutions/centers reflecting their views which do not necessarily represent the view of the corresponding country.

7.3.1 Comparison of the types of innovation-related activities of the organisations in Australia and Sri Lanka

Respondents in both countries gave technology development activity the highest weight (Table 7.3). This suggests that technology development is the main type of innovation-related activity of the organisations surveyed. However, in Sri Lanka technology training was equally important. Further, comparing the types of innovation-related activities in the surveyed organisations, it is clear that there is a significant difference in the weight given to those activities.

Sri Lankan innovation activity is relatively much higher than the corresponding values for Australian activity (as indicated in Table 7.3). The percentage weight of Sri Lankan surveyed organisations more than doubled those of Australian organisations in some activities such as technology financing, technology evaluation, technology demonstration, technology introduction/selling, technology acquisition (local/international), technology integration and technology use.

It can be seen, however, that except for technology policy activity and technology financing, for other activities more than 50 per cent were innovation-related in Sri Lankan organisations. In Australia, except for technology development, technology

diffusion, technology training and technology demonstration, the remaining innovation-related activities represented less than 50 per cent.

Table 7.3 Types of innovation-related activities of the organisations surveyed

Types of innovation	Australia (%)	Sri Lanka (%)
Technology policy	27	37
Technology financing	13	47
Technology development	93	100
Technology evaluation	47	93
Technology demonstration	53	90
Technology diffusion	67	80
Technology introduction/selling	20	67
Technology acquisition (local/international)	20	60
Technology training	60	100
Technology integration	33	83
Technology use	27	57

Note: We do not claim our samples represent populations of Australia and Sri Lanka.
Source: Author survey (2004/2005).

From Table 7.3 it is evident that 4 types of innovation-related activities were given high priority (>50%) in Australia organisations with remaining types of activities (<50%) given low priority. Comparatively, a large number (9) of activities were given high priority in Sri Lanka counterparts using the same criteria (i.e. >50%).

7.3.2 Comparison of the goals of innovation-related activities between Australia and Sri Lanka

At first glance, the comparative percentage values of the goals of innovation-related activities in Table 7.4 indicate that Sri Lankan values are relatively higher than many activities mentioned in the table for Australia. However, there is no significant difference in several goals, like introduce new products and services, increase commodity quality, reduced environmental damage and provide knowledge and information between countries.

Table 7.4 Goals of innovation-related activities of the organisation

Goals of innovation	Australia (%)	Sri Lanka (%)
Introduce new products or processes	80	87
Increase market opportunities	60	73
Improve production flexibility	47	63
Increase commodity production	73	70
Increase commodity quality	80	77
Reduced labour costs	33	73
Reduced material costs	27	80
Reduced energy consumption	27	47
Reduced environmental damage	67	73
Fulfil regulation or standards	33	73
Provide knowledge and information	87	93
Generate own income	33	77

Note: We do not claim our samples represent populations of Australia and Sri Lanka.
Source: Author survey (2004/2005).

7.3.3 Comparison of behaviour of the organisation which acts as a barrier and/or incentive to innovate between Australia and Sri Lanka

In line with organisational/institutional constraints and/or incentives for innovation, a comparatively high percentage level of the behaviours listed in the table existed among respondents in Sri Lanka. From Table 7.5 it is clear that the percentage weight of each category of behaviour in Sri Lanka is between two and three times higher than the corresponding behaviour in Australia except for the 'Other' category. This indicates that these organisations may have different behaviours in terms of their culture, norms and values. Comparing the results indicates that the behaviour of the organisations listed in the survey influenced a relatively lower percentage to innovate in Australia than in Sri Lanka. It is interesting, however, that a large percentage of respondents surveyed indicated the 'Other' category in both countries (53% in Australia and 40% in Sri Lanka). Due to ethical reasons, we didn't ask them to elaborate 'Other' behaviours.

Table 7.5 Extent to which behaviour of the organisation is shaped by organisational/institutional constrains and/or incentives for innovation

Behaviour	Australia (%)	Sri Lanka (%)
Laws	20	67
Health Regulations	20	43
Cultural Norms	33	60
Social Rules	20	53
Technical Standards	13	40
Other	53	40

Note: We do not claim our samples represent populations of Australia and Sri Lanka.
Source: Author survey (2004/2005).

7.3.4 Comparison of funding sources of innovation activities between Australia and Sri Lanka

At first glance, it is clear that there is significant difference in obtaining funding from international donor assistants between Australia (7%) and Sri Lanka (87%) showing the latter heavily dependent on overseas funding sources.

Table 7.6 Funding sources of innovation activities

Funding sources	Australia (%)	Sri Lanka (%)
From central government	87	63
From local government	13	23
Funding bodies/agencies	80	87
Own resources	20	40
Collaborative contracts	67	63
Competitive grants	60	53
Non-competitive grants	40	17
Patents and copy rights	20	40
Awards and prices	20	33
Loans and credits	0	30
International donor assistance	7	87

Note: We do not claim our samples represent populations of Australia and Sri Lanka.
Source: Author survey (2004/2005).

7.4 Comparison of survey results: Approaches and attitudes to diffusion

7.4.1 Comparison of major communication channels used for diffusing information about innovations

With respect to comparative figures for the percentage and frequency usage of major communication channels used to diffuse information about innovations in Australia and in Sri Lanka, it is clear that both countries used a mix of channels and in varying percentages (Table 7.7). Australia used extension network Very often, more than Sri Lanka. The second highest percentage in the Very often category for Australian channels were research reports, local newspapers, website and written materials (booklets, leaflets, pamphlets, posters, etc.) with more or less equal percentage weight. However comparative corresponding figures of Sri Lanka were almost half that of Australian figures. When comparing the Often category, Australians used the radio almost twice as much as Sri Lankans and magazines equally with Sri Lanka. However, Sri Lankan organisations used websites almost twice as much as Australian ones.

Australian organisations rarely used the more traditional channels such as TV, films/video, fax and written material. It was interesting to see that Sri Lankan organisations still use fax as a small percentage (17%) for diffusion Very often, however, Australian and Sri Lankan organisations use fax equally Often.

To see clear differences between both countries, an overall measure was calculated by giving some quantitative values to Very often, Often and Rarely categories as 2, 1 and 0 respectively. Then given quantitative value was multiplied with the corresponding calculated value of the respective channel and added up to get the overall measure. Results indicate that there are clear differences in each country with respect to approaches that use to diffuse information about innovations. Comparative figures indicate that organisations surveyed in Australia used extension network, written material (booklets/leaflets/pamphlets/posters) local newspapers, fact sheets, newspapers, bulletins and websites with a significantly higher percentage than Sri Lanka. Likewise comparative figures shows that Sri Lankan organisations interviewed used TV, films/videos, software, technical manuals, fax and educational programs more than their Australian counterparts.

However, both countries rely on a mix of channels for their diffusion exercise giving various weights to different channels available to them considering the type and the goal of innovation-related activity. This mix also maximises the coverage as well as satisfying the needs of each adopter categories.

In conclusion, Australia used a comparatively higher percentage of channels listed in Table 7.7 in terms of overall use. As a result, Australian organisations may mix channels more efficiently for innovation diffusion than their Sri Lankan counterparts. In comparison Sri Lankan organisations still rely on much older/traditional mass media channels (except extension network) which are also regarded as less efficient in terms of direct and immediate feedback ability when compared with Australia. These results reflect that there is an unbalance in using modern and effective technologies like bulletins and websites with regard to senders and receivers in Sri Lanka.

Table 7.7 Percentage and usage of major communication channels for diffusing information about innovations in Australia and Sri Lanka

Channel	(%)						Overall measure	
	Very often		Often		Rarely			
	Aus	SL	Aus	SL	Aus	SL	Aus	SL
Extension network	73	43	27	27	0	20	173	113
TV	0	20	7	30	93	40	7	70
Films/Videos	0	20	13	47	87	23	13	87
Radio	0	6.7	93	57	7	27	93	70.4
Newspapers	47	13	40	27	13	47	134	53
Local newsletters	60	13	33	30	7	27	153	56
Bulletins	13	30	53	13	20	23	79	73
Website	60	27	20	40	13	23	140	94
CDs/DVDs	13	13	47	47	33	27	73	73
Fact sheets	40	13	47	10	7	37	127	36
Booklets/Leaflets/Pamphlets/Posters	60	27	33	23	0	6.7	153	77
Research reports	67	27	27	30	0	17	161	84
Magazines	13	17	60	57	27	6.7	86	91
Fax	0	17	20	23	73	30	20	57
Educational programs	20	37	33	17	47	30	73	91
Software	13	30	13	3.3	67	37	39	63.3
Technical manuals	13	30	20	3	60	17	46	63

Note: We do not claim our samples represent populations of Australia and Sri Lanka.
Source: Author survey (2004/2005).

7.4.2 Comparison of presence of an official website

Comparison figures indicate that there is no significant difference in terms of presence of an official website of Australian organisations and Sri Lankan organisations. However, the Australian figure (100%) is little higher than Sri Lankan figure (97%).

Table 7.8 Presence of an official website

	Australia (%)	Sri Lanka (%)
Yes	100	97
No	0	3

Note: We do not claim our samples represent populations of Australia and Sri Lanka.
Source: Author survey (2004/2005).

7.4.3 Comparison of purpose of the website

Even though more Sri Lankan organisations recognized a website as a more cost-effective and/or efficient channel of communication than Australian organisations, they use it as a vehicle for providing service to clients comparatively less than Australia.

Table 7.9 Comparison of purpose of the website

Purpose	Australia (%)	Sri Lanka (%)
Provision of useful information for users	100	100
Publicity for your organisation	93	93
As a vehicle for providing service to clients	80	53
As means of conducting commercial or financial transactions	13	17
As more cost-effective and/or efficient channel of communication	53	73

Note: We do not claim our samples represent populations of Australia and Sri Lanka.
Source: Author survey (2004/2005).

7.4.4 Comparison of target audiences for the website

Comparative percentages of target audiences for the internet site indicate that Australian organisations have much higher percentage rates than Sri Lankan organisations in every targeted audience except professional/technical support. It was very clear that Australian organisations target farm business as their top priority. The reason for not targeting farm businesses in Sri Lanka is that most farmers do not have access to IT and the internet.

Table 7.10 Target audiences for the internet site.

Target audiences	Australia (%)	Sri Lanka (%)
General public	73	60
Farm businesses	87	33
Other businesses	53	37
Professional/technical support	67	83
Their own staff (i.e. an intranet)	87	67

Note: We do not claim our samples represent populations of Australia and Sri Lanka.
Source: Author survey (2004/2005).

In conclusion, Australian organisations have more ability to diffuse their innovations to farmers than Sri Lankan organisations, using their website as a communication tool of innovation dissemination.

7.4.5 Comparison of reasons to use information technology

It is interesting that the proportional representation of reasons to use IT for innovation diffusion in Australian organisations were relatively less than Sri Lankan organisations in terms of percentage weight. Every Sri Lankan organisation interviewed agreed that

IT is an effective as well an efficient communication tool. However, Australian organisations did not agree to that extent. Australian organisations stated that low maintenance cost was the least likely reason to use IT, while Sri Lankan organisations stated low overhead and establishment cost.

Table 7.11 Reasons to use information technology.

Reasons	Australia (%)	Sri Lanka (%)
Low cost	53	67
Timely information about an innovation	80	93
Low overhead and establishment costs	20	33
Low maintenance costs	7	47
Low employee training costs	20	43
Convenient	73	77
Easy to manage/edit information	60	97
Effective	53	100
Efficient	67	100
Can combine with other media such as DVDs, sound video camera, etc.	53	87

Note: We do not claim our samples represent populations of Australia and Sri Lanka.
Source: Author survey (2004/2005).

The reason behind this is, in Australia labour cost is higher than Sri Lanka. Therefore, when it comes to maintenance, Sri Lankan organisations can afford to employ a person, but comparatively Australians cannot.

7.4.6 Comparison of proportion of budget allocated to information dissemination

The majority of Sri Lankan organisations allocate more than 10 per cent of the budget to information dissemination. However, about double the percentage of Australian organisations allocate 10-20 per cent of their budget for information diffusion as did so in Sri Lanka. Additionally, a very large percentage (13%) of Australian organisations spent 40-50 per cent of their budget for diffusion while only a small number (3.3%) of Sri Lankan organisations spent the same proportion for diffusion. It was interesting to see that no organisation in Australia allocated more than 50 per cent of their budget to diffusion, however, about 7 per cent of organisations in Sri Lanka did. The reason being that those organisations were predominantly involved in innovation dissemination in Sri Lanka.

Table 7.12 Proportion of budget allocate to information dissemination

	Australia (%)	Sri Lanka (%)
<10%	27	67
10-20%	53	23
40-50%	13	3.3
>50%	0	6.7

Note: We do not claim our samples represent populations of Australia and Sri Lanka.
Source: Author survey (2004/2005).

7.4.7 Comparison of use of feedback facilities

Table 7.13 indicates the comparative results of use of feedback indicators by Australian and Sri Lankan surveyed organisations as a percentage weight. Even though a high percentage (43%) of Sri Lankan organisations use interactive facilities like bulletin boards and forms, etc., a relatively low percentage (27%) of Australian organisations rely on such facilities as their feedback mechanism. The reason is that in Australia labour is much more expensive than in Sri Lanka.

Table 7.13 Use of feedback facilities

Indicators	Australia (%)	Sri Lanka (%)
Hit counter	80	43
Email feedback facility	80	83
Interactive facilities such as bulletin boards, forms, etc.	27	43

Note: We do not claim our samples represent populations of Australia and Sri Lanka.
Source: Author survey (2004/2005).

However, more Australian than Sri Lankan organisations rely on more sophisticated methods to count how many individuals browse their web-pages such as fixing a hit counter to their website. These hit counters operate automatically, with initial software instalment the only cost. This analysis supports the argument that Australian organisations automatically monitor their feedback mechanisms more effectively than their Sri Lankan counterparts. On the other hand the Sri Lankan organisations surveyed have an ability to employ a person to manually check their interactive facilities due to low labour cost. There is no apparent difference when comparing the two countries with respect to use of email as a feedback facility. It is interesting to note that both countries use email as a primary feedback tool. These results also suggest that there is room to improve feedback facilities in research and development organisations in both countries.

There is ample room to improve the use of Australian interactive facilities as well as the introduction of hit counters to Sri Lankan websites.

7.4.8 Comparison of links to search engines

Comparative figures indicate that Sri Lankan websites subscribed to search engines slightly more than Australian. Both countries have recognized the importance of links to search engines, having equal to or more than 80 per cent linkage. Search engines are helpful to find website addresses of organisations if someone knows only the name of the organisation. Having a live link to a website or a search engine will allow agents in AIS to have direct access to the material or provide him/her with additional information about the innovation of interest.

Table 7.14 Link to search engines

	Australia (%)	Sri Lanka (%)
Yes	80	87
No	20	13

Note: We do not claim our samples represent populations of Australia and Sri Lanka.
Source: Author survey (2004/2005).

7.4.9 Comparison of future applications to agricultural extension

Comparative figures in the Table 7.15 indicate that there is no significant difference regarding statement 1 between countries. The overwhelming majority accept that IT is an emerging technology that can facilitate diffusion of technology in agriculture.
There was mixed responses to statements 6, 7 and 10 reflecting that the respondents have a diverse spectrum of opinions from Strongly agree to Strongly disagree. This result may be due to the personal characteristics of respondents namely age, educational background, gender, experience, exposure to IT and its application, etc. Responses to statement 10, reflect that the majority of respondents do not believe that IT channels can replace the existing extension network in the near future. IT can act as a complimentary tool, rather than a substitute to existing methods.

To get a balance measure and clarity of opinions reflected in the Lickert scale the following equation was used. The balance measure clearly demonstrated the significant

differences of opinions regarding computer use, training, ISP availability and telephone connection charges, between two countries, reflecting that Sri Lanka has to improve its IT infrastructure making more investments in this regard. Opinions of Sri Lankan respondents had a more optimistic view than Australian counterparts in terms of statements one and ten. However, regarding statement 7 they had a more pessimistic view than their Australian respondents.

Balance measure = (Agree + Strongly agree – Disagree – Strongly disagree)

Then corresponding measures of each statement and country was calculated. Results are shown in Table 7.15 (see following page).

7.5 ICT usage and expenditure in Australia and Sri Lanka

Computer aided learning in agriculture is becoming a reality in Australia and farmers use a number of agricultural software applications which have already been developed in Australia and are ready to apply in farming practices.
There have been various studies conducted in Australia to evaluate ICT use in agriculture. As a result, there is a developed knowledge base and expertise. Comparatively, Australia is investing more in the cutting-edge fields of ICT and has a potential to export products, services and expertise providing solutions to improve productivity in farming in countries like Sri Lanka (e.g. wireless data transmission technology to rural telecentres).

Computer use was found to be significantly correlated with information-seeking behaviour, farmer's age, gender, property size, formal education and income. Public policy in Australia aims to increase access to the internet among rural and remote Australians, especially primary producers, on the understanding that there are social and economic benefits from such access which are sufficient to justify the costs of policy intervention (Groves and Rin, 2000). This is a good lesson for Sri Lanka to emulate.

Table 7.15 Opinion of respondents towards future IT applications to agricultural extension

Statement	(%)										Balance measure	
	Strongly disagree		Disagree		Neither		Agree		Strongly agree			
	Aus	SL	Aus	SL	Aus	SL	Aus	SL	Aus	SL	Aus	SL
1. IT is an emerging technology that can facilitate diffusion of technology	0	0	0	0	20	0	53	43	27	57	80	100
2. Almost all researchers have the ability to use IT for their day-to-day activities	0	0	7	13	7	6.7	20	47	67	33	80	67
3. Computers are no longer a luxury item for ordinary people	0	6.7	13	27	7	0	33	33	47	33	67	39
4. IT can overcome constraints of time and distance on technology transfer	7	0	0	0	13	6.7	53	37	33	57	79	87
5. There are plenty of computer training courses for novice users	0	0	0	27	27	0	73	53	0	20	73	46
6. To find an ISP is not that difficult	0	6.7	7	17	13	23	33	33	40	20	67	36
7. Due to competition, the cost of ISP and telephone connection charges are decreasing	0	20	7	37	40	10	20	23	20	3.3	33	-11
8. Portable laptops make the technology transfer task easier	0	0	7	6.7	20	6.7	60	57	13	27	66	77
9. In future it is possible to use mobile/wireless internet technology	0	3.3	0	0	20	17	53	60	27	23	80	83
10. IT channels can replace the existing extension network in the future	13	3.3	33	17	27	20	27	33	0	27	-19	30

Note: We do not claim our samples represent populations of Australia and Sri Lanka.
Source: Author survey (2004/2005).

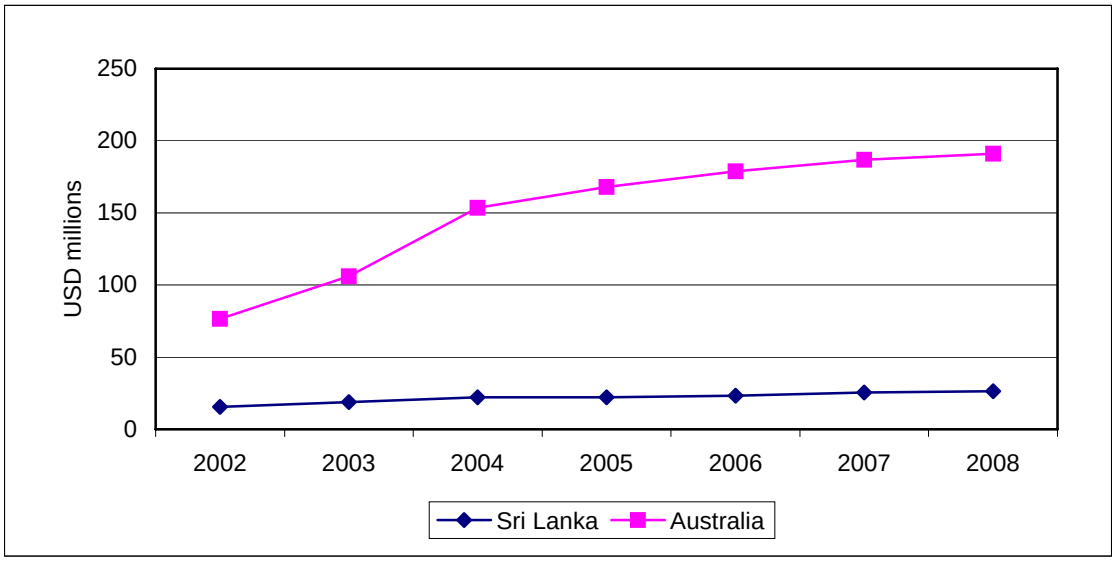
Australian ICT spending is approximately 38 times higher than in Sri Lanka. This indicates the difference between a developed and developing economy in terms of spending on technology such as ICT. Spending on computer services is also higher in Australia than in Sir Lanka. This is likely to be due to the level of market development and high propensity to outsource in Australia. However, spending on communications in Sri Lanka is proportionately higher. This is a characteristic pattern of developed and developing countries, and reflects relative progress in the deregulation of telecommunications.

Information on the extent of IT use in diffusion in Sri Lanka is not available. However, the large plantation sector and some innovative farmers in the small holding sector use their IT facilities to search for information about innovations. Fifty-three per cent of Australian farmers used the internet in business operations in 2005-06. Even though they mostly search for information about weather and markets, they also search for product and technical information. The majority of Sri Lankan farmers surveyed in the two regions discussed also looked for other information (e.g. agriculture in general, politics, education, health, etc.) more than technical information of innovations. Nevertheless, it seems that there is considerable potential for finding technical information using various IT applications and the internet.

The following Figure 7.1 illustrates the comparison between total ICT spending in agriculture in Australia and Sri Lanka. It very clearly indicates the significant gap between ICT spending in dollar terms.

Use of computers for any farm purpose more than doubled in Australia during the 1990s, 17 per cent to 39 per cent, and it has continued increasing since 2000 to 55 per cent in 2004 (ABS, 2005). This demonstrates Australian farmers are keen to embrace new technology, to learn and develop new skills, and to remain competitive. A strong positive relationship also exists between farm size, measured by the estimated value of agricultural operations, and the use of computers and the internet, with larger farm operations making greater use of IT in Australia, as is the case in Sri Lanka. Obviously, scale, cost and profitability are major determinants of affordability.

Figure 7.1 Total ICT spending in agriculture (US$ millions)



Note: 2006 to 2008 forecast.
Source: WITSA (2005).

7.6 Conclusion

The comparative results presented in this chapter can be used to illustrate a broader argument about the potential of IT and the internet as an emerging diffusion tool. Evidence presented in this chapter, in terms of crops/animal industries, scale and products, reflects the differences with respect to the AISs in both countries. A subjective examination to identify actors of the AIS in Sri Lanka and Australia found no great difference with respect to there number and functions.

However the size and climatic conditions of the two countries compared differ significantly and as a result, there AIS also differ from each other. Similarities and differences between crops grown and animals reared can be found in both countries. The Australian AIS is more highly developed and effective than in Sri Lanka in terms of the number of products developed and penetration of export markets.

In both countries we can see a geographical concentration of crops as well as dispersion of crops in order to match climatic requirements. Except for the scale and number of players there is no significant difference between types of players involved in the AIS in both countries. In Sri Lanka we find a dualistic nature of land use and tenure farmers however these are not found in Australia.

In conclusion, the Australian AIS is very effective in terms of using leading edge technologies and diffusing innovations quickly among its members. The Sri Lankan AIS has been disturbed by civil unrest and more recently the Tsunami disaster, likewise the Australian AIS, especially the farming sector has been drastically affected by severe drought resulting from climate change.

In this chapter, a practical model of innovation dissemination in agriculture in developed as well as developing countries was derived by consideration of the two identified barriers of time and distance. While it is consistent with the theory of Chapter 2, special attention was focused on how well the model suits the developing country, peasant farming environment in Sri Lanka.

In spite of the computer ownership difference between countries, there are a number of lessons that can be drawn for Sri Lanka from Australia's use of IT in the diffusion of agricultural innovations. These lessons include the following.

1. Australian farmers increasingly rely on software packages that can assist them in learning, planning and decision-making. These packages are often developed by local companies for use in Australian conditions in a range of applications, such as weather predictions, pest outbreaks, soil monitoring, crop system simulation, etc. These software packages could also be used in similar Sri Lankan farming conditions and/or the content modified for Sri Lankan conditions, providing Australian farm-related software developers potential markets in developing countries.

2. The Rural Research and Development Corporation conducted several studies on IT in agriculture in rural areas of Australia, identifying farmer use of ethnology, bottlenecks to adoption (i.e. farmer personal characteristics for ICT adoption), impact and current use, and purposes. The knowledge documented can be used in similar farming conditions in Sri Lanka when planning or conducting feasibility studies in Sri Lankan farming conditions. In other words, this knowledge can be transferable to similar conditions in developing countries, and/or modified for specific conditions.

3. Sri Lankan public extension has to cater for a large number of farmers in a given time. Public extension also faces numerous barriers to maintaining a quality service, for instance, infrastructure problems, message distortions, funding issues, language issues, etc. Present approaches used in Australia to overcome such barriers can provide valuable lessons for Sri Lanka.

CHAPTER 8

CONCLUSION

Integrating IT with agribusiness can help any country to enhance its overall economy and trade. Agribusiness has also been greatly influenced by IT. Apart from introducing the different IT application technologies, such as Remote Sensing, Decision Support Systems, Rural Networking, Computer Aided Accounting, e-Procurement, etc., IT can also play a pivotal role in increasing agricultural production by facilitating communication channels between the actors of agricultural innovation systems (AIS). It also has an ability to service a huge number of users and provide feedback and multi-channel communication.

One of the great advantages of the internet is its ability to overcome physical distance. One can access information in the USA or Sri Lanka just as easily as in Sydney or Perth. IT can disseminate much needed information, for example, about improved seed varieties, improved irrigation practices, more productive agricultural machines, better soil conservation methods, the application of effective pesticides and herbicides, and so on. Agribusinesses can instantly access information on innovation at any time of the day, when they need it, in a cost effective manner. Furthermore, IT has the ability to present information in all media, such as data, text, voice, image and video, in ways that increasingly match human preferences and cognitive styles (Hanna, 1991). Users can choose their view (i.e. where to skim and where to drill down) and their pace.

Agribusiness needs new tools and techniques to increase production as well as to compete on world markets. Therefore, it is important to use available technologies like the internet and mobile communication technologies to increase productivity. As a result, leading edge Australian agriculture uses sensors to monitor soil parameters, along with precision agriculture to provide controlled environments for crop production on the other hand and decision support systems for farmers and computer aided distance learning techniques for farmer education and training short courses on the other. Computers are also finding an increasing place in Australian agriculture, particularly for

keeping records of breeding and cropping programs, obtain information (weather and market), purchase or order goods and services, pay bills and communication via emails, etc.

Information technology (IT) can improve the planning, management and productivity of all types of economic activities: agricultural and rural development, poverty alleviation, environmental management, infrastructure development, and population and human resources development (Hanna, 1991). Distance education via the internet can assist farmers to undertake university and TAFE course without attending formal classes in the capital cities and major towns. Knowledge gained could lift barriers to the uptake of new technology and to improvements in efficiency and profitability. Distance education can also solve the problems associated with travel and/or the cost of accommodation when attending formal courses in the colleges and universities far away from home (Christopher, 2002).

8.1. The Process of Innovation Diffusion in Agriculture and the Role of IT

The resurgence of research interest in the phenomenon of diffusion of innovations in agriculture has come from a wide range of disciplines, including sociology, anthropology, communication studies and economics, and has resulted in an enormous volume of literature. While these studies have made valuable contributions to an understanding of the process of innovation diffusion in agriculture, there have been a limited number of empirical studies conducted to examine how IT can facilitate the diffusion of agricultural innovations. Since the rapid emergence of the computer and the internet during the 1990s, substantial research efforts have been directed to identifying, evaluating and examining the impact of IT on the farming sector, both nationally and internationally. The literature found in this regard was canvassed in chapters 2 and 5 of this thesis.

When considering the nature of agricultural innovation diffusion, the pattern of diffusion curve depends on a number of factors affecting diffusion (listed in the Introduction) and the type of the innovation (listed in Chapter 1). Hence to achieve the

best possible results in terms of speed of diffusion, diffusion partners must select the most suitable method(s) to cater for potential adopters (innovation end users) who are in various stages of the adoption process. According to Rogers (1995) the adoption process can be divided into five stages, namely: (1) awareness, (2) interest, (3) evaluation, (4) first trial, and (5) repeated use or rejection. Normally, every potential adopter follows the sequence listed above, however, this is not always exactly necessary. Information technology and the internet have an ability to support most of these stages: informing potential adopters, and providing the necessary information. Even in the interest and evaluation stages, IT applications (e.g. CD-ROMs and DVDs, as well as online content) can play an important role in raising awareness and in evaluations and trials.

The dissemination of an agricultural innovation has been defined by Rogers (1995) as the process by which that innovation is communicated through certain channels over time among the members of the farming community. As such, there are four key elements in the diffusion process: the innovation, channels of communication, time and the farming community. Communication channels are the means by which information is transmitted to or among the potential adopters. This study concludes that IT and the internet have an ability to act as a communication channel to diffuse to an unlimited number of potential adopters without compromising the richness and quality of information, as both a mass media and interpersonal mechanism, faster than conventional channels, overcoming physical boundaries as well as language barriers. Therefore, IT, the internet and IT applications can influence the shape of the diffusion curve (see Chapter 2), making it steeper, indicating rapid diffusion, and reducing the time component. Furthermore, providing necessary information on the economic advantages and reducing the degree of uncertainty associated with the innovation can speed-up the adoption process, further reducing the time component. Moreover, IT can bypass traditional opinion leaders and dependence on the trickle down, over the farm fence approach to adoption.

One of the prime objectives of this thesis, as its title implies, was to explore what role IT plays in the dissemination of agricultural innovations to farmers. In a broad sense, this study concludes that the role of IT in the dissemination of innovations in agriculture is mainly complementary to existing means, rather than being a substitute. However, IT has the ability to replace most of the printed as well as audio-visual material that is

commonly used for innovation diffusion purposes in agriculture. Most importantly, IT can be used to promote awareness of innovation and ask potential adopters to evaluate it with current practices/methods, approaching them as a group as well as individuals. Emails, forums, chat facilities, bulletin boards and other internet based application are among the possible feedback loops.

Theoretically, this study contributes significantly to the identification of players (actors) that may contribute to diffusion of innovation in agriculture. On the other hand, the evidence should also assist policymakers from both private and public sectors, in understanding and implementing as well as improving current systems of innovation diffusion through the IT-innovation diffusion model depicted in Chapter 7.

Today, agribusiness has an opportunity to choose whether they should seek assistance, depending on the complexity of the innovation and stage of adoption. They can seek information from their peer groups, sales agents, extension specialists or go it alone with the information regarding the particular innovation available on the internet.

It is generally acknowledged that public extension in developing countries has to cater for a large number of farmers in a given time. Therefore an average agribusiness has to wait a considerable time for the information (s)he requires. But farming is a seasonal activity and most crop farming and animal farming needs time sensitive information. The most important feature of the internet channel is that, if needed, an agribusiness can by-pass extension specialists and sales agents (or opinion leaders in developing countries) when seeking information on an innovation.

In this study, we found that computers and the internet can act as both a mass media and interpersonal communication channel. Therefore, this channel can be an effective way of reaching and persuading agribusinesses to adopt new innovations. This characteristic of the internet (i.e. the role of IT as both a mass and interpersonal medium) has not been widely recognised in the past. This thesis concludes that IT and the internet is an emerging technology that can be exploited as a type of mass media channel as well as interpersonal channel which has the ability to overcome the old constraints which severely limited in agricultural innovation dissemination in the past.

8.2. The Agricultural Innovation System in Australia

Agribusiness in Australia is highly diversified in terms of farming activities and regions and also faces great challenges that need innovative to stay competitive in the world market and meet ever increasing local demand for innovative products and process.

This thesis takes a systems approach to describing agricultural innovation systems in Australia and exploring the players who participate in it. This study found that agricultural innovation systems consists of eleven major actors (stakeholders) in terms of their function, namely: policy, education, finance and credit, marketing, input supply, research, extension and information, logistics, processing and storage, farmers and farm organisations, and consumers. Where possible the actors in these nine components (policy, education, finance and credit, marketing, input supply, research, extension and information, logistics, processing and storage) of the systems were identified. This study also found that innovation in agriculture is a collaborative activity which involves the sharing of knowledge, information and resources among these actors. However, emphasis has been given to actors primarily involved in diffusion, such as research, extension and information.

8.3. The Agricultural Innovation System in Sri Lanka

Actors in the AIS in Sri Lanka are similar to those in Australia with respect to the function they perform. However, there are major differences in terms of the size of the AIS and the effectiveness of various innovation diffusion methods. Sri Lanka's AIS lags behind with respect to size and productivity, and in terms of the functioning of innovation diffusion.

Transfer of technology across 'the last mile' to the farmer is the most important but the weakest link in the AIS in Sri Lanka. Traditional extension technology is far from ideal in meeting the present needs of farmers and private investors. The extension service has to be streamlined and modern information technology is utilized to communicate needed information and disseminate innovations. To achieve their objectives government and NGOs have followed an array of methods, backed by policies for the

promotion and dissemination of IT and the internet among farmers in Sri Lanka. Nevertheless, there is scope for further development of these new innovation diffusion channels.

8.4. The Role of IT in the Diffusion of Agricultural Innovations in Australia.

According to the study findings, the majority of respondents support the idea that IT has great potential as a diffusion channel. However, few thought that IT channels would replace existing methods, with most seeing IT and the internet as supporting existing modes of information delivery. In Australia, IT applications, such as websites, CDs/DVDs, etc. are the second most frequently used communication tools and mechanisms.

This research identified and documented an IT-based direct innovation dissemination method (i.e. the Mouser Program) developed and introduced in Australia. This program itself is an innovation related to agriculture. Further, this research documented IT applications (e.g. CD-ROMs) in agribusiness marketing and supply-chains in Australia. The expertise gained in developing these IT based applications could be marketed in developing countries as well as products and services.

We conclude that Australian organisations already recognise the potential of IT as a communication channel to diffuse much needed information on agricultural innovations. However, they are reluctant to entirely replace existing extension networks due such issues as the importance of tacit knowledge and trust between extension officers and the farmers. Nevertheless, if needed, Australian farmers can browse the relevant websites and find the information needed, and are no longer dependent on extension services.

8.5. The Role of IT in the Diffusion of Agricultural Innovations in Sri Lanka

Transfer of technology is the most important but weakest link in the research-extension systems in Sri Lanka. This could be attributed to various causes. The recent

decentralization of the extension service to the provincial governments in Sri Lanka may be an example. The extension service has to be streamlined and modern information technology utilized to disseminate innovations. Despite lagging behind in terms of access and speed issues, there have been signs that IT use has begun to change in Sri Lankan agriculture, where It applications are the third most frequently used communication tools and mechanisms. Nevertheless, there is considerable scope for further development of IT communication channels, and for their adoption in support of agricultural innovation.

8.6. Comparative Analysis and Lessons for Sri Lanka

The aim of this thesis was to analyze the role of IT in disseminating agricultural innovations in Australia and compare it with the same role in Sir Lanka. Notwithstanding the gap in knowledge about the role that IT can play, planners, policy makers and governments in most developing countries have relied, and many continue to rely on diffusion of innovations in agriculture to support their development strategies. Hopes were high that the new IT and internet facilities would revolutionise agricultural extension and provide a great impetus to agricultural development.

IT can accelerate innovation diffusion in both Australia and Sri Lanka, for reasons including:

- speed, potential reach and cost;
- ability to diffuse information in a variety of forms (e.g.: text, video, websites etc.) and mix of audio-visual techniques;
- ability to bypass traditional opinion leaders and dependence on “trickle-down” to farmers; and
- provision of link to the best available information worldwide.

However, IT also requires complementary action on many fronts, such as extension workers, social networks, and so on, to achieve maximum results. Therefore when formulating diffusion policy, consideration should focus on the complex nature of AIS, multi-links between the actors of AIS and some of the key linkages as well as

infrastructure in relation to IT. Further, in the Sri Lankan context, much attention should be given to IT infrastructure and the know-how factor of IT use.

This study found that the driving forces of innovation in Australia and Sri Lanka have similarities as well as differences. For instance, while the Australian AIS is dealing with capital intensive technologies, the Sri Lankan AIS seeks labour intensive technologies and solutions. However, market forces to lower cost inputs and increase yields are similar in both countries. Compared to Australia, the AIS in Sri Lanka is less effective in terms of using leading-edge technologies, producing highly competitive products to world market, or inventing and quickly diffusing innovations from R&D organisations to end users.

Formal and informal networks underpin the spread of information, knowledge and resources between players in the AIS in both countries. These networks contribute to efficient and effective information transfer among actors at district, regional, national and international levels, and collaborative links are shown to increase the cost effectiveness of diffusion, by making better use of scarce resources and providing incentives for the commercialisation of new technology.

This thesis identified and documented unmet local ICT needs in Sri Lanka, including access to the internet and to the global market, with the objective of making Sri Lanka an attractive, less risky location for global technology companies to set-up operations.

This study concludes that IT can be used to enhance the efficiency and effectiveness of the innovation diffusion process in agricultural innovation systems. To do so, all stakeholders identified by this study should be adopting relevant IT applications for their specific role in the innovation diffusion process.

In the conceptual framework (Chapter 2) of this thesis it was suggested that despite a large volume of literature available in various disciplines on innovation diffusion in agriculture, a robust model for using IT as a tool to facilitate dissemination has not so far been available. Several models of innovation diffusion to farm businesses were identified and documented.

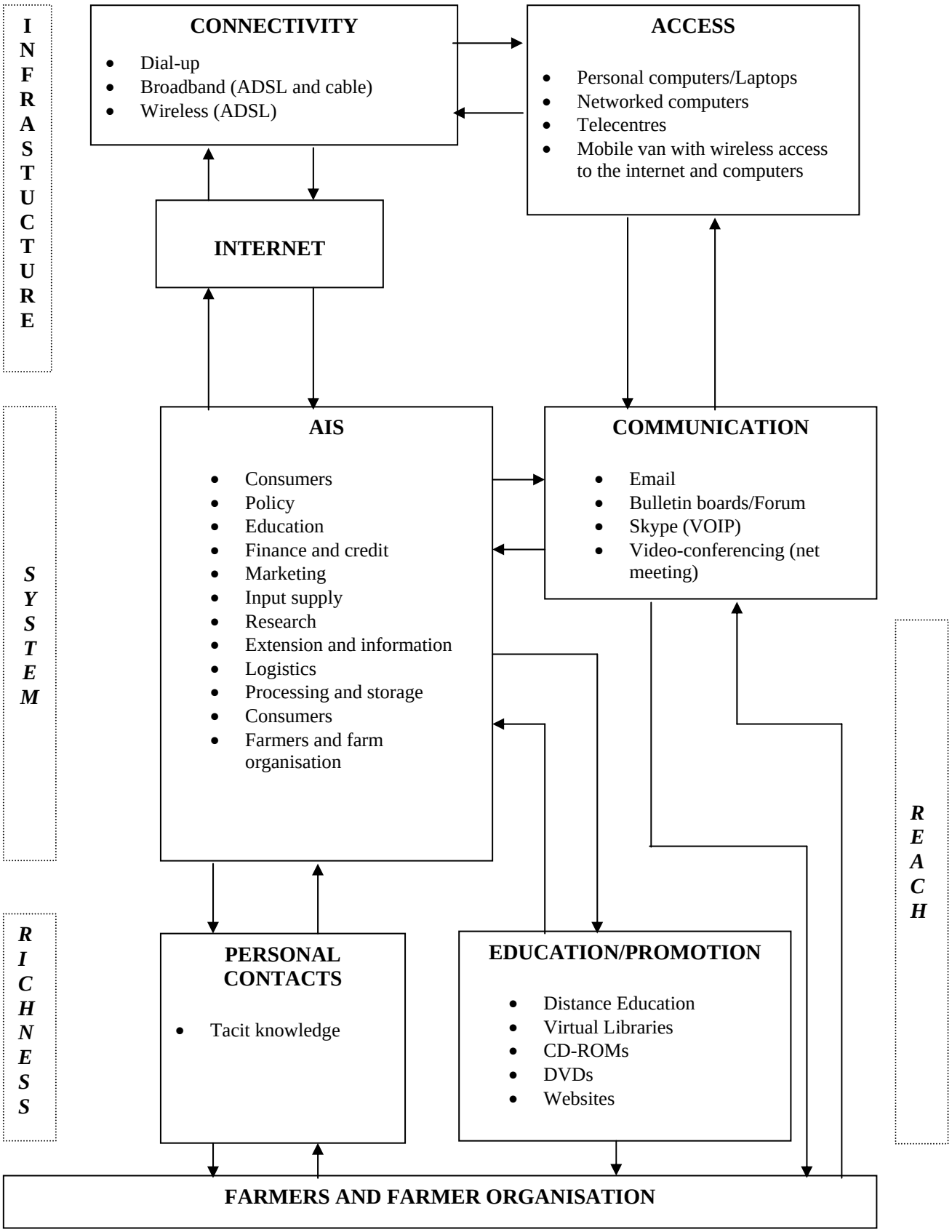
8.7 IT agricultural innovation diffusion model

IT will play a different role in agriculture, nurturing and linking communication among stakeholders of an innovation system. IT has the capacity to substitute most of the written material, as well as some of the interpersonal components of communication channels. Generally, IT's role in innovation diffusion can be seen as complementary rather than as a substitute. IT can enhance the efficiency of existing channels, integrating with them to provide on-demand information access, and two-way interactive feedback and peer group networks.

Figure 8.2 depicts not only the systematic nature of innovation diffusion in agriculture, but also how linkages are visualised between and among members of the AIS. Further it shows two-way communication channels by arrows linking identified major components of the model. In other words Figure 8.2 depicts a visualization of how IT diffusion works practically in simple way.

When formulating policies to enhance efficiency and effectiveness of innovation dissemination in agriculture, it is paramount to consider all elements of the model and cater for them equally. If there is a bottleneck, this model can help determine where it is and what action is needed to clear it. The model also shows how the nature of agricultural innovation emerges within a stakeholder of the AIS and how the inventor can communicate via the internet seeking necessary information, knowledge and resources from other stakeholders of the AIS.

Figure 8.1 Model of the role of IT in innovation diffusion in agriculture



In conclusion, when formulating policies to enhance the efficiency and effectiveness of an innovation it is imperative to take in to account that all necessary components of the model are integrated and that policy must work on all of these fronts. This will maximise the rate of innovation diffusion through IT in agriculture.

Figure 8.2 illustrates four major steps (required IT infrastructure, AIS, communication/education channels, and richness and reach) of innovation diffusion in agriculture. IT infrastructure consists of internet, connectivity and access components and AIS consists of 12 actors and richness and reach covered by communication channels including personal contacts and education/promotion. It clearly shows the information and knowledge channels between and among actors of AIS with special reference to farms/farm organisations. Invention of agricultural innovation takes place within the AIS, exchanging various information, knowledge and resources. IT infrastructure is a critical and main issue in Sri Lanka.

Depending on individual and/or group circumstances of farmers, the above IT innovation diffusion model posts 5 promotion/education channels that address farmers. Likewise other actors among the AIS can also use the same methods when they interact with each other. Moreover the above model identified individual as well as mass communication channels for this interaction. As we already know the combination of individual and mass methods maximises the result through complementary roles. The communication competence of the model listed the channels of interpersonal mass media separately and also how these channels can be used simultaneously to reveal the ability and power of IT and its interactive facilities to perform as a diffusion channel.

In conclusion, the above model helps policy makers identify possible malfunctions of steps as well as components and issues in relation to effectiveness, and address enhancement of innovation diffusion in agriculture. This study found that IT will play increasingly positive role in the agricultural diffusion exercise in the future.

8.8 The Use of IT in Diffusing Innovations in Sri Lankan Agriculture- Conclusions and Recommendations

Most agricultural research and extension is provided as a public good, and investment in rural infrastructure is often funded by government at little or no cost to the farmer. There is strong public interest in gaining the greatest possible returns for this public investment, which, in turn, requires rapid and effective technology diffusion to farmers.

Developing IT as a diffusion tool for agriculture in developing countries such as Sri Lanka requires action on a number of IT-related fronts (e.g. building local awareness, capability and IT provision, developing suitably tailored digital information packages in relevant languages, etc.). Moreover analysis of the diffusion process by this study suggests that the system has not so far generated information of the kind and quality which is adequate for policy makers. The present study indicates the importance of introducing IT access to farmers in Sri Lanka.

In terms of access and speed, there are strong arguments in favour of wireless broadband. If all stakeholders and their stations could be connected with a reliable broadband connection running through reliable service providers, the case for them would be very strong in Sri Lanka. But these two conditions are not likely to be fully met in the near future. Even with the rapid growth of the telephone network, the last mile issue will be a major one the Sri Lankan government will have to address.

For development assistance agencies, both national and international, to respond to rapidly evolving markets, they must understand the current and potential demand for ICT in developing countries like Sri Lanka. The study addresses directly the simple yet important issue of whether or not to pursue a policy to promote IT and the internet to the farming sector for the purpose of supporting cost effective and time efficient innovation diffusion.

The IT-diffusion model presented in Chapter 7 may have real potential for further extension and application. Some of these applications are straightforward and obvious,

whilst others are not immediately apparent. Just as the model developed here has allowed for the identification of stakeholders in the innovation diffusion system in agriculture and is a potential tool for diffusion, further empirical tests in real situations need to be done.

All of these various components of the IT-innovation diffusion model are integrated and necessary, and hence that policy must work on all of these fronts to increase the rate of innovation diffusion through IT in agriculture.

Finally, this study concludes that IT and the internet (with IT applications) can act as a dissemination channel replacing the most commonly used printed materials and some audio-visual channels, as a complementary tool, rather than a substitute. IT has several inherent limitations as a vehicle for agricultural innovation dissemination:

- there are problems with tacit knowledge and the necessity for the contextualisation of information to the individual farmer needs;
- there are also problems with the systems and social nature of innovation; and
- IT is essentially a complementary tool in agricultural innovation dissemination (the medium, not the message).

This thesis argues that more investment should be made in IT applications for agricultural development in developing countries, such as Sri Lanka, not only to redress the growing imbalance in information about innovations, but also to help reduce poverty, increase participation, improve governance, manage natural resources and provide more opportunities for rural women and for the young.

This study has its own limitations due to its confined scope and a focus on public R&D institutes and universities. In terms of scope, this study is limited to institutional/organisational factors in their relation to innovation diffusion in agriculture. The low number of respondents examined may also somewhat limit our understanding of IT use in diffusion. Therefore, subsequent studies may need to focus on other actors. Further research should also look into the empirical studies on the role of IT in innovations diffusion among AIS and farmers. Other limitations include the sampling frame where the survey and interviews were only based on 30 selected organisations.

Further studies should include more private as well as public organisations in different settings and locations.

REFERENCES

Adams, C. W., Amarasiri, S., Dias, G. V., and Induruwa, A. S., 1992, 'Implementing Computer-Based Communication Services in Sri Lanka', in *Proceedings of the 12th National Computer Conference*, University of Colombo, Sri Lanka.

Almonte, E., 1998, *The Internet as a Source of Extension Information for Grape Growers in the Yarra Valley Region*, PhD thesis, La Trobe University, Melbourne.

Ariyaratne, A. R., 2000, *Prospective Agricultural Technologies*, Department of Agricultural Engineering, University of Peradeniya, Sri Lanka.

Ariyaratne, V. S., 2004, 'Networking Grassroots', Sarvodaya, no. 98, Rawatawatta Road, Moratuwa, Sri Lanka.

Ariyawickrama, R. S., 2004, *Virtual Villages in Sri Lanka*, Sarvodaya, Social Empowerment Division, Rawatawatta Road, Moratuwa, Sri Lanka.

Australian Bureau of Statistics, 2007a, *Australian National Accounts: National Income, Expenditure and Product Table 33*, Cat. No. 5206.0, Canberra.

Australian Bureau of Statistics, 2007b, *Year Book Australia 2007*, Cat. No. 1301.0, Canberra.

Australian Bureau of Statistics, 2006, *Australian Farming in Brief*, Cat. No. 7106.0, Canberra.

Australian Bureau of Statistics, 2003, *Research and Experimental Development, All Sector Summary*, Cat. No. 8112.0, Canberra.

Australian Bureau of Statistics, 2002a, 'Agriculture Special Article: Agricultural Inventions', in *Year Book Australia 2007*, Canberra.

Australian Bureau of Statistics, 2002b, *Australian National Accounts, Input-Output Data*, Cat. No. 5209.0.55.001, Canberra.

Australian Bureau of Statistics, 2000, *Use of Information Technology on Farms*, Cat. No. 8150.0, Canberra, June.

Bell, C., 2002, 'Internet Delivery of Short Courses for Farmers: A Case Study of a Course on Precision Agriculture', RIRDC Publication No. 02/085, Rural Research and Development Corporation, Canberra, http://www.rirdc.gov.au/reports/Index.htm, accessed 13 November 2007.

Benjamin, P., 2000, 'African Experience with Telecentres, e-OTI: On the Internet', Internet Society, Ottawa, http://www.isoc.org/oti/articles/1100/benjamin.html , accessed 13 November 2007.

Boston Consulting Group, 1991, *Innovation in Australia*, Report for the Industry Research and Development Board, Australian Government Publishing Service, Canberra.

Brown, P., Singleton, G. R., Norton, G. A., and Thompson, D., 2004, *Mouser (Version1.0): An interactive CD-ROM for Managing the impact of House Mice in Australia*, CSIRO Sustainable Ecosystem, Canberra.

Brown, P., Singleton, G. R., Norton, G. A., and Thompson, D., 2001, *Development of Second Stage of Mouser, a DSS and Information Transfer System for Mouse Plague Management*, Final Report, National Feral Animal Control Program, Bureau of Rural Sciences, Canberra.

Bryant, K., 1998, *Evolutionary Innovation Systems: Their Origins and Emergence as a New Economic Paradigm*, Department of Industry, Science and Tourism, Canberra.

Central Bank of Sri Lanka, 2003, *Annual Report 2003*, Colombo, Sri Lanka.

Central Bank of Sri Lanka, 2006, *Sri Lanka Socio Economic Data*, Statistics Department, vol. 29, June, Colombo, Sri Lanka.

Chamala, S., 1987, 'Strategies to Overcome Communication Deficiencies in Achieving Sustainable Farming Systems', *The Journal of the Australian Institute of Agricultural Science*, vol. 53, no. 3, pp. 164169.

Chitty, N., 2003, *Faces of Globalisation*, Centre for International Communication, Macquarie University, Sydney.

Chairatana, Pun-arj, 2000, *The Economics of the Agro-Innovation System (AIS*), IKE Group and DRUID, Department of Business Studies, Aalborg University, Aalborg.

Clark, N., and McCarthy, M., 2001, *Farm Management 500 Global: Global Networks and Adoption of the Web*, Report for the Rural Industries and Development Corporation, RIRDC Publication No. 01/16, Rural Industries Research and Development Corporation, Canberra.

Cook, P., and Memedovic, O., 2003, 'Strategies for Regional Innovation Systems: Learning Transfer and Applications', Policy Paper, United Nations Industrial Development Organisation (UNIDO), Vienna.

CSIRO, 2007a, 'Farming and Food, Canberra', http://www.csiro.au/csiro/channel/ich7.html, accessed 30 November 2007.

CSIRO, 2007a, 'Agricultural R&D Institutions', Canberra, http://www.csiro.au/csiro/channel/ich3b.html, accessed 1 May 2007.

Delaney, N. E., and Chamala, S., 1985, 'Electronic Information Technology Relevant to Agricultural Extension in Australia*:* A Review and Discussion Paper', Department of Agriculture, University of Queensland, Brisbane.

Department of Agriculture, 2002, 'Administrative Report', Peradeniya, Colombo, Sri Lanka.

Department of Agriculture, Fisheries and Forestry, 2005, 'Australian Food Statistics', Canberra.

Department of Agriculture, Fisheries and Forestry, 2004, 'Made in Australia, New Industries Development Program, Entrepreneurship and Innovation in Australian Agribusiness', No. 1, Canberra.

Department of Agriculture, Fisheries and Forestry, 2003, 'Made in Australia', New Industries Development Program, Entrepreneurship and Innovation in Australian Agribusiness, No. 3, Series 3, Canberra.

Department of Census and Statistics, 2003, 'Statistical Abstract – Sri Lanka', Colombo, Sri Lanka.

Department of Census and Statistics, 2004, 'Census of Agriculture, Report on Estate Sector', Colombo, Sri Lanka.

Department of Communications, Information Technology and the Arts (DCIT&A), 2003, *Statistical Highlights of the Portfolio*, The Communications Research Unit (CRU), April, Canberra.

Department of Education, Science and Training, 2007, 'CRC Directory 2006', Canberra, https://sciencegrants.dest.gov.au/CRC/HTMLDocuments/Documents/PDF/CRC_Directory_2006.pdf, accessed 13 November 2007

Department of Industry, Science and Resources, Science and Technology Policy Branch, 1998, *A New Economic Paradigm, Innovation-based Evolutionary Systems,* Discussions in Science and Innovation 4, Canberra.

Department of Census and Statistics, 2003, 'Statistical Abstract – Sri Lanka', Colombo, Sri Lanka.

Department of Census and Statistics, 2004, 'Census of Agriculture, Report on Estate Sector', Colombo, Sri Lanka.

Dodgson, M., and Rothwell, R., (eds), 1994, *The Handbook of Industrial Innovation*, Edward Elgar, Chelthanham.

Edquist, C., (ed.), 1997, *Systems of Innovations, Technologies, Institutions and Organisations*, Pinter, London.

Edquist, C., 2001, 'The Systems of Innovation Approach and Innovation Policy: An Account of the State of the Art', paper presented at the DRUID Conference, Aalborg, June.

Eponou, T., 1993, 'Integrating Agricultural Research and Technology Transfer', *Journal of Public Administration and Development*, vol. 13, pp. 307-318.

Evans, P., and Wurster, T. S., 2000, *Blown to Bits: How the New Economics of Information Transforms Strategy*, Harvard Business School Press, Boston.

Farmwide Pty Ltd, 2000, *Unmet Demand for Online Services in Rural Australia*, Report for the Rural Industries Research and Development Corporation, RIRDC Publication No. 00/177, November, RIRDC, Canberra.

Freeman. C., 1987, *Technology Policy and Economic Performance: Lessons from Japan*, Pinter, London.

Freeman. C., 1995, 'The National System of Innovation in Historical Perspective,' *Cambridge Journal of Economic*, vol. 19, pp. 5-24.

Freeman, C., and Soete, L., 1997, *The Economics of Industrial Innovation*, 3rd edn, MIT Press, London.

Gelb, E., and Parker, C., 2008, Is ICT Adoption for Agriculture Still an Important Issue? http://departments.agri.huji.ac.il/economics/gelb-gelb-parker.pdf accessed 19 May 2008.

Google, 2007, 'Images' http://images.google.com.au/imghp?oe=UTF-8&hl=en&tab=wi&q, accessed 13 November 2007.

Groves, J., and Rin, J. D., 1999, *Demand and Supply of Internet Content for Australian Farm Businesses,* Report for the Rural Research Industries and Development Corporation, RIRDC Publication No. 99/02, January, RIRDC, Canberra.

Gunasena, H. P. M., 2003, *'Agriculture and Agricultural Education in Sri Lanka: A Collection of Essays'*, Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Sri Lanka.

Hall, P., 1986, *Technology, Innovation and Economic Policy*, Philip Allan Publishers, Oxford.

Hall, A. J., Yoganand, B., Sulaiman, R.V., and Clark, N.G., 2003, *Harvest Innovations in Innovation: Reflection on Partnership and Learning*, Crop Post-Harvest Programme (CPHP), South Asia, International Semi-Arid Tropics (ICRISAT), Andhra Pradesh.

Hanna, N. K., 1991, 'The Information Technology Revolution and Economic Development', World Bank Discussion Papers No. 120, The International Bank for Reconstruction and Development, Washington D.C.

Hartley, R., 1991, 'Did You Get The Message', *The Journal of the Australian Institute of Agricultural Science,* vol. 4, no. 1, pp. 40-43.

Heinze, A. S., 1998, 'From Hierarchy to Cooperation: The Concept of Agricultural Innovation Systems', paper presented at the ISAG/GTZ Workshop on, 'New Partnerships for Agricultural Innovations', Den Hagg, January 27-30.

High, J., and Jacobson, M., 2005, 'Internet-Based Natural Resource Extension, *Journal of Extension*, vol. 43, no. 3, article no., 3BIB8, http://www.joe.org/joe/2005june/rb9.shtml , accessed 13 November 2007.

Houghton, J. W., Steele, C., and Henty, M., 2003, *Changing Research Practices in the Digital Information and Communication Environment*, Report to Department of Education, Science and Training, Canberra.

Houghton, J., Rose, M., and Morris, J., 2005, *Australian Electronic Industry Capability Mapping Report*, Department of Communications, Information Technology and Arts, Canberra.

Ingelstam, L. 2001, 'System och systemforskning: en resonerande översikt, med sikte på forskning kring energi, teknik och samhälle', (Systems and systems research: a 'reasoning' overview with regard to research on energy, technology and society'), Linköpings Universitet, Sweden

Jayasuriya, R. T., 2005, 'Farming Systems in Australia', AGRIPP, Food and Agriculture Organisation of the United Nations (FAO), Rome, http://www.fao.org/docrep/article/agrippa/686_en.pdf, accessed 13 November 2007.

Jayasuriya, S., and John, M. K., 2002, 'Sri Lanka's Telecommunications Industry: From Privatisation to Anti-Competition? ', Working Paper Series No. 14, Centre on Regulation and Competition, Institute for Development Policy and Management, University of Manchester, Manchester.

Long, L., and Long, N., 2001, *Computers: Information Technology in Perspective* (9th edn), Pearson Education, Upper Saddle Rover, New Jersey.

Lopez, R. M., 2004, 'The Mapping of the Agricultural Innovation System in Nicaragua', paper presented at the DRUID Summer Conference, Elsinore, Denmark, June 14-16.

Lundvall, B., 1992, *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*, Pinter, London.

Mahajan, V., and Peterson, R. A., 1985, *Models for Innovation Diffusion*, Sage Publications, New Delhi.

Metcalfe, S., 1995, 'The Economic Foundations of Technology Policy: Equilibrium and Evolutionary Perspectives', in P. Stoneman (ed.), *Handbook of the Economics of Innovation and Technical Change*, Blackwell, Oxford.

Metcalfe, I., Holloway, B., McWillam, J., and Inall, N., 2005, *Research Management in Agriculture*: *A Manual for the Twenty First Century*, The University of New England, Australia.

Ministry of Agriculture and Livestock, 2003, *National Agricultural Research Policy 2003-2010*, Sri Lanka Council for Agricultural Research Policy, Colombo, Sri Lanka.

Moore, B., 2002, *The Australian Concise Oxford Dictionary of Current English* (3rd edn), Australian National Dictionary Centre, Oxford University Press, Sydney.

Nelson, R. R., (Ed) 1993, *National Innovation Systems: A Comparative Analysis*, Oxford University Press, New York.

Nielsen, R. L., 1999, 'Cyberspace and Agricultural Technology Transfer: An Indiana Experience', Purdue University, West Lafayette, presentation, http://www.agry.purdue.edu/ext/corn/talks/cyberspace/index.htm, accessed 13 November 2007.

Pasqual, G. M., 1998, 'The Future for Agricultural Extension', *The Journal of the Australian Institute of Agricultural Science*, vol. 1, no. 2, pp. 28-29.

Piana V., 2003, 'Innovation', Economics Web Institute, Rome, http://www.economicswebinstitute.org/glossary/innovate.htm, accessed 13 November 2007.

Prescott, M. B., and Slyke, C. V., 2003, 'The Internet as an Innovation', http://hsb.baylor.edu/ramsower/ais.ac.96/papers/PPRESCOTT.htm, accessed 14 March 2003.

Priyaratna, D., 2004a, 'Survey on the Present Use of ICT Tools, Deep South Region', e-Sri Lanka Initiative, VGK Project, unpublished report, Information and Communication Agency of Sri Lanka (ICTA), Colombo, Sri Lanka.

Priyaratna, D., 2004b, 'Survey on the Present Use of ICT tools, North and East Region', e-Sri Lanka Initiative, VGK Project, unpublished Report, Information and Communication Agency of Sri Lanka (ICTA), Colombo, Sri Lanka.

Priyaratna, D., 2004c, 'Telecentre Survey', e-Sri Lanka Initiative, VGK Project, unpublished report, Information and Communication Agency of Sri Lanka (ICTA), Colombo, Sri Lanka.

Productivity Commission, 2005, *Trends in Australian Agriculture*, Research Paper, Melbourne.

Proenza, F. J., Buch, R. B., and Montero, G., 2001, 'Telecentres for Socio Economic and Rural Development in Latin America and Caribbean: Investment Opportunities and Design Recommendations and Special Reference to Central America', FAO Investment Centre, Washington D.C.

Ramanayake, M. C., 1997, 'Internet as a Business Tool', *The Journal of the Computer Society of Sri Lanka*, March, pp. 5-8.

Ranaweera, N. F. C., 2002, 'Impact of Trade Liberalization on Small Farmers: Sri Lanka's Experience', paper submitted at 17th International Farming Systems Association Symposium, Lake Buena Vista, Florida, November 17-20,

ftp://ftp.fao.org/UPLOAD/AGRIPPA/615_EN.PDF, accessed 13 November 2007.

Ratnasiri, P. A. J., 1984, 'Technology Development and Transfer', Report of a Seminar, Physical Science Section, Sri Lankan Association for the Advancement of Science, 28 March, Colombo, Sri Lanka.

Reid, R. L., 1990, *The Manual of Australian Agriculture*, Butterworths, Sydney.

Rickert, U., Helbig, R., and Schiefer, G., 1999, 'Role and Potential of IT, Intranet and Internet for Advisory Services', paper presented to the European Association for Information Technology in Agriculture, Food and Environment (EFITA), European Symposium (EFITA 99), Bonn, September 27-30.

Richardson, D., 1997, *The Internet and Rural and Agricultural Development: An Integrated Approach,* Communication for Development Publication Series, Food and Agriculture Organisation of the United Nations (FAO), Rome.

Rin, J. D., and Groves, J., 1999, *Economic and Social Impacts of Farm Internet Use*, Report for the Rural Industries and Development Corporation, RIRDC Publication No. 99/35, January, RIRDC, Canberra.

Rin, J. D., and Groves, J., 2000, *Realising Potential: Farm Management Impacts of the Internet,* Report for the Rural Industries and Development Corporation, RIRDC Publication No. 00/55, May, RIRDC, Canberra.

Risdon, P., 1994 'Transferring Technology Through the Internet Channel', *Journal of Extension*, vol. 32, no. 1, June.

Rogers, E. M., 1995, *Diffusion of Innovations* (4th edn), The Free Press, New York.

Rogers, E. M., and Shumaker, F. F., 1971, *Communication of Innovations: A Cross-Cultural Approach* (2nd edn), The Free Press, New York.

Ross, B., and Waksman, G., 2001, 'How Developments in Internet and E-Commerce Use are Changing the Agricultural Industry in Europe', paper presented at EFITA 2001, Montpellier, France, June 18-20.

Samantha, R. K., 1990, *Development Communication for Agriculture*, D.K. Publishers, New Delhi.

Sharma, V. P., 2004, 'Cyber Extension: Changing the Face of Indian Agriculture', National Institute of Agricultural Extension Management, Rajendranagar, Hyderabad, http://www.manage.gov.in/CyberExtension/cyberext.htm, accessed 13 November 2007.

Schumpeter, J. A., 1939, *A Theoretical, Historical and Statistical Analysis of the Capitalist Process*, McGraw-Hill, New York.

Simpson, R., and Hunter, A., 2001, *The Internet and Regional Australia*, Report for the Rural Industries and Development Corporation, RIRDC Publication No. 00/177, November RIRDC, Canberra.

Smith, K., 1996, 'The Norwegian National Innovation System: A Pilot Study of Knowledge Creation', STEP Report, STEP, Oslo.

Shakeel, H., Best, M., Miller, B., and Weber, S., 2001, 'Comparing Urban and Rural Telecentres Costs', *The Electronic Journal of Information Systems in Developing Countries*, vol. 42, no. 1, pp. 1-13.

Sheehan, P. J., 2005, 'Sociological Approaches to Innovation Diffusion', mimeo, Centre of Strategic Economic Studies, Victoria University, Melbourne.

Sri Lanka Council for Agricultural Research Policy, 2004, *National Agricultural Research Policy 2003-2010*, Ministry of Agriculture and Livestock, Colombo, April.

Taragola, N., and Gelb, E., 2005, Information and Communication Technology (ICT) Adoption in Horticulture: A Comparison to the EFITA Baseline. http://www2.vlaanderen.be/landbouw/downloads/cle/pap17.pdf assessed 15 May 2008.

Temel, T., Janssen, W., and Karimov, F., 2002, 'The Agricultural Innovation System of Azerbaijan: An Assessment of Institutional Linkages', ISNAR Country Report 64, International Service for National Agricultural Research, The Hague.

Temel, T., Janssen, and W., Karimov, F., 2001a, 'System Analysis by Graph Theoretical Techniques: Assessment of the Agricultural Innovation System of Azerbaijan' Paper No. 01-06, International Services for National Agricultural Research (ISNAR), The Hague.

Temel, T., Janssen and W., Karimov, F., 2001b, 'The Agricultural Innovation System of Azerbaijan: Functions, Linkages, and Constrains', Paper No. 01-3, International Services for National Agricultural Research (ISNAR), The Hague.

Tornatzky, L., 1990, *The Role of Public Agencies in Fostering New Technology and Innovation Building*, National Academies Press, Washington.

Unamboowe, I., 1984, 'The Role of Extension Service Organisations in the Transfer of Technology', Report of a Seminar, Physical Science Section, Sri Lankan Association for the Advancement of Science, Colombo, March 28.

UNESCO, 2005, *UNESCO Science Report 2005*, United Nations Education, Science and Cultural Organization, Paris, http://www.unesco.org/science/psd/publications/science_report2005.pdf , accessed 30 November 2007.

Waksman, G., 1999, 'Dissemination of Information on IT and the Internet in Agriculture and Rural Areas', paper presented at EFITA 99, Bonn.

Wijeratne, M., 1998, 'Farmer Extension and Research in Sri Lanka: An Empirical Study of the Agricultural Knowledge System with Special Reference to Matara District', Wageningen Agricultural University, Wageningen, The Netherlands.

Wijesinghe, U. P., 2002, *Use of Information Technology for Agricultural Extension and Rural Development in Bibile, Sri Lanka*. Bachelor of Science in Agriculture, University of Ruhuna, Mapalana, Sri Lanka.

Wijewardane, R., 2007, 'Sri Lanka goes WiMAX Dialog Broadband', http://lankapage.wordpress.com/2007/01/24/sri-lanka-goes-wimax-with-dialog-broadband/ , accessed 13 November 2007.

WITSA 2005, *Planet: The Global Information Economy*, World Information Technology and Services Alliance, October, Arlington, VA.

Wong, J., and Romm, C., 2004, 'Establishing Organisational Web Sites (EOWS): Toward an Integrative Conceptual Framework', University of Sydney, Sydney, http://wwwfaculty.arch.usyd.edu.au/kcdc/conferences/VC97/papers/wong.html , accessed 13 November 2007.

Zijp, W., 1994, 'Improving the Transfer and Use of Agricultural Information: A Guide to Information Technology', World Bank Discussion Papers No. 247, World Bank, Washington, D.C.

APPENDIX 1

LETTER AND SURVEY

The Role of Information Technology (IT) in Disseminating Innovation in Agribusiness: A Comparative Study of Australia and Sri Lanka

Dear Prof/Dr/Mr/Ms……..

I am writing to invite you to participate in a survey on the role of IT in diffusion of innovations in agribusiness in Australia/Sri Lanka. This research is being conducted under the supervision of Professor Peter Sheehan, as a part of my PhD in the Centre for Strategic Economic Studies at Victoria University.

We would really value your information regarding what role can IT play as a diffusion tool to diffuse innovation to the farm level within the agribusiness system. Your response will help us to understand and to describe the agricultural innovation system of the country. We are seeking to survey organisations that involved in agricultural innovation diffusion both in Australia and Sri Lanka and compare the results.

This survey aims to investigate three aspects of agricultural innovation system with special emphasis of information technology in Australia and Sri Lanka.

1. To describe and analyse innovation system of the country;
2. To ascertain the channels which are presently used to diffuse innovations and;
3. To evaluate efficiency and effectiveness of IT as a diffusion tool.

The survey will take approximately 15 minutes to complete. Please note that the information you provide is **strictly confidential**. Nothing in the survey identifies the individual respondents or organisation. Participation in this survey is entirely voluntary.

Upon completion please return the questionnaire in the Reply Paid envelope provided. If you have any queries or would like a summary of the results of the survey please contact me on (03) 9462 1354 or via email: sudath.arumapperuma@research.vu.edu.au

Thank you very much for your contribution. Your time and participation is greatly appreciated.

Sudath Arumapperuma Professor Peter Sheehan

SURVEY

THE ROLE OF INFORMATION TECHNOLOGY IN DISSEMINATING INNOVATION IN AGRIBUSINESS: A COMPARATIVE STUDY OF AUSTRALIA AND SRI LANKA

Directions

- Please answer the questions by simply ticking the most appropriate response or writing a few words where required.

- Please try to answer all the questions. If you have difficulty with answering any question please write your best possible guess and continue to the next one.

- Please write in CAPITAL letters and you may select more than one answer**.**

- **When you have completed the questionnaire, please return it before 31 January, 2006 in the enclosed envelope.**

September 2004

PART 1. GENERAL ORGANIZATIONAL INFORMATION

Name of the organization: _____

Status of the organization: Public □ Private □ NGO/Semi public □
Scope of the organization: Local □ Regional □ National □ International □
Number of employees: Professional _____ Support _____ Total _____

MAIN INNOVATION ACTIVITIES OF THE ORGANISATION

1.1 Kinds of innovation related activities of your organization (you may select more than one answer).

Technology policy □
Technology financing □
Technology development □
Technology evaluation □
Technology demonstration □
Technology dissemination □
Technology introduction/selling □
Technology acquisition (local/international) □
Technology training □
Technology integration □
Technology use □
Other (please specify)_____

1.2 Goals of innovation related activities of your organization (you may select more than one answer).

Introduce new products or processes □
Increase market opportunities □
Improve production flexibility □
Increase commodity production □
Increase commodity quality □
Reduce labour costs □
Reduce material costs □
Reduce energy consumption □
Reduce environmental damage □
Fulfil regulations or standards □
Provide knowledge and information □
Generate own income □
Other (please specify) _____

1.3 In the pursuit of innovation, what organisations/institutes does your organisation interact with other organisations to gain, develop and exchange various kinds of knowledge, information, and other resources? (list company/organisation name)

Policy _____
Finance _____
Research_____
Extension_____
Education _____
Information _____
Credit _____
Input supply _____
Processing _____
Marketing _____
External assistance _____
Other _____

1.4 What are the organisational/institutional constraints for innovation? (please tick more than one answer if applicable).

Laws ☐
Health regulations ☐
Cultural norms ☐
Social rules ☐
Technical standards ☐
Other (please specify) _____

1.5 How are your innovation activities funded?

Central Government ☐
Local Government ☐
Funding bodies/agencies ☐
Own resources ☐
Collaborative contracts ☐
Competitive Grants ☐
Non-competitive Grants ☐
Patents and copyrights ☐
Awards and prizes ☐
Loans and credits ☐
International donor assistance ☐
Other (please specify) _____

PART 2 DIFFUSION OF INNOVATIONS

2.1 What channels does your organisation use to diffuse information of innovations and how often (you may select more than one response)?

Channel	Very often	Often	Rarely
Extension Network	☐	☐	☐
TV	☐	☐	☐
Films/Videos	☐	☐	☐
Radio	☐	☐	☐
Newspapers	☐	☐	☐
Local Newsletters	☐	☐	☐
Bulletins	☐	☐	☐
Website	☐	☐	☐
CDs	☐	☐	☐
Fact sheets	☐	☐	☐
Booklets/Leaflets/Pamphlets/ Posters	☐	☐	☐
Research Reports	☐	☐	☐
Magazines	☐	☐	☐
Fax	☐	☐	☐
Educational Programs	☐	☐	☐
Software	☐	☐	☐
Technical Manuals	☐	☐	☐

2.2 Given the benefit of your experience in Australia/Sri Lanka please indicate the extent to which you agree or disagree with the following statements.
Please circle the most appropriate response

	STATEMENT	**Strongly Disagree**	**Disagree**	**Neither**	**Agree**	**Strongly Agree**
1.	IT is an emerging technology that can be used to diffuse technology	1	2	3	4	5
2.	Almost all researchers have ability to use IT for their day-to-day activities	1	2	3	4	5
3.	A computer is no longer a luxury item for ordinary people	1	2	3	4	5
4.	IT can overcome constraints of time and distance of technology transfer	1	2	3	4	5
5.	There are plenty of computer training courses for novice users	1	2	3	4	5
6.	It is not difficult to find an ISP	1	2	3	4	5
7.	Due to competition the cost of ISP and Telephone connection charges are becoming less	1	2	3	4	5
8.	Portable lap-tops make technology transfer tasks easier	1	2	3	4	5
9.	In future it will be possible to use mobile/wireless internet technology	1	2	3	4	5
10.	IT channels may replace existing extension network in the future	1	2	3	4	5

2.3 Do you have an official website?

Yes ☐

No ☐

2.4 If yes what is the web-site address? _____

2.5 What purpose does your website serve for your organization?

Provision of useful information for users ☐

Publicity for your organization ☐

As a vehicle for providing service to clients ☐

As means of conducting commercial or financial transactions ☐

A more cost-effective and/or efficient means of communication ☐

Other (please specify) _____

2.6 Who are the target audiences for your Internet site?

The general public ☐
Farm businesses ☐
Other businesses ☐
Professional/technical support ☐
Your own staff (i.e., an Intranet) ☐
Other (please specify) _____

PART 3 REASONS TO USE INFORMATION TECHNOLOGY

(please tick more than one box if applicable).

1. Low cost	☐
2. Timely information about an innovation	☐
3. Low overhead and establishment costs	☐
4. Low maintenance costs	☐
5. Low employee training costs	☐
6. Convenient	☐
7. Easy to manage/edit information	☐
8. Effective	☐
9. Efficient	☐
10. Can combine with other media such as DVDs, Sound Video Camera etc.	☐

3.2 What is the proportion of the budget which do your organisation allocate to information dissemination? <10% 10%-20% 40%-50% >50%

3.3 Do you have any indicators which you can use to measure the effectiveness and efficiency of your website?

Hit counter ☐

Emil feedback facility ☐

Interactive facilities such as bulletin boards, forms etc ☐

3.4 Is your website linked to the most commonly used search engines?

Yes ☐
No ☐

3.5. From your experience what is the potential for Information Technology as a diffusion channel

_____
_____
_____
_____
_____
_____
_____

Thank you for completing this survey. Please return your completed survey in the reply paid envelop by 31 January 2006.

FOLLOW UP INTERVIEWS

If you would like to participate in a further discussion by phone or via email regarding some of the issues raised by this survey please contact me at your earliest convenience.

APPENDIX 2

LIMITATIONS FACED

Limitations Faced During Data Collection in Sri Lanka

1. Due to the poor public transport system in Sri Lanka I had to spend considerable time for travel. However supplying fuel for his car, my father-in-law agreed to provide transport within the Colombo (capital city) area.
2. Private buses dominate the Sri Lankan public transport system. Unfortunately there was a private bus strike taking place during the data collection period and it drastically affected to my mobility.
3. Heavy monsoonal rains and minor flood conditions also disturbed my movements during the data collection task the southern part of Sri Lanka.
4. University minor staff started a pay dispute with the government and eventually went on strike. As a result all universities of the country were closed for approximately 2 months. This unhealthy situation prevented me access to university libraries for collection of Sri Lankan literature.
5. There is an ongoing unrest/war between the Sri Lankan army and separatist Tamil tigers since 1989. Because of my Singalese ethnic origin I didn't want risk my life visiting Tamil Tiger controlled areas such as the north and north-eastern parts of the country.
6. Lack of computer facilities (except in universities) with the internet connections gave me a very hard time and even I had to ask my father for funds to buy a used computer. Also the downloading speed of Sri Lankan ISP facilities hindered my work and a lot of time was spent just checking my VU emails.
7. Due to very high telephone charges (in Sri Lanka, local calls and inter-province calls are charged differently than in Australia) and poor availability of potential respondents over the telephone, it was not possible to conduct telephone interviews as I suggested in my proposal consistent with my budget.

Limitations Faced During Data Collection in Australia

1. Due to high travelling costs to conduct interviews, a mail survey was selected as a data gathering tool.
2. There was a low response rate mailed surveys.

APPENDIX 3

REFERENCE TABLES

Table A3.1 Total ICT spending in agriculture in Australia, 2000-2008, US$ million

Country	2002	2003	2004	2005	2006	2007	2008
Australia	76.6	106.0	153.6	168.0	178.8	186.8	190.9

Source: WITSA (2005).

Table A3.2Total ICT spending in agriculture in Sri Lanka, 2000-2008, US$ million

Country	2002	2003	2004	2005	2006	2007	2008
Sri Lanka	15.5	18.8	22.1	22.2	23.2	25.4	26.5

Source: WITSA (2005).

Table A3.3 Annual per cent change in ICT spending, 2001-2005 and 2005-2008

	Total per cent change (2001-2005)	Total per cent change, forecast (2005-2008)
Computer hardware	15.2	16.0
Computer software	29.5	29.6
Computer services	29.8	30.2
Communications	5.5	6.7
Total ICT spending	**8.7**	**11.8**
ICT spending in agriculture	6.0	4.6

Source: Author's estimates based on Table 6.2.

APPENDIX 4

BOTANICAL NAMES OF CROPS

Table A4.1 Botanical names of food crops grown in Australia, but not in Sri Lanka

Fruits	***Botanical Name***	**Vegetables**	***Botanical Name***
Custard apple	*Anona species*	Broccoli	*Brassica oleracea*
Duku	*Lansium domesticum*	Silver beet	*Beta vulgaris*
Figs	*Ficus benjamyna*	Snow peas	*Pisum sativum*
Peaches	*Persica americana*	Green peas	*Pisum sativum*
Nuts	***Botanical Name***	**Oil-plants**	***Botanical Name***
Almonds	*Prunus dulcis*	Olives	*Olea europaea*
Macadamia	*Macadamia claudiensis*	Canola	*Brassica Napus*
Walnuts	*Juglans regia*		
Hazelnuts	*Corylus avellana*		
Pistachios	*Pistacia vera*		
Grains	***Botanical Name***		
Oats	*Avena sativa*		
Barley	*Hordeum vulgare*		
Wheat	*Triticum aestivum*		

Table A4.2 Botanical names of food crops grown in Sri Lanka but not in Australia

Fruits	***Botanical Name***	**Vegetables**	***Botanical Name***
Lovi	*Flacourtia inermis*	Mukunuwenna	*Alternanthera sessilis*
Beli	*Aegle marmelos*	Lotus roots	*Nelumbo nucifera*
Sapota	*Mainlkara zapota*	Murunga	*Moringa oleifera*
Anona	*Annona reticulate*	Kohila	*Lassia spinosa*
Woodapple	*Feronia limonia*	Nivithi	*Basella alaba*
Nuts	***Botanical Name***	**Oil-plants**	***Botanical Name***
Cashew nuts	*Anacardium occidentale*		
Beetle nuts	*Areca catechu*		
Kottamba	*Terminallia cattapu*		
Grains	***Botanical Name***		
Kurakkan	*Eleusine coraccana*		