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The adoption of low-cost low head drip irrigation in small-scale farms in Kenya

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Plate 1. The drum low-cost low head drip irrigation kit
(Kajiado - Kenya)

The adoption of low-cost low head drip irrigation in small-scale farms in Kenya

Abstract

Population growth and development will increase the demands on water resources in Africa, and hence there is a need for agriculture to use water efficiently. Drip irrigation is widely promoted for water saving at the farm level. Moreover, it is easily adaptable to small-scale farming common in Africa. The use of low-cost drip irrigation, especially the low-cost medium head (LCMH) drip system, is growing rapidly in some Asian countries. However, the uptake of low-cost drip irrigation in general has been slow in Kenya, which has scarce water for irrigation.

Using the theory of the adoption and diffusion of innovation, this research aimed to identify the factors affecting the rate of adoption and continued use of low-cost low head (LCLH) drip irrigation in Kenya. Following a review of experiences of low-cost drip irrigation from India and sub-Saharan Africa, primary information was obtained using informal interviews in a two-phase survey. A total of eighty-six respondents were interviewed in the two phases. Phase 1 examined the factors influencing the adoption of LCLH drip irrigation. The key respondents in phase 1 were irrigation farmers (drip and non-drip), government officials, irrigation industry representatives, and staff of non-governmental organisations (NGOs). Phase 2 examined the factors affecting discontinuation of LCLH drip irrigation. In phase 2 only LCLH drip irrigation farmers and those who had discontinued using it were interviewed

While the low-cost medium head drip irrigation was the dominant irrigation in India, the low-cost low head drip irrigation, gravity fed and in a kit form, was found to be the most common system on smallholder farms in Kenya. The results showed that for the rate of appropriate low-cost drip irrigation uptake to increase in Kenya, it was important to remove political and institutional inhibiting factors dominant during the implementation stages of the innovation-decision process. It was necessary for farmers to have a need to save irrigation water, reliable irrigation water resources, effective water user organisations, efficient marketing facilities, efficient technical support services, relevant cultural background, and good security for the kit. The LCLH drip irrigation kit appeared to have more maintenance problems than the alternative irrigation methods. Furthermore, government policies and extension services as well as irrigation industry efforts appeared limited. It appeared that the technology would most likely be adopted where farmers have a reliable but limited (in volume) water supply.

In some situations, the LCLH drip technology, and particularly the smaller (bucket) kits, did not appear to be appropriate and should not be promoted. For other conditions, recommendations were made for helping to overcome the problems identified in the study.

The Rogers innovation-decision model was shown to lack sufficient consideration of external factors. A revised model was proposed to suit the conditions of small-scale irrigation technology adoption in less developed countries.

Acknowledgement

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Table of contents

CHAPTER 3 REVIEW OF LOW-COST DRIP IRRIGATION IN INDIA AND SUB-SAHARAN AFRICA

CHAPTER 4 OVERVIEW OF STUDY AREAS AND IRRIGATION IN KENYA

APPENDICES

List of tables

List of figures

List of plates and boxes

List of acronyms

ALIN	Arid Land Information Network
ApproTEC	Appropriate Technology for Enterprise Creation
BIS	Bureau of Indian Standards
DFID	Department for International Development (UK)
DDC	District Development Committee
EAC	East African Community
FAO	Food and Agriculture Organisation of the United Nations
FPEAK	Fresh Produce Exporters Association of Kenya
GNP	Gross National Product
GDP	Gross Domestic Product
HA	Homogeneity Analysis
I-D	Innovation-decision
IDB	Irrigation and Drainage Branch
IDE	International Development Enterprise
IIMI	International Irrigation Management Institute
ISO	International Standards Organisation
IWMI	International Water Management Institute
JICA	Japan International Co-operation Agency
JIIT	Japanese Institute for Irrigation and Technology
KARI	Kenya Agricultural Research Institute
Ksh	Kenya shilling
LDC	Less Developed Countries
LCLH	Low-cost low head
LCMH	Low-cost medium head
MOA	Ministry of Agriculture
MOARD	Ministry of Agriculture and Rural Development
NARL	National Agricultural Research Laboratories
NGO	Non Governmental Organisation
NGOs	Non Governmental Organisations
NIB	National Irrigation Board
ODA	Overseas Development Administration

PCD	Plastic-culture Development Centres.
PTA	Preferential Trade Association of Africa
RRA	Rapid Rural Appraisal
SACDP	Sustainable Agricultural Community Development Program
SADC	Southern African Development Community
SAFDC	Swiss Agency for Development and Co-operation
SITARC	Small Industry Testing Agricultural Research Centre
SIDP	Smallholder Irrigation and Drainage Project
SISDO	Smallholder Irrigation Scheme Development Organisation
SSI	Small-Scale Irrigation
USAID	United States Agency for International Development
WI	Winrock International
WUA	Water Users' Association
WCED	World Commission on Environmental Development
WUO	Water Users' Organisations

CHAPTER 1
INTRODUCTION

1.1 Chapter introduction

The purpose of this chapter is to present the general background to the study. It explains how and why the study came about, outlining its main objectives. The first two sections describe the history and the role of irrigation in Africa. This is followed by a brief description of drip irrigation. The aims and the research questions are presented next, after which an explanation of the scope, justification and outline of methodology of the study are outlined. The last two sections describe the thesis structure and the chapter summary.

1.2 Background to the study

1.2.1 Irrigation experience in Africa

Although Africa has practised small-scale lowland irrigation since Egyptian times, in the 20^{th} century colonial governments introduced many large-scale surface irrigation schemes. During this period the approach to irrigation was characterised by resource mobilisation for external interests (Slabbers 1990). Consequently, most irrigation projects, some of which still exist, were government controlled for commercial or resettlement purposes.

By the 1970's, most of the schemes started to have problems. They became expensive, inefficient, difficult to manage and could not serve their intended purpose (Underhill 1990). The failure was evident, among other things, by diminishing returns, declining yields, lack of interest by farmers and their continued indebtedness (Makadho 1984). Recently (1999) there were fierce battles in Mwea Irrigation scheme in Kenya between large-scale irrigation tenants and government management agencies due to some of these problems. By the 1980s, many African countries realised that the approach of planning irrigation projects from the top, instead of from the grassroots, was the main problem because it created conflicts between the aims of the government irrigation agencies and the expectations of the small farmers (Carter 1989). Therefore, the emphasis started to change to small-scale irrigation (SSI) projects (appendix 1.0). In

Kenya, for example a smallholder irrigation and drainage project (SIDP) unit was established in 1991 (Osoro et al, 1992) while in Nigeria informal small-scale irrigation contributed more to food production than the formal sector by 1990 (Underhill 1990).

1.2.2 Role of irrigation in African agriculture

Despite the above problems, irrigation has a potential role in African development. Hillel (1997) estimates that the potential irrigatable area in sub-Saharan Africa alone is between 15-20 million hectares. Only 25% of the total African area is suitable for rain-fed agriculture while 10% is marginally suitable (FAO 1987). The rest has unreliable and insufficient rainfall potentially leading to famine and starvation. Hence new crop husbandry methods and technologies are required to improve agricultural production, in order to provide an economic basis for stability and industrial development. In this respect, smallholder irrigation may have a potential role in farming practice.

1.2.3 Micro-irrigation

A typology and detailed description of irrigation methods is given in appendix 1.1. Micro-irrigation may be defined as the method of slow and frequent crop water application to the crop root zone through tiny water drops, streams, or sprays, by means of bubblers, micro-jets, micro-sprinklers and drippers (Fig 1.1). The focus in this study is on the drip irrigation since it is the most widely used form of micro-irrigation and forms the basis of this study. It can be suitably applied to small irrigated areas of African small-scale farming. This irrigation method is preferred in some situations because if properly managed it may generally: -

- Increase the agricultural return per unit of water used;
- Increase the quality of agricultural products; and
- Increase the return per labour unit.

Research, extension, NGOs, and other bodies whose primary clients are farmers, sometimes tend to believe that they must promote the technology because of these benefits. But there is no guarantee these benefits will be realised or that the technology will work. This is because the benefits have to be realised in an environment governed by uncertainty and risks that may determine the success of the technology. Furthermore, the method is generally more expensive, needs higher level of design, management, and maintenance, is prone to clogging of emitters and tends to accumulate salt on the outer edges of the wetted perimeter of the soil. Careful management is required to make sure the salt does not migrate into the active root zone of the crop, which might affect its performance. This is particularly a problem where poor saline irrigation water quality is used or the soil is saline.

Cornish (1998) states that the African continent contains 13 of the 18 countries of the world with a situation of absolute water scarcity, which means that they have less than 1,000 m^3/head/year of water. Despite this, the African record on the use of its water resources is poor. Hence, water saving irrigation methods may have a potential role in Africa

1.2.4 Types of micro-irrigation technologies

Fig 1.1 categorises the common types of micro-irrigation technologies Two types of drip irrigation system can be seen - the conventional high-cost high head systems and the low-cost medium/ low head systems. Low-cost drip irrigation is a simplified version of the conventional high cost drip developed by removing or simplifying filtering, pumping, and other precision devices associated with conventional drip (Hillel 1997). A low-cost drip system can be used to irrigate small areas of 3 hectares or less, has low precision, and uses simple filtration. The category can be further subdivided into the larger customised units using medium head (pressure) (LCMH) and the smaller units usually obtained in kit form operating on very low head (pressure) (LCLH).

Whereas commercial systems operate around 10m head (Kay 2001), low-cost medium head (LCMH) drip irrigation for small holder farmers generally operates from about 3 metre head. They require larger water storage capacity. Hence, they often use small pumps irrigating relatively larger areas of 1-3 hectares. The use of pumps and higher irrigated area size makes them relatively expensive.

A low-cost low head (LCLH) drip irrigation system is generally gravity fed operating at between 1 and 2 metres head. This system is designed to irrigate small areas of 15m^2, and is adaptable to irregular small landholdings. It has the lowest absolute cost, if the cost per unit area is ignored (Chapter 6). The systems include bucket and drum kits (See plate 1). The various types of LCLH drip irrigation used in Kenya are discussed in chapter 4.

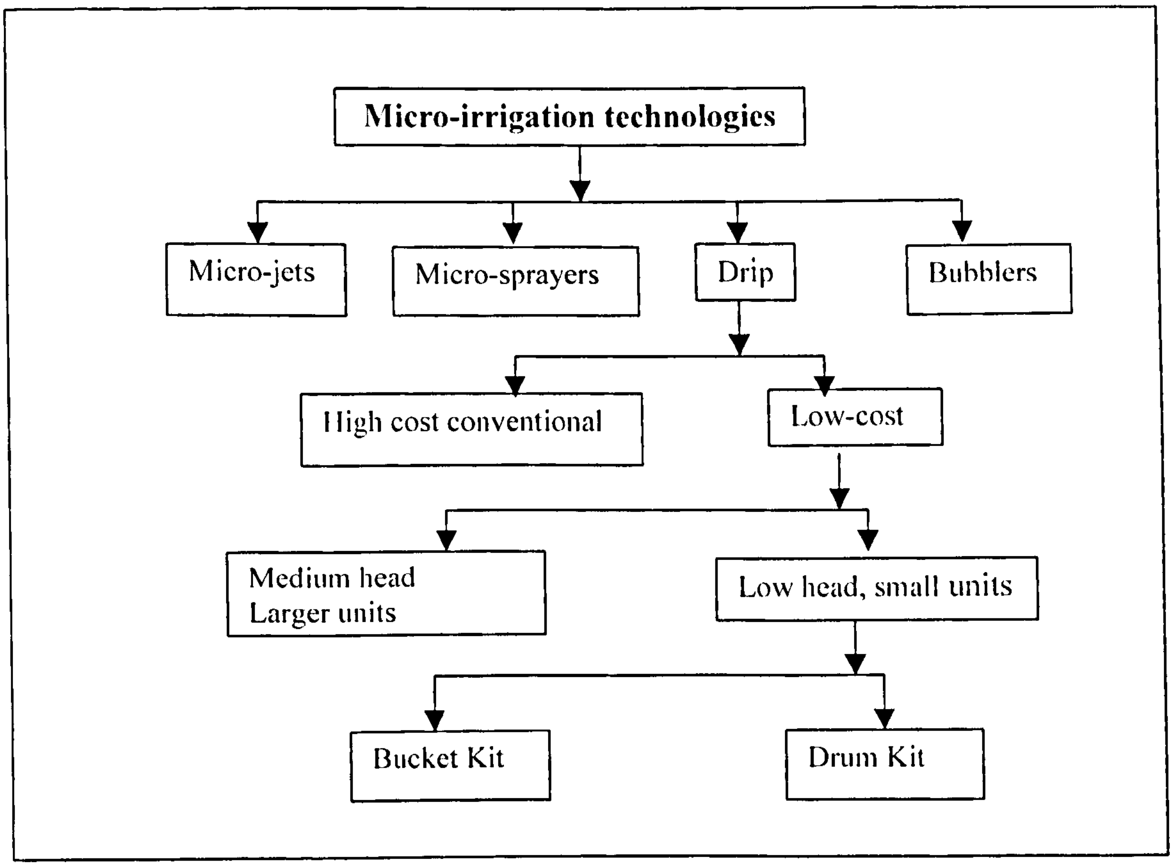


Fig 1.1 Typology of micro-irrigation technology

1.3 Aims and research questions

1.3.1 Research aim

The research aims to identify and explain the factors affecting the adoption of low-cost drip irrigation in order to understand how they influence the adoption and continued use of small-scale low-cost drip irrigation in Kenya. The resulting information may be useful to policy makers and development agencies in decision making on promotion of the technology. Such bodies may include government, NGOs, irrigation industry and other bodies involved in small-scale irrigation.

1.3.2 General research question

Population growth and development will increase demand on water resources in Africa, increasing further the need to be water efficient, especially in agriculture. The use of low-cost drip irrigation has the potential to reduce water wastage at the farm level, improving irrigation water utilisation. Moreover, this system is potentially suited to the small size of African small-scale farmers. Available literature suggests that low-cost medium head drip micro-irrigation is growing rapidly in India. However, from personal experience, low-cost drip irrigation is not yet significant in Kenya. Why is this so?

1.3.3 Specific research questions

To answer this, a number of questions emerged: -

1. What are the existing methods by which low-cost drip irrigation is made available to farmers in India, Africa and Kenya?
2. What irrigation systems are being adopted by small-scale farmers in Kenya and why?
3. For which small-scale farmers is continued adoption of low-cost low head drip irrigation applicable and why?
4. Is the low-cost low head drip irrigation available to the Kenyan small-scale farmer appropriate to his needs?

In order to answer the above questions there is need to identify and explain the main factors responsible for adoption and non-adoption of LCLH drip irrigation, with reference to the theory, by:

- Examining existing methods of introducing low-cost drip irrigation to farmers;
- Identifying problems of low-cost low head drip irrigation;
- Determining the factors required for the adoption and continued use of low-cost low head drip irrigation ; and
- Assessing the appropriateness of the low-cost low head drip irrigation systems available to the small-scale farmer

1.4 Scope of the study

The study was limited to small-scale irrigation farmers using any irrigation method on less than 3.0 hectares, and other major stakeholders of low-cost drip irrigation in Kenya, such as irrigation industry, NGOs, and Government representatives. It also included smallholder farmers who had discontinued low-cost drip irrigation.

In terms of location, the study was limited to Uasin Gishu, Kajiado, Rachuonyo, Kiambu, Yatta, Kathiani, and Kitui areas of Kenya. These areas were selected because they were likely to have sufficient number of low-cost drip irrigation farmers for the survey work.

The emphasis of Phase 1 questionnaire was on the process of the adoption of low-cost drip irrigation with lessons from the review of the Indian experience of low-cost drip- irrigation development.

1.5 Justification of the study

Low-cost drip irrigation is promoted for its potential to save water. However, such potential may not be realised in practice. This study could establish whether such potential could be realised in practise in the study areas, and or whether other factors would make the technology unsuitable. This is in view of the fact that:

- Small-scale irrigation is increasingly being recognised in Africa by many governments and organisations as important in the improvement of agricultural production and rural development after the fateful experience of many large-scale irrigation schemes (Carter 1989); low-cost drip irrigation may be appropriate method;
- Africa has one of the lowest amount of water available relative to its population due to climate;
- The study will add to the available literature on small-scale irrigation (SSI) farms in Africa; and
- It will provide programme managers, policy makers and planners, researchers, with information on low-cost drip irrigation, which might help them effectively, decide the best way forward for low-cost drip irrigation programmes.

1.6 Outline of methodology

1.6.1 Brief review of methodology

Figure 1.2 illustrates the methodology outline followed in this research. The study started with formulation of research objectives and questions. This was followed by the identification of the theoretical framework; this was subsequently based on the Rogers (1995) model of innovation -decision process. Then literature on experiences of low-cost drip irrigation in India and Africa was reviewed. The key question was what Kenya could learn from the Indian experience.

Based on the information from literature review and the research questions, questionnaires were formulated which were used in the first phase survey in Kenya. The purpose of the first phase survey was to identify factors influencing low-cost drip irrigation. The key informants were farmers who practice LCLH drip irrigation, non drip irrigation farmers, government, irrigation industry, and NGOs representatives.

The results in the first survey led to the formulation of the questionnaire in the second phase. The objective of the second phase survey was to identify factors associated with discontinuation of low-cost drip irrigation in Kenya. Consequently, the informants were farmers who had discontinued low-cost drip irrigation and those who had continued using it. The study ended with the synthesis and discussion of the results of the two survey phases before finishing with the summary and conclusions.

1.6.2 Reviewing documented records

The main information sources were literature review, document records and the case study in Kenya. Literature on low-cost drip irrigation developments in India and Africa was reviewed to understand existing development approaches and identify factors of important influence. Secondary information was also obtained from reviewing published and unpublished materials related to the development of low-cost drip irrigation in Kenya. The main documents available were reports and guidelines, workshop proceedings, brochures and magazines. These were reviewed considering possible bias due to their commercial origins, public relation aspects, and/or the need to portray a positive image of the office.

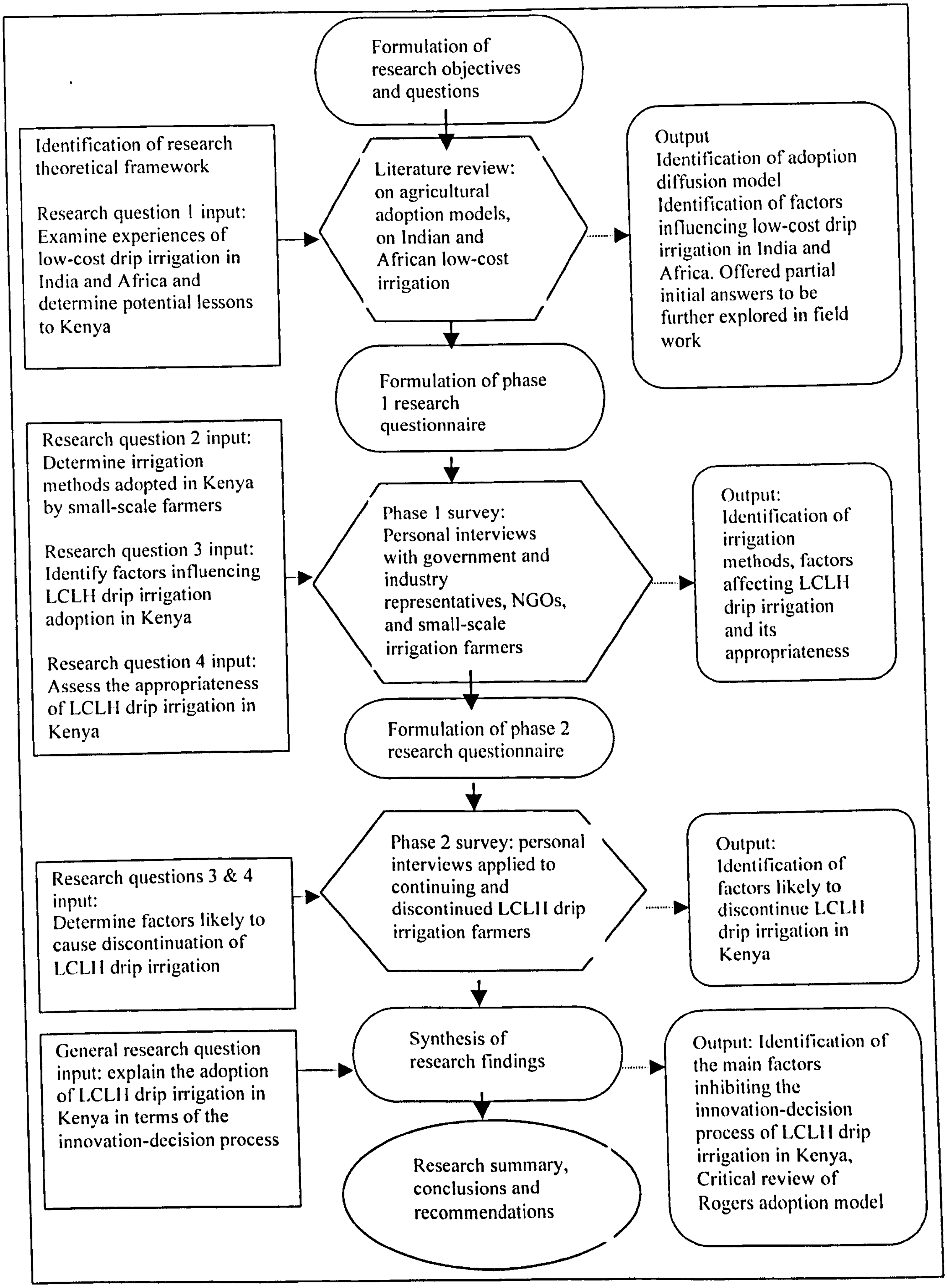


Fig 1.2 Outline of research procedure

1.6.3 Semi-structured questionnaire

The first phase questionnaires were developed based on the literature review of experiences of low-cost drip irrigation adoption in India and Africa - a different questionnaire was formulated for each target group. The questions were generally semi-structured and open-ended in order to obtain additional information as well as to verify some of the information collected through the literature review. The second questionnaire was developed based on results from the first phase.

1.6.4 Interviews

The surveys were carried out during the dry seasons (January-April) of 2001 and 2002, when irrigation was likely to be at its peak, using face-to-face interviews and informal discussions in parts of North Rift Valley, Central, and Eastern Kenya. The interviews were recorded using a cassette recorder and later transcribed for analysis.

1.6.5 Data analysis

In the analysis of the first phase data, descriptive statistics and qualitative methods were employed. The SPSS homogeneity analysis statistical package was used to analyse the second phase data to identify factors associated with discontinued adoption (Meulman & Heiser 1999).

1.7 Overview of thesis structure

This study document comprises of 9 chapters and several appendices as follows:

Chapter One is the introduction to the thesis starting with an outline review of irrigation practice in Africa and the potential role of low-cost drip irrigation. A typology of micro-irrigation methods is given. The research questions and the scope of the study are then discussed. Then the study justification and thesis structure are presented.

Chapter Two reviews literature on the theory of the innovation-decision adoption process and other models of technology adoption in agricultural development. In addition, it gives an outline of features of agricultural development in less developed countries, sustainable agriculture, appropriate technology, technology change and rural knowledge

Chapter Three is the review of low-cost drip irrigation experiences in Asia and Africa.

Chapter Four reviews irrigation in Kenya with emphasis on small-scale irrigation and the drip kit.

Chapter Five describes the development of the research methodology, starting from the design, sampling and data collection methods. It also gives a brief explanation of the approach to phase 1 data analysis and the limitations of the data collected.

Chapter Six presents the data collected from the first phase survey and explains the analysis procedure adopted. The findings are used to set the research objectives for Phase 2 survey in next chapter.

Chapter Seven combines the objectives, procedure, and the results of the Phase 2 survey. It introduces the concepts of Homogeneity analysis used to analyse the results of the Phase 2 survey. A discussion of why some farmers discontinue the adoption of LCLH drip irrigation follows together with an outline of the limitations of the phase 2 survey.

The synthesis of the study findings is carried out in Chapter Eight. This chapter combines discussions of the findings of the literature review, the Phase 1 survey and the Phase 2 survey. These are then reviewed in terms of the innovation-decision process.

Finally, the thesis summary, conclusions and recommendations are presented in Chapter Nine.

1.8 Chapter 1 Summary

Africa has a potential for irrigation but large-scale irrigation has been experiencing problems. Consequently, some African countries have been turning to small-scale irrigation in which low-cost drip irrigation could have a potential role to play.

Research questions were raised to answer why low-cost drip irrigation is not significant in Kenya. The scope and the outline of the methodology were described. The research is to be achieved through a two-phase informal survey on small-scale irrigation (SSI) farmers, NGOs, and irrigation industry and a literature review on low-cost drip irrigation development in India and Africa. The findings could be useful for policy makers, researchers, and implementers of low-cost drip irrigation in Kenya.

CHAPTER 2

TECHNOLOGICAL CHANGE AND MODELS FOR ADOPTION IN AGRICULTURAL DEVELOPMENT

2.1 Chapter introduction

This chapter begins with a brief overview of agricultural development in less developed countries, technology change and appropriate technology. In addition, sustainable agriculture and rural people's knowledge are explained. This forms part of the background to the study. Then, the theory of technology diffusion and the Innovation-Decision process are discussed as the framework for the study. This will be used to identify factors influencing the adoption of LCLH drip irrigation in Kenya. Consequently, recommendations that may affect the promotion of appropriate low-cost drip irrigation may be derived. The chapter finishes off with an outline of other models available for explaining adoption of agricultural technologies and assessment of suitability of the Rogers (1995) innovation-decision model.

2.2 Agricultural development in less developed countries (LDC)

The process of agricultural technology adoption in less developed countries (LDC) is part of the overall development of a nation. The exact universal meaning of development is difficult to define. It is usually associated with the process of growing, advancement, improvement or progress. Technically, development may be defined as the process of improving the quality of all human lives by raising their living standards, increasing their freedom to choose goods and services, and creating conditions conducive to the growth of self esteem (dignity and respect) (Todaro & Smith 2003). Development is seen as a modernising force or process, one that acts to transform traditional practices, in agricultural research and extension (Scoones & Thompson 1994). However traditional practices may not always be necessarily inferior.

Evolution and development can be viewed as process of change driven by need to solve a problem in existing systems (adaptive change), rather than as a series of inventory and discoveries whereby older and intrinsically inferior systems are steadily replaced in a linear fashion by newer and intrinsically better systems or progress (Khon Kaen University 1987).

The importance of agricultural development in LDC is evident when it is realised that the majority of the people in LDC are poor living in rural areas dependent on agriculture for food production and income generation and its role in Gross National Product (GNP). Regrettably, in Africa agricultural production has been falling per head resulting in lower land and labour productivity. African real Gross Domestic Product (GDP) grew at only 0.6% annually between 1820 and 1992, which was half the rate of world growth (Binswanger & Townsend 2000). Much of the Gross Domestic Product (GDP) is from agriculture, and this sector has done poorly. Some of the causes are:-

- Adverse resource endowment- low population density makes provision of infrastructure expensive and provides low market capacity;
- Poor policies and institutional failures are common;
- Adverse trade regimes of organisation - Unfavourable international trade practices have accelerated the decline in world agricultural prices and therefore limited export and the growth potential of agriculture in LDC;
- Endemic political conflicts, e.g. Rwanda, Angola, Liberia, Sudan have inhibited beneficial exploitation of natural resources including agricultural production;
- Erratic weather conditions, e.g. famine causing starvation.

Other factors are: -

- High population growth;
- Lack of investment;
- Some LDC giving more emphasis to cash crops;
- Mismanagement of agricultural projects;
- Unreliable local and international markets ; and
- Dependence on external loans.

With so many adverse factors, smallholder farmers in LDC operate under high-risk conditions and uncertainty (Ellis 1988). Such a background for introducing a technology such as the low-cost drip irrigation in Kenya present problems, even when the technology has the potential to increase agricultural production. Often the need for smallholder farmers to survive under such high risk overtakes the economics (profits) of agricultural production as driving force.

2.3 Technology-change

A variety of terms are used to define technology. Wilson (2002) writes that technology is the purposeful, organised application of knowledge to practical tasks, involving an interaction of tools and people. It is linked to development that ultimately is about practical activity. The tools can be both hardware such as drip kit in this study or software such as management practices and techniques (e.g. the techniques of introducing the drip kit). Technology embraces increment in knowledge, which can be through our culture (traditional knowledge) or may be modern - knowledge - or combination of the two (Farrington 1993). Its acceptance may be reflected in the nature of its impacts on the culture. The knowledge may be something "hard", e.g. written information or something we feel and which is acquired by doing (skills).

Rogers (1995) describes technology in a similar way, stating that it has both physical and abstract components. The physical aspect - the hardware consists of the tool that embodies the technology as physical object while the abstract aspect - the software consists of the information base tool. He defines technology as a design for instrumental action that reduces uncertainty in the cause-effect relationship involved in achieving a desired outcome. This covers the low-cost drip irrigation in this study because it is aimed at reducing uncertainty in agricultural production.

The purpose of the low-cost drip irrigation is to reduce uncertainty in crop production thereby minimising the risk. It reduces the risks of crop failure from erratic or poor weather conditions and may increase the intensity of crop production. The results are increased yields, increased job opportunities, and agricultural development into new areas. This may lead to better food provision, reduced risks of malnutrition, and increased disposable incomes from surplus produce. The consumers may benefit too from lower food prices.

Technology change is the process of modification and expansion of the hardware or the software of the technology. It is a change in the set of available technologies, which can range from minor modification to radical changes. People are often suspicious of the latter (Mogavero & Shane 1982). Technology change is important in development because an improvement of technology may allow users to produce more goods with fewer factors.

2.4 Appropriate technology

The concept of appropriate technology emerged in the 1970s when it was realised that technology transfer from the western countries to LDC was not taking place despite great efforts. It became apparent that perhaps the technology designed in western countries for the western environment and problems could not just be simply transferred to LDC. What was needed perhaps was appropriate technology for LDC (Schumacher 1973). A number of appropriate technology project were initiated in LDC countries such as cashew processing in Honduras, the rower pump in Bangladesh, improved extraction of palm oil in Ghana, and mini hydro power development in Nepal (Buatsi 1988). This trend has continued to date. However, there is a danger of using inferior adapted and under-designed technologies as an excuse for appropriate technology.

When it was first introduced, appropriate technology was defined generally - in terms of which technology was able to best use production resources such as labour, land, skills, capital and natural resources. Today the definition for appropriate technology has been expanded to include other social-economic factors and the characteristics of the technology itself. For LDC, appropriate technology means it should first and foremost be affordable, efficient, reliable, and durable in its work, e.g. by improving the quality or quantity of its services under the local conditions. For example, a study on appropriate sanitation systems in South Africa based on cost effectiveness for the poor looked at the impact of alternative technology considering technology efficiency and focus, replicability and desirability (MjoliMncube 1997). In Malawi, the performance of a locally constructed solar air dryer for food dehydration was found to be effective and suitable for preservation of mangoes (Madhopa et al 2002). In addition, simple technologies which may be easy to understand the principles of working may lead to proper operation without subjecting it to unnecessary abuse which might render it in-operative. For instance, a survey conducted in Nigeria on appropriate oil seed processing found that 28% of the total number of them had failed due to breakdowns, inadequate raw materials, and lack of markets. Most of the oil seed machines operators could not perform some processes because of lack of knowledge. (Faborode et al 2002)

From the economic school of thought, an appropriate technology is that technology that is appropriate for the existing factor endowments (Todaro & Smiths 2003). It seeks to economise on the use of the most expensive production factors by using a set of techniques which makes optimum use of available resources in a given conditions. It was found that additional labour requirements, at the time when local labour demand was high, discouraged farmers in Madagascar practising appropriate system of rice intensification (SRI) despite its potential for high yields. (Moser & Barret 2003)

With reference to mechanical appropriate technology (such as LCLH drip irrigation), Wicklein (1998) considers other factors needed for a technology to be appropriate which include the system independence in terms of supporting facilities. A technology, which requires a lot of supportive facilities to operate, has increased external risk. This is the risk associated with the support system needed to keep the technology working. For example, for low-cost drip to operate it needs a water supply. If the water supply is not easily accessible but needs development, or the water needs pumping, the water has to be bought or fetched from long distances then this will add extra costs, which may discontinue the adoption of the technology. All these elements could be fiscal barriers for the majority of the poor African smallholder farmers who may need the technology. Moreover, there may be little point in introducing a technology that is unlikely to be compatible with local and user values, attitudes and preferences. For instance, the pastoral communities in Kenya whose culture depends on meat and dairy for their food, arable and irrigation in particular, may regard it as arduous activity (Hogg 1988). In contrasts with other cultures that place high priority on individual responsibility and accomplishment. This may be true of communities growing cash crops in Kenya.

An image of modernity may also be an important factor for an appropriate technology because few people would like to be associated with a technology that looks old-fashioned or appears to be for the lower class of the society. The small LCLH bucket drip kit may be a victim of this factor.

Most farmers do not want to fully adopt a new technology at once without assessing the associated risks it may bring with it. This is because the development

/introduction of a technology carries with it a given chance of either success or failure. For example, low-cost drip irrigation is introduced to reduce risks of crop failure and increase agricultural production. Nevertheless, the introduction of this technology may also introduce other risks, some of which may be greater than the original risk. Therefore, an appropriate technology should allow for the assessment of such risks by being phase-able or divisible in its application. This means it should be able to be tried in small doses or pieces. Moreover, the chances of such technology succeeding are enhanced if it can serve or is capable of serving several purposes at the same time (Wicklein 1998). This could be one reason why the treadle pump has been so successful in parts of Asia and Africa. It can be used to get water for low-cost drip irrigation, for domestic use or for livestock.

Lastly, an appropriate technology should be able to employ local skills and labour which removes the need for patents, duties and shipping costs.

From the foregoing discussion on criteria for a general appropriate technology, the description for an appropriate technology for African smallholder irrigation may be derived. Cornish (1998) gives the following criteria for an appropriate technology for sub-Saharan Africa:

1. Should be cheap (affordable);
2. Easy to operate and maintain;
3. Reliable;
4. Durable;
5. With minimum imported material- reproduced locally;
6. Using low energy requirements; and
7. It should be portable and suitable for use on small irregular shaped plots.

The following points may also be important in designing or evaluation of such technology:

8. The technology should compatible with local user values, attitudes and preferences;
9. It should have some image of modernity; and
10. Should be expandable.

The evaluation of an appropriate technology such as low-cost drip irrigation can be based on these criteria and they will be used to assess its performance/suitability in this study. These aspects will be incorporated in the interpretation of the theoretical framework of the study. However, there is no appropriate technology suitable for all conditions. Each has to be gauged in the context under which it operates, and that is why it is difficulty to come up with an appropriate technology without involving fully the local farmers and considering the conditions under which they operate. This is part of the subject of this study.

2.5 Sustainable agriculture

A consensus among social scientists on the meaning of sustainable agriculture has been difficult to find. Ikerd et al (2003) quoting Allen et al (1991) gives the following definition: "A sustainable agriculture is one that equitably balances concerns of environmental soundness, economic viability, and social justice among all sectors of the society". While the World Commission on Environmental Development, WCED (1987) described it thus:

> "Humanity *has the ability to make development sustainable - to ensure that it meets the needs for the present without compromising the ability of future generations to meet their own needs. The concepts of sustainable development does imply limits - not absolute limits but limitations imposed by the present state of technology and social organisations on environmental resources and by the ability of the biosphere to absorb the effects of human activities".*

These definitions and others seem to agree on three element of sustainable agriculture: a sustainable agriculture must be economically viable, socially responsible, and ecologically sound (Ikerd 1994). This suggests a steady state between human activity and the environment. It shows the need to strive socially and economically to achieve sustainable development.

Thus, the low-cost drip irrigation can be regarded as a potentially sustainable technology because it is potentially economical by bringing in benefits for farmers if they are able to continue using it. The technology must demonstrate that it is economically viable. Otherwise, it discontinues.

The technology is also potentially socially supportive to smallholder farmers because it may provide food and health at a reasonable cost and opportunities for employment incomes that can be used to improve social welfare.

The low-cost drip irrigation can enhance environmental conservation since it does not waste a lot of irrigation water, and does not lead to water logging or overabstraction of ground water. It minimises erosion. Therefore it conserves the integrity of the natural ecosystem; hence, it is potentially a sustainable agricultural technology.

2.6 Rural people's knowledge

Knowledge may be regarded as the facts or experiences known by a person or group of people. It therefore relates to the way people view and understand the world around them and is linked to social, cultural, environmental and institutional contexts.

Many discussions of knowledge have been characterised by classification of knowledge systems into two broad categories, such as scientific knowledge and local knowledge. These have further been described as either Western or indigenous, formal or informal, inside or outside knowledge (Okali et al 1994). Informal knowledge gained by rural people outside schooling has also variously been referred to as Peoples Science (ethnoscience/village science), Indigenous Knowledge, Local Knowledge and Rural Peoples Knowledge. Local Knowledge is that which pertains to a place or position in space. It is the knowledge that has been adopted and developed or transformed into local life hence it is dynamic. Because local knowledge is dynamic, the distinction between different knowledge is sometimes blurred and may vary depending on who classifies it and why.

Chambers (1983) when reviewing this subject, states that the term "People Science" can be confusing because it can be and has been used to describe science for the people instead of science of the people. "Indigenous" implies originating from naturally produced knowledge. However, rural people's knowledge is also influenced by exogenous knowledge. "Local Knowledge" has a weakness of implying knowledge of a local environment rather than the knowledge of local people, which exist as a system of concepts, beliefs, and ways of learning.

"People's Knowledge" is adopted here because it seems the most inclusive term. In this case, the term "Rural" includes those farmers, both small and large-scale that produce and or market crops. The "People's" part of the terminology emphasises that much of the knowledge is located in the people and only rarely written down. "Knowledge" refers to the whole system of knowledge, including concepts, beliefs and perceptions, the stock of knowledge and the process by which it is acquired, stored, and transmitted. For example, for the low-cost drip irrigation people's knowledge would include any experience of the effectiveness, efficiency, and accessibility of the system and the risk associated with it. These are the criteria for the suitability / appropriateness of the technology. Rural people's knowledge and modern scientific knowledge are complimentary, and if combined they can sometimes achieve what nether would do alone.

2.7 Diffusion of new technology

In spite of a lot of research work on the subject of technology adoption, there are no universal explanations of technology adoption. This could be due to different background and disciplines which the authors empathise. Besides, the adoption process is multi-dimensional and highly complex process depending on physical factors and human factors, all of which are always changing with time. Adoption-Diffusion research emphasises the communication of ideas and personal attributes of potential adopters as a means of explaining the adoption process. It is sometimes referred to as the diffusion or communication model and typically describes five stages of the innovation-diffusion process from initial awareness of the innovation, through interest, evaluation, trial and adoption. Different communication methods are most effective in different stages of the diffusion model.

The beginning of the diffusion model started with a French sociologist who proposed the S-shaped diffusion curve and role of opinion leaders at the beginning of the last century (Harrier 1988). Sociologist continued to pioneer in the technology diffusion field until the 1960s when most of the work was on the diffusion of hybrid seed corn among Iowa farmers. Research in the field has examined the adoption and diffusion technologies both in US and abroad, with extensive studies of agricultural technologies in developing countries (Skaggs 2001). Rogers (1995) took a leading role in studies of adoption and diffusion and published a series of books from 1960s to 1995 in which he proposed a model of adoption and diffusion.

The methodology of this research is designed to identify factors affecting the adoption process of LCLH drip irrigation in Kenya. After studying the alternative models, the Rogers (1995) innovation-decision model was selected as a research framework for reasons explained in sections 2.9 and 2.13. The identified factors will be used to test the model to determine if there is a relationship between the model expectations and evidence from fieldwork. If the evidence presented by the identified factors is different then the model is not appropriate and revisions will be made. The survey interview will contain questions based on the Rogers (1995) innovation-decision process, which is now briefly reviewed.

2.7.1 The Rogers (1995) Innovation-Decision process

Rogers (1995) defines diffusion as the spread of a new idea from its source of invention or creation (an innovation) over time to its ultimate users or adopters. His model focuses on the diffusion of technology as a process of communication over space and time influenced mainly by potential users. As such, there are four key elements in his diffusion process: the innovation, time, the channels of communication, and social system. Fig. 2.0 outlines the main stages of this paradigm, the knowledge, persuasion, decision, adoption and confirmation stages which are now outlined below:

2.7.1.1 Knowledge stage

Knowledge is the first step in the adoption model. This is the stage when an individual is exposed to the innovation's existence and gains some understanding of how it functions. It is a process of first awareness and secondly - preliminary information seeking in which impersonal sources tends to dominate. The information is necessary to reduce uncertainty and potential risks in the innovation-decision process. Awareness in the Knowledge stage can be either accidental or induced. Individuals tend to have selective exposure to ideas that are in accordance with their interests, needs and attitudes. It follows therefore that the need for an innovation must precede awareness of the innovation.

There are three forms of knowledge:

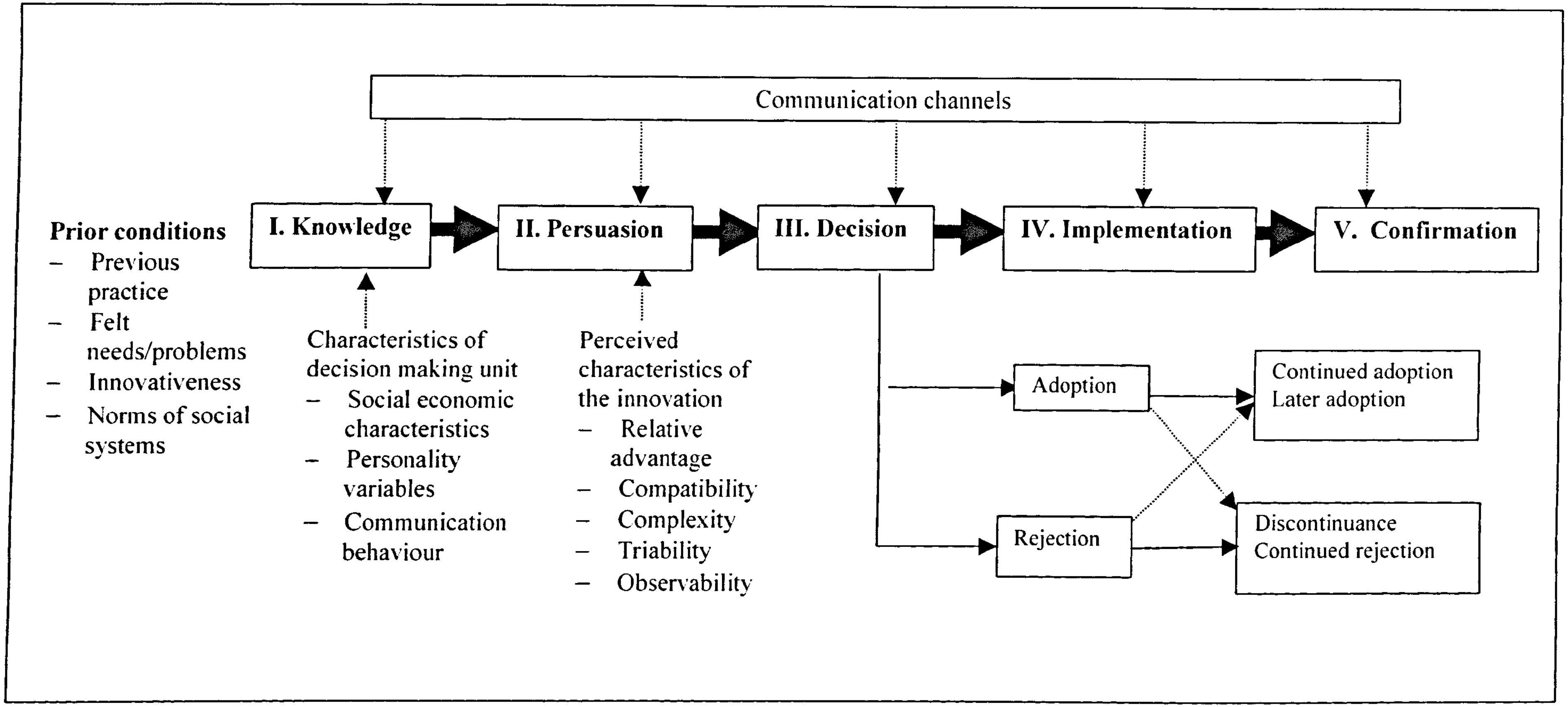
- Awareness-knowledge-to know that the innovation exist;
- Information of how to operate the innovation; and
- Understanding of the principles (theory) on which the innovation is based.

In this research finding out the knowledge the potential change agents and farmers have of the low-cost drip irrigation is important; to understand how this factor affects the adoption of the technology in Kenya. For example, "Information Knowledge" is crucial for proper maintenance of the low-cost drip irrigation technology. Farmers who decide to take up the technology without proper "Understanding Knowledge", without proper comprehension of the principle behind it, have a high risk of misusing it with consequent rejection of the innovation. The latter is likely to be the case in communities whose background (education, culture) would limit the ability to grasp the understanding knowledge of the innovation.

2.7.1.2 Persuasion Stage

At the persuasion stage the individual is "interested" in the innovation and actively seeks information. However, what messages he/she gets and how he interprets the information determines the general perception and finally the type of attitude he forms about the innovation. These perception factors - relative advantage, compatibility, perceived risky, divisibility, complexity and observability - are important considerations in the adoption process and are discussed in the next section. At this stage, the individual wants information from trusted sources, which are peers and friends, on specific issues as to the advantages, the disadvantages and the consequences of adopting. In this research, it is important to know what sources are available in the adoption process in order to understand whether appropriate sources were used.

Attitudes do not correlate well with prediction of adoption or rejection. Rogers (1995) quoting several sources, states that studies of knowledge-attitude-practice show that an attitude-use discrepancy may exist (KAP-gap) as a result of other factors coming into play beyond the individual's control. Therefore, in this research any attitude expressed by respondents may have to be treated with caution in terms of its future implication for low-cost drip adoption. The term gap here implies a mismatch/discrepancy. An attitude–adoption gap is specific to innovations that are preventative like adopting low-cost drip irrigation to prevent future water shortages. These are innovations that an individual could adopt in order to avoid a possible unwanted event in the future. The unwanted event may or may not happen if the innovation is not adopted



Source: Rogers 1995

Fig 2.0 Rogers (1995) Model of Innovation-Decision Process

Therefore, the rate of adoption of preventative innovations is relatively slow compared to non-preventative. However, "compelling or precipitating factors" can sometimes close the attitude-adoption gap for preventative innovation. These factors develop a favourable attitude towards change. Such factors may include a rise in problems of cost drip irrigation in this study such as increase of salinity hazards.

2.7.1.3 Decision stage

Following persuasion, the individual may decide to adopt or reject an innovation. This may also include a decision to implement on a trial basis. Adoption is making a decision that to make full use of an innovation is the best course of action available, while rejection is making a decision not to adopt. If the decision is to adopt then a limited trial may be carried out as a start, to reduce any uncertainty. For others, trials by friends may suffice. The adoption trial process can be speeded up by demonstrations. In the case of low-cost drip irrigation, it may be important to investigate what role demonstrations played in speeding the trial process in the study areas. On the other hand if the decision is to reject then they may do so actively by having first going through some or all of the adoption process or passively by never considering the innovation.

2.7.1.4 Implementation stage

Implementation is the fourth stage in the Rogers innovation decision process. It is recognised when an individual puts an innovation into use and it usually follows the decision stage directly. During this stage, the following information is vital for the farmer:

- Availability;
- The operation;
- Possible problems.
- Source of technology;
- Possible solutions; and

The implementation stage ends when the innovation finally loses its distinctive quality and the separate identity of the idea or problems.

2.7.1.5 Confirmation stage

Figure 2.0 shows the adopter who follows the implementation channel may finally decide to confirm the adoption. Even at this late stage, the individual may discontinue the adoption if exposed to different messages.

2.7.1.6 Discontinuance

Discontinuance can be of two types: First it may be a rejection in order to adopt a better innovation. This is called replacement discontinuance. The second type may be rejection based on poor performance which may or may not result from misuse. This is disenchantment discontinuance. Rogers (1995) states that high discontinuance is characterised by low education status and less change agent contact.

The type of discontinuance of LCLH drip irrigation and the reasons why some farmers have discontinued form part of this study.

2.7.1.7 Causes of incomplete adoption

Oliver (1990) discusses the potential frustrations in the adoption process model. For example, if at the inception level there has been no research or the wrong research, the benefits of the technology may not meet the potential adopters' needs. Moreover, although there may be needs and benefits, the majority of people may not understand how the technology fits their problem. Without this, there is no interest in getting information about the technology.

Conversely, selective exposure and distorted perception could lead to rejection. Therefore, it is imperative that communication is sufficient for the farmer to form a positive attitude to the technology.

At the evaluation stage, conviction may fail because of past experiences, while a trial may fail because of lack of availability of spares or customer confusion about how to buy or operate the technology. The other factor leading to dissonance is when the technology does not live up to expectations.

2.8 Factors influencing adoption in the innovation-decision process

2.8.1 Adoption as a function of characteristics of technology

This section highlights the main technological factors that affect rate of adoption process - these are most important at the persuasion stage. From his study work, Rogers (1995) states that in general, 49% to 87% of variance in the rate of adoption is explained by the perception factors of technology. Therefore, in studying the adoption of low-cost irrigation in Kenya it is important to look at how these factors may affect the rate of adoption. There are five main perception factors that will affect the rate of adoption of a new technology (Rogers 1995). These are:

– ***Relative advantage***

The first reason why individuals choose a new technology is because it is considered superior. This may be in terms of cost, profit, reliability, ease of operation, disease control or some value considered by the potential adopter. This superiority is the relative advantage, which is the degree to which an innovation is perceived as better than an existing one (Baker, 1996). Consequently, the greater the perceived benefit possessed by the new technology, the quicker and the higher the likelihood of adoption.

Therefore, it will be of interest, in this study, to examine whether the low-cost drip irrigation as a technology in Kenya is affordable, profitable, reliable and how easy it is to operate. How do these relate to the methods prior the implementation of the low-cost irrigation?

– ***Compatibility***

Compatibility is the second major factor in the perception and subsequent adoption of a new technology by an individual. A common question likely to be asked by a potential adopter is, "is the innovation consistent with my existing values, attitudes, habits, experiences and operation?" This defines the compatibility of the innovation. Adoption is quicker if the innovation is consistent with current use and practice, without requiring modification to itself or current work practices.

- *Complexity*

The complexity of a technology defines how difficult it is to understand and/or operate. A new technology, which is compatible as explained above but is complex to understand and operate, may not be adopted quickly. The low-cost drip irrigation is designed to be simple, but is it complex to use in practice?

- ***Triability/divisibility***

Triability is the degree to which a new technology can be tried on a limited basis, whether in terms of amount or time. Adoption is faster if individuals can obtain the innovation in small bits/fractions for trials and/or if it can be tested for a limited period. The adopters then could expand usage in relation to the results. This factor is important in the adoption process in reducing perceived risks. However, it is important to examine whether the divisibility of low-cost low head drip irrigation offers any real advantages.

- ***Perceived risk***

The aim of the triability is to assess risks by asking, "What degree of risk is associated with this technology?" The greater the economic or social risk attached to a new technology failure, the more reluctant buyers will be to try it. This is particularly pertinent to the adoption of low-cost irrigation method because the potential farmers already operate under high-risk conditions and any additional risks will discourage the adoption.

- ***Observability (Communicability)***

The factor of observability is particularly important during demonstration in the implementation stage. The results of the technology should be apparent and easy to communicate to others. Adoption is faster where the technology performance can be easily seen or demonstrated.

2.8.2 Adoption as a function of characteristics of decision maker

Even if all the necessary factors are present, not all individuals will take on the innovation at the same time. They may start at different times and adopt or reject the technology at different stages. Others may never start at all. The difference among individuals in their take-up response to a new technology is called their innovativeness. This represents the degree to which an individual is relatively early or late in adopting a new technology or idea. In social science (Rogers 1995), potential adopters are generally classified into 5 groups from innovators to laggards based on their innovativeness (Appendix 2). Although there is some uncertainty (Wind 1982) as to the traits of individuals used for grouping, the following factors are generally employed:

- Social economic factors - mainly, income, social status.
- Personality traits – mainly age which may determine flexibility of an individual. Adoption is more likely when the individual is flexible and a non-risk evader.
- Communication behaviour - mainly determined by education level, which may allow the individual access to a wide range of communication from social exposure, mass media, or with promoters.

The most important factors of relevance to this study to be investigated are the role played by social status, education, and age of the adopters in the adoption of low-cost in Kenya.

2.8.3 Adoption as a function of communication channels

In the Rogers (1995) definition of diffusion, the "communication channel" was its second element. Communication can be thought of as "the exchange of information, ideas, or feelings". It should therefore be a two-way process. It is an important part of the diffusion-adoption process, in which the innovators, promoters and adopters have to exchange ideas. An unsuccessful communication leads to rejection, misinterpretation, and/or misunderstanding (Smith 1993). A communication channel is the means by which messages get from one individual to another, such as publications, mass media and interpersonal channels.

Baker (1996) distinguishes two communication channels: personal and non-personal. The former embraces situations in which a direct, face to face communication takes place, while the later is the transmission of messages without face to face exchange. Personal channels are ineffective in establishing awareness knowledge but their influence is important in moving members further in the adoption process. The promotion of innovations perceived to have a relatively high risk is more effective with personal communication channels.

During the persuasion and decision stages, individuals seek information and opinions from other close associates while in the adoption; individuals depend more on sales or other promotion agents. Nevertheless, distortions occasionally occur to communication caused by group influences, which include leadership, norms, attitudes, beliefs and roles (Dibbs et al 1997). These interfere with the communication process.

2.8.4 Adoption as a function of characteristics of change agents

Formal change agents attempt to influence the clients in direction desired by the agent. Their role is important throughout the Innovation-Decision Process. This group may include technical support staff, sales men, extension staff, and opinion leaders. Rogers (1995) suggest that their success in securing adoption of a new technology is related to: -

- Efforts of the change agent;
- Change agent understanding and relationship with the clients;
- Information gradient;
- Credibility of the change agent to increase clients ability to evaluate the technology

Opinion leaders also act as change agents but they do this informally. They are individuals from whom others seek information and advice and who therefore influence the action of later adopters. Rogers (1995) reports that opinion leaders play a major role in the evaluation stage, especially for risky innovations. The majority are those who have more information than others, and others do depend on them for perceived advantages of the innovation. Most people do not evaluate an innovation because of its scientific values, apart from the very early adopters. Instead, most of them depend on information from others. In general, it is difficult to define the typical characteristics of opinion leaders.

The problems of information transfer are increased when there is more frequent horizontal communication (i.e. among individuals similar (homophilous) in terms of beliefs, education, social status) than vertical communication (i.e. among those who are different (heterophilous) in these aspects). The first problem is that for information to be transmitted there must be an information gradient. Secondly, the promoters are generally different from the clients. This creates a paradox. Although this is necessary for the information gradient, two heterophilous classes have less effective communication between them.

2.9 Criticism of Rogers (1995) Innovation-Decision Process

As with many concepts, the Rogers model may be useful for the insights that it gives, rather than in direct applications (Barker 1996). Morris et al (2000) quoting several sources, state that the paradigm has been criticised for being prescriptive, static, and deterministic. Thus, it may suggest an orderly, predicable and linear progression occurs throughout the process. Furthermore, the theory has led to an emphasis on the demand (adopter) side of the technology change rather than the supply (promoter) side. They state the importance of supply side is apparent in the role of the lead-user inventor, change agents and commercial organisations. They suggest that focusing on individual behaviour may inadequately account for the influences of the economic inducements. Moreover, the external factors associated with political and institutional changes are particularly critical especially when there is significance policy shift or uncertainty.

2.10 Innovation-Decision Process studies in agricultural development in LDC

The Rogers (1995) Innovation-Decision model has been used in several studies in less developed countries (LDC) in agricultural development: -

A case study in Ghana about factors associated with the adoption of three improved maize production technologies showed that three factors affected the adoption (Morris et al 1998):

- Characteristics of the technology complexity and risk
- Characteristics of farming environment-type of agro-ecological zone
- Characteristics of the farmers -availability of resources to farmer, and the education attained.

The role of education in adoption and diffusion of agricultural innovations was studied in Ethiopia (Sharada & Knight 2000). It was found that educated farmers were early innovators, providing an example which could be copied by less-educated farmers; and educated farmers were better able to copy those who innovate first, enhancing diffusion of new technology more widely within the site.

A survey of farmers was conducted in Mexico to assess commercial pepper producers' knowledge of and attitudes to drip irrigation, as a result of low uptake of the drip technology (Skaggs 2001). It was found that drip irrigation system tended to be adopted first in areas with relatively poor quality land where farmers gained more profits and had expensive irrigation water. The future of drip irrigation in pepper producing in Mexico was a complex one.

2.11 Criticism of adoption and diffusion approach

Rogers (1995) discusses in detail why diffusion research has received particular criticism and summarises them as follows:

- Its pro-innovative bias - the implication of most diffusion research that an innovation should be diffused and adopted by all members of a social system, that it should diffuse more rapidly, and that the innovation should neither be re-invented or rejected. This implies that all innovations are appropriate and the responsibility of adopting these technologies for agriculture development lies with the individual. However, in practice this is not necessarily so. A technology that is appropriate under certain conditions may be inappropriate in different set of conditions. That is why part of this research work is to find out whether the low-cost drip irrigation is appropriate in Kenya.

- The individual-blame bias - the tendency to hold an individual responsible for his or her problems rather than the success or failures of the system. This approach implies the individual needs to be more innovative and that the responsibility for development lies with him/her. This seems to ignore factors outside the farmer's control within the system of adoption for example the problem of lack of an adequate technical support service for low-cost drip irrigation.

- The recall problem - in diffusion research respondents are often asked to remember the time at which they adopted a new idea. This is likely to lead to inaccurate information. This point is important to this study because some of the questions require farmers to recall information due to lack of farm records. In fact, in this study questions relating to yield and farm input to estimate gross margins for various small-scale irrigation methods were cancelled due to the difficulties of obtaining such information in the field.

- The issue of equality - in the diffusion of innovation, social economic gaps between members of social system are often widened as a result of the spread of a new technology. The innovators are usually "the better off in a society", and generally get and utilise the technology earlier than others; hence they are likely to reap off the benefits of it before the "market" is saturated. Furthermore, change agents tend to concentrate on them instead of the needy and poorest members of the society. Moreover, a technology that has been targeted at this upper social group has little or no chance of vertical diffusion through to lower stratum classes, which contains the majority of smallholder farmers.

Despite these criticisms other models with emphasis on different factors exist as the following brief review indicates:

2.12 Other agricultural development models

The classification of different agricultural development models is complex, and may differ between different reviewers. Morris et al (2000) list other models developed for adoption for studying technology, some of which are briefly outlined in this section. The review of the main classes gives examples as far possible to demonstrate the application of the models in the adoption process in agricultural development (World Bank 1998, Garforth & Usher & 1997). This is followed by a review of the suitability of the Rogers (1995) model for this study.

2.12.1 Models of research management

These models suggest that the main determinant of uptake of relevance is the care and collaboration with which research goals are determined and research implementation is monitored and managed. These models give better information on research project preparation methods, commissioning and management such as:

- Rational project framework
- Close monitoring
- Full consultation with users
- Research and development using local equipment
- Strong management of both research and technology transfer personnel
- References to results of previous research
- Involvement of all relevant actors

After two case studies of the introduction of two technologies in Philippines and Vietnam, Boru (1998) suggested that research institutes should:

- Adopt fewer hierarchical ogarnisational structures to allow more flexibility and responsiveness to evolving situations;
- Have more flexible mandates that allow teams to be involved in the adoption of a new technology;
- Develop innovators who motivate researchers to work to solve farmers problems;
- Acknowledge that the innovation of first-adopters and manufacturers are often essential before widespread adoption will take place;
- Plan project to allow time and resources for working in partnership with manufacturers and first users to capture these innovations; and
- Give much more priority to monitoring, evaluation, and responses during the course of the project.

A study for Bangladesh Department for International Development support projects for sustainable agriculture showed among other factors the approach to manage the projects and influence of monitoring and evaluation as a learning mechanism (DFID 2001)

2.12.2 Models of technology development processes.

These are technology transfer models which are based on top-down processes that suppose that innovations are created by scientists and then transferred down a chain of intermediaries to their end users (World Bank 1998). Models of this kind suggest questions about the nature and efficiency of linkages between the different elements (process, institutions) within a sequence of stages, moving from research, through the generation, testing and adaptation of technology, to the dissemination and diffusion of proven technology. Such elements include agricultural research and technology transfer institutions. It is suggested that these elements do not simply pass information to one another. But both are involved in technology testing, adaptation and integration into farming systems.

The output of such models is the identification of barriers to effective transfer or uptake which may include institutional, human/cultural and management constraints. The criteria for evaluating links include:

- Integration of agriculture technology;
- Availability of new technologies:
- Relevance of new technologies; and
- Responsiveness of new technology to the needs of the poor.

A case study on adoption and impact of a new cassava variety in north-east Brazil showed that communities that successfully adopted cassava clipping's /drying plant had good support for their practice from institutions that provided training. In only a few cases was availability of credit a specific factor influencing adoption.

2.12.3 Models of information flow and process

Models of information flow and process are rare in adoption literature. These models focus on the fact that information is not just passed on between the various elements but it is interpreted evaluated, reformulated and then communicated. In doing so the various elements form perceptions about the technology. Therefore, these models highlight the extent to which perceptions of various actors may determine its uptake. The key factor is the role played by institutions of change such as the extension agencies.

In an empirical study, Harrer et al (1988) recommended that the influence of change agents be included in planning the communication and promotion strategy for innovative new technology. They found that change agents can be as important to the overall success of a new technology as mass advertising and other promotional efforts. The key questions/criteria were:

- Who are the change agents that have frequent contacts with potential adopters?
- What are the relative levels of trust and perceived expertise placed in these change agents by potential adopters?
- How can the individuals and groups comprising the most important change agents and influencers be convinced of the benefits of the irrigation technology so that they will disseminate information on these benefits to potential purchasers?

2.12.4 Multi-source of innovation model

In the Central Source model, innovations are seen to come from systematic work of central/international research centres (Biggs 1990). New innovations are then passed down one way, to (national) systems extension agencies and finally to farmers. The question is whether the only sources of innovative are central sources and whether it is passed down one way. In the Multiple Source model, innovations are seen as coming from diverse sources of which the (international/ central) centre are just one. Other sources include, research minded farmers, extension staff, NGOs, and private companies. In this model, there are several directions of flow of new ideas.

The Central Source model appears to dominate in research practice. For example terms like "transfer of technology, second generation, outreach programmes, farmer demonstration, and field days" akin to the Central Source model concepts, are commonly used in agricultural development.

2.12.5 System models (Information systems)

System models move away from uni-linear conception of technology development, and can deal more effectively with diversity of information sources and channels available to potential users. They range from models based on concepts of agricultural information as well as agricultural knowledge systems.

Research to explore in detail the sources and types of information accessed by grassroots farmers, in Uganda and Ghana (DFID 1999) found a considerable shortage of printed agriculture information that might prove of relevance to grass root farmers. Even where such material existed, distribution networks were inadequate. Few of the organisations visited, gave priority to meeting the needs of grassroots farmers for printed information. Instead, their efforts were directed towards networking with similar organisations through news-letters. Key information sources for all organisations producing agricultural information were books and newsletters.

2.12.6 Farmer first and beyond farmer first models

These are based on Participatory Action Research and are not so much a model of adoption as a strategy for enhancing the probability of adoption (World Bank 1998). These are learning process approach, centering upon the participation of local people and gradual but sustained evolution of successful solutions to development (Chambers 1983). These "models" arose from the fact the Transfer of Technology (TOT) models appeared not to be very effective. "Farmer first" was started in the 1980s (e.g. Chambers 1983, Chambers et al 1989) whiles "Beyond farmer first" superseded it in the 1990s (e.g. Scoones & Thomson (1994) reversing the model of Central and Multiple sources by starting with farmers first in the research process. Thus, placing him at the centre of research. The current emphasis in much agricultural development work is in understanding and involving the farmer where resources allow. That is why "Farmer participatory research methods" have become popular more recently within research into technology transfers alongside the established top-down progression ones. Hence, terminology and phrases such as "Bottom-up, Participatory, involve farmers first, farmers should view project as theirs" are presently common.

The key features of "Farmer first" was that farmers were not just adopters and rejecters but active participants by being assisted by researchers or technological transfer agents to perform their own experiments at the farm level. The role of the change agents had to move from an "instructor" to facilitation only. The unilinear framework of transfer of technology is replaced by user analysis, choice while experimentation and trial are decentralised.

Unlike the "Farmer First" model "Beyond Farmer First" considers differences in interests within communities and rural (local) knowledge which is not uniform across the community. These differences can be incorporated in research to improve adoption of technology.

2.13 Suitability of the Rogers (1995) innovation-decision process

The review of these models demonstrates the need for different approaches to planning and implementation of agricultural development research. It is important to understand the given conditions, the type of research, the desired output, and any particular issues at hand for application of the respective model.

The models of "research management" may give better information on the role of research and monitoring of the LCLH drip adoption while the " technology development process" model focuses on barriers to adoption that may include farmers needs and availability the drip kits.

Better assessment of the role of change agents can be obtained from "information flow" model. In contrast, both "multi source of innovation" and "systems models" may provide useful information on sources and communication channels available to potential adopters.

By putting the farmer at the centre of the adoption process, "learning process" models can provide assessment of farmers' needs and characteristics as well as the factors influencing the adoption process. However, this may require more time than is available for the study of LCLH drip irrigation in Kenya.

This review indicates that most of the models may be limited for this study because they do not appear to emphasise complete assessment of the important issues which are likely to influence LCLH drip irrigation in Kenya. Such information includes characteristics of the technology and the potential users, the communication channels and change agents' efforts. In-spite of the criticism the Rogers model; can provide a useful tool for understanding the adoption process incorporating the communication methods and the role of the change agents. It can also be extended to cover most of the factors in other models, making it more versatile. With this understanding, the Rogers Innovation-Decision model was selected as a suitable framework for this study.

2.14 Chapter 2 Summary

It was found that sustainability issues and Rural Knowledge are important for technological change. Many factors determine an appropriate technology. However, no technology is universally appropriate. It is important to understand the factors affecting the adoption of a technology, by understanding the basic principles of adoption process. There are different models for adoption in agricultural development, which give different emphasis to the various elements of the adoption process. The Rogers' Diffusion model appears to be the most versatile hence more suitable for this study. This is because it can be extended to incorporate other models or aspects of them. It can thus provide a versatile and accessible framework for understanding low-cost drip irrigation adopter behaviour. For instance, it was found in the model, that the communication channels, change agents, personal traits of potential adopters, and technological factors played an important role in influencing the rate of adoption of new technology. Since this study aims at identifying these factors influencing the adoption of LCLH drip irrigation, the adoption diffusion model was selected as a suitable framework for the study.

CHAPTER 3
REVIEW OF LOW-COST DRIP IRRIGATION IN INDIA AND SUB-SAHARAN AFRICA

3.1 Chapter introduction

This chapter reviews the use of low-cost drip irrigation in Africa and India in order to understand and identify the factors influencing its adoption. The chapter begins by exploring the approach of International Development Enterprise (IDE) for promotion of low-cost drip irrigation. Next, it explores why the use of low-cost medium head drip irrigation has grown first in India. In doing so, it considers the agronomic, economic, political, social and technological factors that influenced the change towards small-scale low-cost medium head drip irrigation. It then looks at the state of low-cost drip irrigation in sub-Saharan Africa outlining potential lessons that could be learned from India (Section 3.3). The chapter concludes with a summary and a link to the research methodology.

3.2 International Development Enterprise (IDE) and promotion of low-cost low head drip irrigation

3.2.1 Introduction

Low-cost drip irrigation was developed to reduce costs associated with conventional drip irrigation systems. This technology has been promoted since 1995 by International Development Enterprises (IDE), an international group of NGOs, mostly in India, Nepal, and China (Kay 2001). The IDE promotes mainly low-cost low head drip kits through local NGOs to small-scale farmers but also low-cost medium head drip irrigation units. Most of the equipment promoted is developed and tested by IDE itself. The IDE equipment irrigates areas as small as $20m^2$ to $20,000m^2$ (2 hectares) using simple punched orifices or micro-tubes and operating heads of 1-3 metres. Work by DFID (2003) showed that the market oriented approach of IDE reached middle and higher economic category farmers while local NGOs reached the poor farmers, who, without subsidies could not get the technology. Hence, the NGO intermediaries make it possible for the poor farmer to get it.

IDE has taken up the global challenge of spreading and intensifying the use of low-cost drip irrigation technology (Keller 2002). There are other organisations involved such as Winrock International (WI); Japanese Institute for Irrigation and Technology (JIIT), and the Swiss Agency for Development and Co-operation (SAFDC).

However, according to Kay (2001) the low-cost drip irrigation concept has yet to be tested and evaluated fully. The potential of institutional and/or commercial interests influencing the promotion of the technology also exists.

3.2.2 The market approach of IDE

The IDE has adopted the market approach for introducing low-cost drip irrigation. The theory underlying the market approach is that innovative farmers should be targeted first for introduction and others would copy and follow (DFID 2003). Working with farmers already growing commercial crops and subsistence farmers, it focuses on using local material, involving local manufacturers and suppliers, emphasising sustained marketing and mass awareness programmes. The goal is to make the manufacture and supply of the equipment commercially attractive. The strategy of mass marketing involves: -

- Affordable technology with high value crops;
- Local manufacturing encouraged with non-profit bodies;
- Supply network developed with fair profit margins;
- Training of local technicians; and
- Massive public information campaign to stimulate demand to develop reliable market.

The market approach is not entirely commercial. Start-up costs, costs of local NGOs, and the price of the products are subsidised to some extent. The supply chain however is allowed to make some profits. The aim is to establish an independent economically viable and profitable supply chain in the private sector which covers all steps from obtaining raw materials through manufacturing and assembly to distribution and spare parts dealers who sell the equipment to the users in rural areas (Heierli et al 2001). Where support services such as agricultural inputs, credit, markets, and extension, are lacking, interventions are made to complete the development chain. Hence, the market approach entails:

- Assessing feasibility and technology requirements;

- Adapting technology to local conditions;
- Social marketing of technology i.e. promotion through awareness, demonstrations, benefits of the technology etc;
- Analysing requirements for the supply chain and building them locally; and
- Analysing requirements for agricultural support and establishing the required links or building necessary structures.

The market approach has been successively used in the promotion of treadle pumps in Bangladesh, India, and South Africa. However, it assumes the technology is appropriate and meets the needs of the people. Otherwise, if low-cost technologies are found inappropriate under some conditions it is likely that this approach will face problems.

3.2.3 Achievements of IDE

The IDE states that low-cost drip irrigation has a huge potential for poverty eradication in many rural areas around the world. This is supported by the information in references below. However, whether low-cost drip irrigation can be adopted favourably under different conditions such as the study areas of this research is a matter for further investigation.

- Field studies have verified the hypothesis that small-plot irrigation technologies are powerful instrument for addressing rural poverty (IDE & WI 2000a & 2000b)

- IDE's experience has been that affordable drip irrigation technology enables smallholders to cultivate cash crops with small amounts of water and increased intensity. This enables farmers to increase their incomes 2-3 times more than income from traditional crops (IDE & WI 2000a)

- Farmers using the bucket kit irrigation have demonstrated that it is possible: to cultivate high value crops on small plots, in many cases year round and sell them in urban markets places. While this is a good start without affordable technology assistance they will never be able to scale up their efforts and grow beyond the 3500-800m^2 to which their labour resource limits them. (IDE & WI 200b)

- Low-cost irrigation has proven it has a substantial potential for poverty reduction in many rural areas around the world - in semi arid, arid areas as well as regions with uneven distribution rainfall. Farmers make good profits out of low-cost drip irrigation systems even in water abundant countries such as Bangladesh and Vietnam (Heierli et al 2001).

- In their efforts to globalise low-cost drip technologies, Heierli et al (2001) state that small-scale low-cost drip irrigation system has a huge potential to contribute to improving the livelihood of the poor farming families by enabling them to earn additional cash income or to grow food for themselves.

- In Nepal, low-cost low head drip irrigation increased income ten times from \$10 to 1000 compared with no irrigation. In most cases, the commercial farmers are able to take the advantage of the new technology. However, the extent to which subsistence farmers can benefit is unknown (Kay 2001).

3.2.4 Study findings by DFID on IDE program

Despite this information, a study by UK Department for International Development (DFID 2003) to identify constraints to adoption of low-cost drip irrigation technologies found that:

i. In India, there was a lack of conclusive evidence of commercially sustainable markets for the very small kits.

ii. Low-cost low head drip irrigation was not recommended in Zimbabwe, because farmers did not perceive water shortage and market demand in rural areas was poor.

iii. Small unit kits did not offer much incentive in terms of livelihood impact to poor farmers;

iv. The larger, "customised" and pressurised systems, irrigating 1-2 hectares, offered greater benefits and were more attractive to farmers who could afford them;

v. It might prove difficult to transfer low Indian prices into Africa. This was due to differences in the capacity to manufacture low-cost irrigation equipment locally.

The market-oriented approach itself could offer advantages in getting technology to the poor farmers, in specific enabling environment, but the need for continued support from NGOs or other intermediaries could not be overlooked. Such enabling conditions included: -

- At the village level
  - Technology must suit prevailing cropping patterns and agricultural practices;
  - There must be actual and perceived water scarcity;
  - The water source must be adjacent to the plot unless the growers are able to buy a pump;
  - Field plots must be visible from the homestead for security;
  - Markets for inputs and for produce should exist and be accessible;
  - Farmers should have access to good quality inputs; and
  - The promoting agent (NGOs) should be present for at least 3 years to provide technical and agronomic support to adopters.
- At the project level
  - Implementing team must be multidisciplinary; and
  - Adequate financial and human resources must be available to plan and implement promotional campaigns

- At regional level
  - Availability of industries capable of manufacturing the equipment;
  - Drip irrigation sector should exist in the commercial farm sector to heighten awareness amongst smallholder farmers and ensure supply of components;
  - Government policies should be supportive i.e. they do not already offer subsidies to low-cost drip irrigation equipment; and
  - Credit should be available for the poorest.

- Enabling conditions for the market approach
  - A functioning private sector and an NGO in the country;
  - The increase of low-cost drip irrigation products must support fair margins for the supply chain;
  - There should be donor funds of at least $5 per family for duration of 5 years to facilitate the market creation, the supply chain establishment etc; and
  - There should be a free market or some degree of liberalisation.

3.3 Review of low-cost medium head drip irrigation in India

3.3.1 Introduction

Saksena (1995) states that agriculture employed 70% of all workers in India contributing 29% of GDP in 1992-93. Most of the arable farming of India is under irrigation. About a quarter (21%) of the world's irrigated land is in India. The dominant irrigation method is surface. FAO (1999) reported that there had been an increase in the uptake of both sprinkler and low-cost medium head irrigation in India because of an increase in the demand for water and the resulting scarcity. From about 1000 ha in 1985, the area under low-cost medium head drip irrigation for small-scale farmers increased to 70,860 ha in 1991. This was in a period of only six years with a remarkably high rate of increase of over 11,000 ha per year. By the year 2000, over 260,000 hectares were under low-cost medium head drip irrigation (Kulkarni 2000). Consequently, India has more area under low-cost medium head irrigation than most African countries (Appendix 3.0). However, low-cost drip irrigation is still a small fraction of irrigated land in India contributing less than 3%. The following are the possible reasons why there was such rapid increase of low-cost medium head irrigation in India.

3.3.2 Factors influencing adoption

3.3.2.1 Agronomic factors

One of the conditions favouring the adoption of low-cost medium head irrigation in India was efforts put into small-scale agricultural development in terms of horticultural development, irrigation of high value crops and emphasis on crops grown with short return economic period. Cornish (1998) quoting Saksena (1995) states that farmers in India were very slow in adopting low-cost medium head irrigation and only in the case of horticulture and cash crops. The progress was uneven and slow.

- ***Development of horticulture***

Table 3.1 shows that horticulture (vegetables and fruits) was a significant part of cash crop production in India accounting for 39% of area under cash crops.

Table 3.1 Area under horticulture and cash crops in India (1994)

Crop	Area (million ha)	% total area	Cumulative % total area
Cotton	6.4	35.7	35.7
Vegetables	4.1	22.5	58.2
Sugarcane	3.3	18.1	76.3
Fruit crops	3.0	16.5	92.8
Tea, coffee, other tree crops	1.1	6.0	98.8
Tobacco	0.3	1.6	100.0
Total	**18.2**	**100.0**	

Source: adapted from Sivanappan 1995

Kulkarni (2000) states that India has promoted horticultural development programme since 1991 bringing about 100,000 hectares under horticulture every year in Maharashtra alone leading low-cost medium head irrigation in adoption State. He concludes that the development of low-cost medium head irrigation was related to the expansion of horticulture, food processing industry and avenues for export of the products.

- ***Irrigation of high value crops***

Chauhan (1995) states that many small-scale farmers in India irrigate high value crops (Table 3.2). These and other industrial crops are cultivated on smallholder plots ranging from less than a hectare to 2 hectares (Appendix 3.1). Among vegetables, tomatoes, okra, onion, brinjals and pepper are the most preferred crops for irrigation (Kulkarni 2000). Table 3.2 shows the fraction of the area of other main drip irrigated crops in the state. Papaya, grapevine, and bananas are mainly produced by drip while most of the land (66%) under drip irrigation is under bananas, grapevine, sugar cane, and citrus cultivation.

Table 3.2 Drip irrigated crops in Maharashtra - India (1999)

Crop	Total area (ha) 1998	Total area under drip (ha)	% of crop area irrigated by drip	% share in total drip irrigated area
Banana	64,000	31,666	49	22
Grapevine	31,000	26,747	86	19
Sugarcane	517,500	19,400	3.8	14
Citrus	182,360	15,.811	8.7	11
Pomegranate	64,375	14,000	22	10
Cotton	27,59,900	6,700	0.2	5
Mango	331,442	5,600	1.7	4
Papaya	1763	1,630	92.5	1
Others *	142,998	8,495	6	6
Total	**4,095,338**	**130,049**		

Source: Kulkarni 2000, * Ber, sapota, guava

- ***Irrigation of short return economic period crops***

Cornish (1998) states that small-scale irrigation (SSI) farmers are likely to adopt a new technology such as low-cost drip irrigation if it has a short payback period of a year with a return of 2-3 times the alternative and durability of at least five years. This statement basically relates to the relative advantages discussed in the Rogers model (Chapter 2). Sivanappan (1995) and Saksena (1995) worked out the cost benefit ratio and pay back period for drip irrigation for major crops of India which showed that most crops had a short pay-back period of a year or less (Table 3.3 and appendix 3.2).

Table 3.3a Pay back periods of some drip irrigated crops of India

Pay-back period	Crops
18 months	Sugar cane, Cotton, Bananas,
12 months	Oranges, Papaya, Grape, Citrus
6 months	Tomatoes

Source: Sivanappan (1995) & Saksena (1995)

Suryawanishi (1995) showed that drip irrigation has potential benefits compared to surface irrigation methods Table 3.3b. The yield increase was found to as high as 88% for watermelon and water saving of up to 62% for chillies. In the Rogers (1995) model, it was stated that an innovation is likely be adopted if it has good relative advantages. These values demonstrate that low-cost drip irrigation has good relative advantages compared to surface irrigation methods.

Table 3.3b Comparison of yields and water utilisation: Flood/furrow irrigation Vs (LCMH) drip irrigation

	Yield (Mt/ha)			Water supplied (mm)		
Crop	Surface irrigation	Drip irrigation	Increase %	Surface irrigation	Drip irrigation	Water savings
Banana	57.5	87.5	52	1760	970	45
Sugar cane	128	170	33	2150	940	56
Tomato	32	48	50	300	184	39
Cotton	2.3	2.9	27	89.5	42	53
Cabbage	19.6	20	2	66	26.7	60
Watermelon	24	45	88	330	210	36
Chillies	4.2	6.1	44	109	41.8	62

Source: Suryawanishi 1995

3.3.2.2 Role of the drip irrigation industry

By 1995 there were over 50 different drip irrigation system manufacturers in India (Chauhan 1995), using basic systems with no reliance on automation or other labour saving devices. Nevertheless, they were not involved in low-cost low head drip irrigation systems. Jain Irrigation Systems Ltd in India, for example, has adopted a successful approach in the promotion of low-cost medium head drip irrigation (Suryawanshi 1995), that include the following:

- Demonstrations were arranged in the field on farmers plots;
- Extension work was undertaken through village level seminars with visual aides;
- The company was able to convince the government of the need for drip irrigation;
- The company developed simple products to simplify the operation and maintenance of the drip systems;
- Local manufacture allowed low-priced equipment because of avoiding import taxes;

- The company designed systems to suit the small size Indian land holding; and
- The company helped in organising subsidies from the government and loans from financial institutions for farmers to purchase their equipment.

Using this substantial manufacturing capacity, India started exporting irrigation equipment components to the USA, Europe, and some African countries. Furthermore, it also produced irrigation pumps for her own use, of which 97% were electric pumps (Sundaram 1997).

- ***Availability of low-cost drip irrigation***

It is generally believed that drip irrigation is one of the expensive irrigation methods. However, because of the promotional approach taken by the manufacturing industry in India, drip equipment was available at affordable prices. Furthermore SSI farmers had access to credit and subsidy organised by the manufacturing industry. This meant that more drip irrigation equipment was affordable. Table 3.4 shows the unit cost of drip irrigation in India, which was adopted for credit financing purposes (FAO 1999).

Table 3.4 Unit cost of (low-cost medium head) drip irrigation equipment for various crops in India

Crop	Spacing	Cost in US$ per ha.		
	m	Minimum	Maximum	Comments
Mango,	10x10	350	487	The cost of the complete system less water supply to the farm and pump sets
Coconut	7.5x7.5	389	706	
Citrus, apple	6x6	460	644	
Orange, Peach	5x5	518	785	
Lemon	4x4	564	766	
Bananas	3x3	688	983	Average $2000/ha
Papaya	1.8x1.8	964	1708	
Grapes	1.5x1.5	868	1462	
Vegetables				

Source: Saksena (1995)

- ***Low cost of borrowing***

One of the ways the financial institutions were active in promoting the low-cost medium head drip irrigation was by availing financial assistance at relatively low interest rates. Saksena (1995) states that national banks gave loans to farmers at low interest rate of 10% per annum under the refinance scheme of the National Bank of Agriculture and Rural Development.

3.3.2.3 Role of government and its agency

The Rogers (1995) model does not emphasise the role of external factors such as government policies that are important in affecting the adoption process. The literature review revealed that the Indian government played a major role in the adoption of low-cost medium head drip irrigation by creating such enabling conditions as:

- ***Liberal government financial development assistance***

The Indian Government was very active in the promotion of low-cost drip irrigation as early as 1988 by providing subsidies for the purchase of the equipment (Dua 1995). This was partly due to the efforts of the Jain company to which the government responded by establishing a grant of about $1 million to state provinces for funding drip systems. Subsides were available to farmers with land holdings of not more than 4 ha. Farmers received 50% of the system cost from the government. The remaining 50% of the cost was usually financed by banks with low interest and soft repayment terms.

- ***Water allocation policy***

The Indian government adopted a national water resources policy in 1987. It placed high priority to irrigation water by placing it only second to drinking water. All states develop their state water policy within the framework of the national water policy (Palanisami 1997), a favourable condition for promotion of irrigation.

- ***Agricultural research***

Research and development of standards are vital for an emerging technology such as drip irrigation. Chauhan (1995) states that India had a good "Small Industry Testing Agricultural Research Centre" (SITARC) and a set of standards from "Bureau of Indian Standards" (BIS) for the manufacture of irrigation equipment. Both Government and manufacturers did their own research before introducing LCMH drip irrigation systems to small-scale farms (Suryawanshi 1995). Furthermore, India has about 26 agricultural universities with several research stations involved in irrigation technology on farms (Palanisami 1997). These were important support factors for the promotion of low-cost medium head irrigation.

- ***Energy supply for rural areas***

97% of irrigation pumps sold are electric (Section 3.2). This was unlikely without an effective policy on implementation of government rural electrification. This, supported by the fact that 53% of the small-scale irrigated land in India used electrical power (FAO 1999), suggests that the investment in electrification has been another important factor in enabling small-scale low-cost medium head irrigation expansion.

- ***Irrigation water development***

Irrigation water supply is relatively well developed in India. Saksena (1995) states in India that canal and small reservoirs (tanks) supply 43% of the irrigation water, shallow wells and tube wells 50% and other sources remaining 7% (Fig 3.1). Although there are large dams, small earth tanks are common in southern India (Reinders 2000). The tanks are maintained by the farmers and used both for irrigation and domestic needs in the dry season. (Palanisami 1997)

Palanisami (1997) reports that there is a large variety of drilling equipment used in India. Egan et al (1997) observed that community owned deep wells for irrigation in Asia have been difficult to take up because a farmer wants the freedom to manage his own pump. It is difficult to organise many farmers to share a water source. For this reason, most smallholder farmers in India have private water sources for their irrigation usually wells (Cornish 1998). The development of tube wells irrigation, supported by investment in electrification for pumping, is another major factor in low-cost medium head irrigation development.

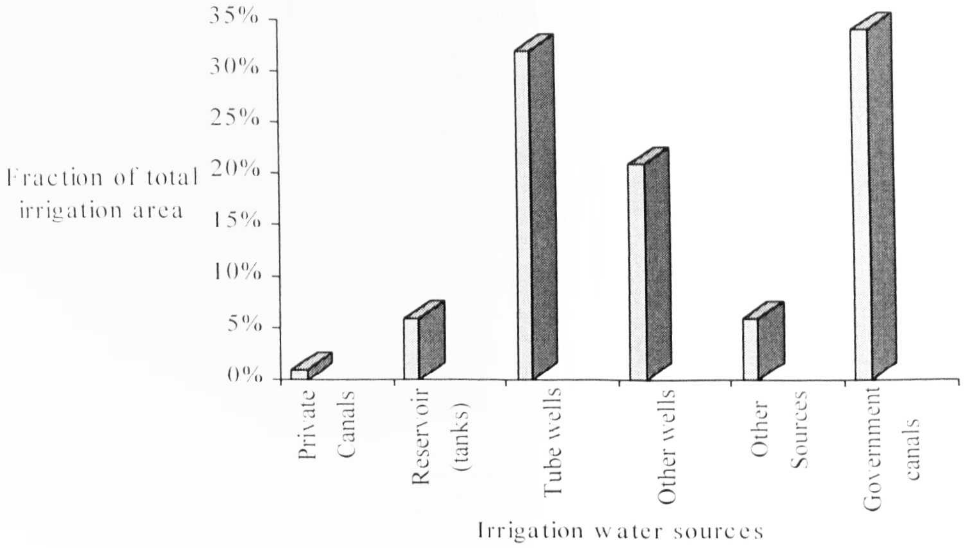


Figure 3.1 Irrigation water sources in India

- ***Water charges***

The cost of water is important in the promotion of water saving irrigation methods such as drip irrigation. In India out of 26 states, 24 charged for the use of irrigation water (FAO 1999). In most states the water charge are based on the irrigated area and sometimes further differentiated according to the source, crop or season. Saksena (1995) states that irrigation water rates on some government canals were so cheap that farmers who had access to the water would not even think of installing low-cost medium head irrigation or sprinkler. Besides, the basing of water charges on area does not create any benefit from water saving whatever the water rate.

3.3.2.4 Problems of non-drip irrigation methods

Suryawanshi (1995) has a good description of the role of the problems caused by surface irrigation methods in the promotion of drip irrigation in India:

> *"After a rapid increase of agriculture by irrigation, India faced a paradox in which salinity increased in the north while in the south the water were being depleted fast due to excessive pumping. Both shallow and deep water tables affected agricultural productivity to a point of stagnation. In the late eighties drip irrigation started to gain popularity because it was more efficient in water use and does not cause water logging and salinity, and can be used on problematic soils. Various research institutes conducted experiment and made people aware of the benefits. Some manufacturers also*

did their own research before venturing into commercial production of drip systems. Today more than 70, 000 ha are under low-cost medium head irrigation."

These "Compelling factors" are another example of external factors influencing the adoption of a technology not fully covered by the Rogers model of innovation-decision (I-D).

- ***Water scarcity***

Drip irrigation was adopted first in areas of acute water shortages before spreading out (Chauhan 1995). This was due to its relative advantage of water saving. Dua (1995) states that recurring drought in the eighties, scarcity of surface water, and depleted ground water had resulted in the need to find new alternatives to save arable farming. In some areas e.g. in Haryana not even drinking water was available. Cornish (1998) adds that one of the reasons for drip technology adoption in India was the low water availability accompanied by relatively affluent farmers who had easy access to markets.

3.3.2.5 Social factors - experience

The farmers were experienced and affluent from long practice of small-scale irrigation farming before the knowledge stage in the adoption process of low-cost drip irrigation. Hence, when drip irrigation was introduced in the 1980s it was easier for them to accept it as an alternative to the existing irrigation technology because of the relative advantages that it brought. Kulkarni (2000) explaining why Maharashtra State is a leading state in adoption of low-cost medium head irrigation in India, states that the farmers are progressive, enterprising and receptive to new technology. These farmers have considerable experience of irrigation and are traditional growers of grapes, bananas, sugarcane and other cash crops. They have established agricultural organisations, which can be utilised for water and marketing organisation.

3.3.3 Section summary and link to the study analytical framework

Fig 3.2 is a conceptual model summarising the "innovation -decision process" relating to the low-cost medium head adoption in India derived from information in this chapter. Most of the promotional factors are institutional, not strongly covered by the Rogers (1995) innovation-decision process.

The adoption process of low-cost drip kit in India starts off (prior conditions) mainly due to the compelling factors of salinity, water scarcity, flooding, and ground water over-abstraction resulting from surface and overhead irrigation methods which had been practised for a long time. The farmers are then made aware of the low-cost medium drip irrigation and are persuaded that it will meet their needs by solving these problems.

Apart from the water saving and increased yields, the Rogers (1995) perception factors have limited application here. The farmers then decide to implement drip irrigation and institutional factors less emphasised in the Rogers model appear to play a major role in this process. The farmers are assisted in the process by government, private sector, and research, institutions which make policies and laws, provide credit etc creating good enabling conditions for the adoption of the low-cost medium head drip irrigation.

The institutions also make available low-cost medium head customised LCMH drip equipment from the private sector, developed water supplies, energy supplies, and subsidies etc. all of which catalyse the adoption of low-cost drip irrigation. The intended result is increased adoption, resulting in water savings and reduced water scarcity, salinity and other problems on the smallholder farms. The "innovation-decision" conceptual model suggests that the following factors were vital in the rapid adoption of low-cost medium head drip kit in India:

- Problems caused by surface irrigation methods;
- Role of the government in provision of credit facilities, tax subsidies, policy, research, water development, and power supply;
- Role of private sector in irrigation equipment manufacturing and supply system, extension, credit, low cost equipment;
- Research focussed on low-cost medium head irrigation;

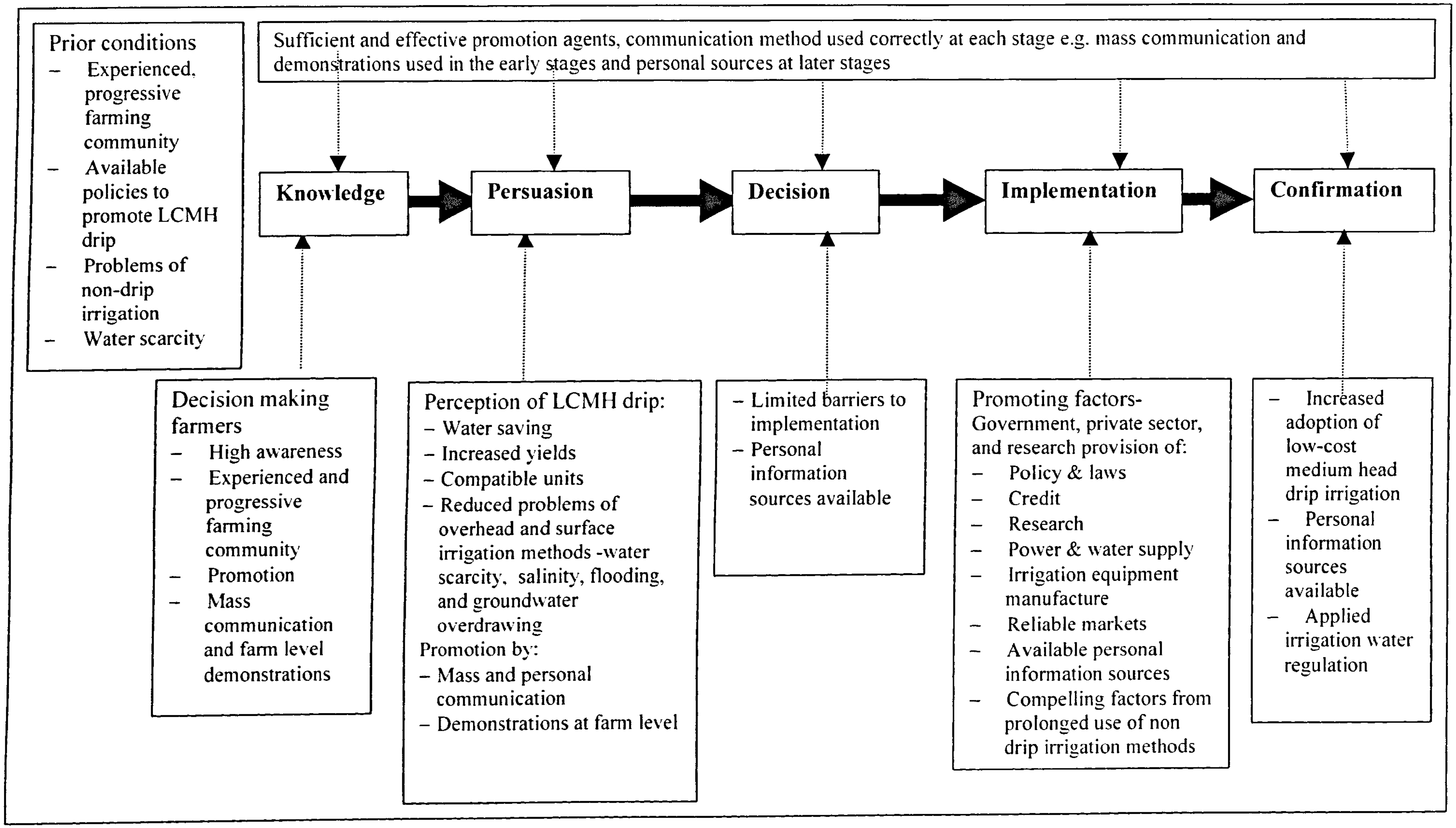


Fig 3.2 Innovation-Decision Process with respect to the Indian adoption of low-cost medium head drip irrigation

- The development and irrigation of cash crops with short pay-back periods with resultant high economic benefits;
- Scarcity of water with subsequent charging for it in some states;
- Good market for the food produced, due to high population density and;
- An experienced and progressive farming community.

3.4 Comparative review of low-cost drip irrigation in sub-Saharan Africa

3.4.1 Introduction

This section reviews the adoption of low-cost drip irrigation in sub-Saharan Africa in comparison to India. It suggests potential lessons that can be learnt from the Indian case if it wishes to expand low-cost drip irrigation. Later it links these to primary data collection methods of the research.

3.4.2 Factors influencing adoption

3.4.2.1 Agronomic factors

The role of the development of horticulture and high value crop in the adoption of low-cost drip irrigation in India was evident earlier in this chapter. Table 3.5 shows the main irrigated crops of Africa. The table shows that irrigated horticultural is relatively insignificant in Africa accounting for only 8% of the total irrigated area. Furthermore, the horticulture irrigation seems to be skewed towards vegetables in Africa unlike in India where it spreads further to fruits.

It was noted that Indian low-cost drip irrigation success was partly due to the growing of high value crops. The question is; are similar high value crops important in African small-scale farming and Kenya in particular? Appendix 3.0 shows that the areas under irrigation in Africa for high value crops such as vegetables, fruits, sugar cane, are relatively very low.

Nevertheless, Cornish (1998) states that in almost all cases identified in Africa, modern irrigation equipment is used to irrigate high value cash crops. In chapter 2 it was stated that African smallholder operates under high risks and may be unwilling to increase this risks. This is supported by Rukuni (19984a) who states that subsistence farmers are more concerned with risk management for their food - implying they were unlikely to adopt such technologies as drip irrigation for intensification of agricultural production.

Table 3.5. Main irrigated crops of Africa

Crop	Percentage area	Irrigation method	Remarks
Rice	30	Surface	Not applicable to low-cost drip irrigation
Cereals (wheat and maize)	34	Most of them	Not applicable to low-cost drip irrigation
Vegetables	8	Most of them	For cash and subsistence
Fodder	15	Most of them	Mainly South Africa, Egypt, Morocco
Industrial	8	Most of them	Sugar cane, Cotton, Oilseed, Cocoa, Coffee, tea
Arboricultural	5	Most of them	Citrus
	100		

Source: FAO 1995

- ***Irrigation of crops of short return economic period***

Table 3.6 shows that, most of the cash crops of Africa are vegetables. Although these are similar to the Indian case, they are not irrigated. Furthermore, the value of processed commodities is small relative to the total exported.

Table 3.6 Main African high value crops

Commodity	Export value $ millions
Fruit and vegetables	1217
Fresh Vegetables	930
Processed commodities	286
Oil seeds/oils	270
Oil seed	112.
Oils	158
Nut/spices	165
Nuts	58
Spices	106

Source: TARS database (World Bank). Cited by Rukuni (1997)

3.4.2.2 Sub-Saharan irrigation industry

India has a well-established drip irrigation-manufacturing base that has helped in the adoption of low-cost rip irrigation by producing irrigation equipment at a low price. In contrast, manual pumps are the only important component of irrigation equipment manufactured in most parts of Africa despite some countries having plastic industries, which could be utilised to manufacture low-cost drip irrigation equipment systems (Kandiah 1997).

Koegelenberg (1997) reviewing the manufacture of irrigation equipment and supply sector of South Africa cites South Africa as one of the few African countries that manufacture and supply irrigation equipment. However, De Lange (1997) adds that the emphasis in the South African farming industry has been on large and medium scale farming.

Consequently, Africa imports most of its pumps as well as other irrigation equipment from different parts of the world. The importation has made low-cost drip irrigation equipment expensive. In some cases (Zimbabwe, Tanzania), the locally manufactured pumps are too expensive for small-scale farmer because of government tariffs and taxes.

The role of private sector involvement in active promotion of low-cost drip irrigation in Africa appears virtually absent, but it was crucial for the success in India where it was effective in manufacturing, extension, financing, research and adaptation. Promotion of a new technology could involve huge investment that the African private sector may not be willing to spend without clear evidence of the potential of the irrigation system. This is particularly true of low-cost low head kits, which may be ignored for lack of potential commercial business. This perhaps explains why in India the private sector did not involve themselves with drum and bucket kits. Besides the private sector may have better business in the other sectors of irrigation industry.

Kandiah (1997) states that the main constraints to irrigation equipment manufacture in Africa are:

- High import duty on raw materials;
- Inadequate electric power;
- Insufficient credit system; and
- High cost of skilled labour.

3.4.2.3 Availability of market for farm produce

India with its large population and numerous urban centres was unlikely to find market problems with its food production in contrast to Africa. Although Africa is not self-sufficient in food production an improved food production technology, such as from low-cost drip irrigation could easily produce a local glut because of its relatively low population density and low purchasing power. Rukuni (1997) states that the bulk of African crops are sold semi-processed, have no guaranteed market and even where a market is available freight or transport facilities are limited.

3.4.2.4 Role of financial institutions and cost of borrowing

The Indian case suggested that for low-cost drip irrigation to be adopted by the African smallholder farmers, where appropriate, financial institutions should offer credit at low interest rates where necessary. However, few African countries have agricultural financial institutions targeting smallholder irrigation (Maurya & Sachan 1984). Instead, several countries use public financial institutions because commercial banks regard agriculture as a high-risk area. Where credit is offered the interest is high and is likely to be prohibitive to low-cost drip irrigation development. For instance, it is as high as 50%-60% in some African countries (Rukuni 1997).

3.4.2.5 Role of Government and its agents

Only a few African countries, such as Zimbabwe, give financial assistance to the cost of smallholder irrigation (Palanisami 1997). In Egypt, the government provided low interest loans for farmers to promote the adoption of drip irrigation after experiencing non drip irrigation related problems similar to India (Cornish 1998). There was little evidence to suggest that African countries promoted low-cost drip irrigation by providing capital, inputs, credit and/or training where appropriate.

High import duty on raw material is an important constraint on the manufacture of low-cost drip irrigation equipment. Kandiah (1997) quotes an import duty averaging about 45% for Tanzania, Malawi, Zambia and Zimbabwe.

- ***Role of agricultural research***

The introduction of a new agricultural technology such as low-cost drip irrigation is more likely to succeed where there is a functioning system of agricultural extension and research. Irrigation research has not been well planned and/or implemented in many developing countries including Africa (Jensen 1990). In general, African agricultural research is biased towards agronomy and economics, and little is in irrigation technology. Rukuni (1984b) states that the link between research and extension in many countries is poor; it is usually government sponsored with limited funding.

- ***Agricultural training and extension support***

Koegelenberg (1997) states that it is difficult to get suitable dealers, irrigation merchants, and extension staff with the expertise to handle even conventional irrigation systems in southern Africa. Demonstrations help as training sites for technicians, extension staff and farmers as well as equipment assessment. However, Kandiah (1997) observed that a number of African countries are without national irrigation demonstration centres. He cites Malawi, Tanzania, Zambia, Ethiopia and Zimbabwe as typical cases. Those that exist are often under-funded with poorer performance than neighbouring progressive farmer plots. This is also confirmed by my experience of localised government experimental farms in Kenya. May et al (1989) state that many agricultural training institutes including institutions of higher learning do not have well run learning and demonstration sites for small-scale irrigation. The training is heavily biased towards theoretical learning. Consequently, extension staff from these institutions may not be versed in the practical operation of irrigation and the knowledge required by the farmer.

In his discussion on the Kenyan experience on smallholder irrigation, Kimani (1984) cites lack of dedication by Government extension staff for disappointing adoption of relatively sophisticated irrigation technology at Kibirigwi. Technical assistance from change agents such as extension staff is very important particularly in initial adoption processes for the successful performance of a system and installs some confidence in the system in the farmers. Purcell (1997) observed that in Kenya, there is little awareness of innovative low cost technologies and their opportunities. Mbogoh (1990) found out that a low rate of adoption of agricultural technologies in Kenya was responsible for poor irrigation scheme performance and attributed this to poor extension work. De Lange (1997) cites the problems of development of SSI in South Africa as: -

- Poor extension work: no interaction between farmers and extension staff who lack skill, and commitment, and have inadequate exposure to technologies - this could be due to lack of incentives; and
- Water saving is often not a farmer's priority.

- ***Water scarcity***

Water resource development in Africa, especially of groundwater, is low. Water drilling appears to be in its introductory stage in many rural areas (Sonou 1997). This is compounded by lack of low-cost drilling equipment. Developed water supplies have often collapsed because of mismanagement. As a result, there is a need to increase water supply development and improve on its management. In addition, there is a low investment in irrigation water storage facilities, causing a wide spread use of direct abstraction for irrigation water (Chapter 6). Jurdell & Svensson (1998) found that labour to fetch irrigation water and water scarcity were important factors for rejection of supplementary irrigation in semi-arid areas of Kenya.

In contrast, the water supply in India is relatively well developed and water charged for in some states. The problems that caused water scarcity in India do not appear to be significant in Africa.

- ***Irrigation water regulation, charging and water rights***

Few African countries have some form of irrigation water levy (Cornish 1998). In Zimbabwe, farmers are required to pay for operation and maintenance of irrigation schemes in a number of gravity irrigation schemes (Kandiah 1997).

Collecting water charges, bureaucracy, and the cost of energy are the main operational issues for a small irrigation unit. For example, the purchase and running costs of the pump can make up to 70–75% of the farmer's production costs (Carter 1989). However, in many cost analyses for irrigation in Africa the cost of supplying irrigation water is often ignored (Maurya & Sachan 1984).

Wichelus (1999) states that farmers will misuse water when water rights are poorly defined. That is why they are unlikely to adopt water saving irrigation technologies. Quoting Meinzen-Dick & Rosegrant (1997), he states that, secure water rights encourage farmers to use their supply more efficiently particularly if the water rights can be sold or leased. This is likely to be more relevant where the water supply is developed rather than from undeveloped natural sources. However, Carter (1989) states that few countries in Africa have well-established legislation on water control. Diemer & Vincent (1992) noted that some of the sub-Saharan African problems arising from poor maintenance of the irrigation system works are because farmers are asked to maintain them but denied the right to invest and own them. Therefore, availability of independent water sources is more likely to promote successful SSI. It becomes more difficult to operate as the flexibility and independence of farmers' to irrigation water sources decreases (De Lange 1997). For example, Diemer & Speelman (1990) state that the village irrigation schemes in Senegal River valley were successful partly because farmers had independent and reliable irrigation water sources at their disposal.

3.4.2.6 Problems of overhead and surface irrigation methods on large-scale irrigation projects

Evidence of large-scale irrigation problems in Africa as experienced in India is scarce. However, this may not imply they are unlikely to occur. For instance, during an evaluation of the effect of water quality on the crop system, El Kadi et al (1997) found that the use of groundwater for surface irrigation on newly developed sandy soils in Egypt, was causing extensive groundwater withdraw. The consequences were high-energy costs, intensive use of labour, increased weeds and salinity. Because of these problems, the country was "compelled" to change towards low-cost drip irrigation method.

3.4.2.7 Role of Non-Governmental Organisations

NGOs are dominant in the development of much of African rural life. They act as agents between the groups and external organisations for credit inputs and marketing. They may also help in training, processing, leadership, organisation and accounting (Carter 1989). They operate on a small scale and it would appear that they are the ideal agents to promote low-cost drip irrigation on small-scale farms if they found it appropriate. Although some NGOs support low-cost drip irrigation, most appear to support local initiatives of the "conventional" irrigation methods such as surface and sprinkler methods. However, in his report on funding irrigation development in Kenya, Gakundi (1997), acting for a local NGO.

3.4.2.8 Social factors

The innovation-decision process shows that the cultural and social set up practices is important in the adoption process of technology. The irrigation predicament in Africa has shown that physical infrastructure rarely changes people's behaviour patterns (Diemer & Speelman 1990). This implies that even if an irrigation project is constructed and handed over to people, this will not necessarily change their cultural practice to start irrigation practice. Hogg (1988) quotes attempts by the Kenya government to introduce irrigation to pastoralists in Isiolo, Turkana, and Garisa, which failed because of their way of life. However, the Indian experience showed that low-cost drip irrigation project was more likely to succeed in areas where the community were enterprising, receptive to new agricultural technologies and with the relevant experience.

Makadho (1984) observed that unlike rain-fed agriculture most irrigation farming is a community affair because very often water and marketing have to be shared. This is likely to be the case with low-cost drip irrigation in many African countries because of the huge cost of developing water supply for individuals. Where this is practised, farmers have to adopt strict discipline in cropping patterns, water use, and water supply system maintenance for it to succeed. Besides introduction of irrigation may create competition with other activities in the social life. The consideration of these activities during planning stages may create a more positive response toward the introduction and adoption of low-cost drip irrigation.

3.5 Chapter 3 Summary and link with questionnaire for primary data collection

This chapter has identified and discussed the approach and the main factors influencing the development of low-cost drip irrigation in India and sub-Saharan Africa with special reference to adoption. The adoption of LCLH drip kit in India, promoted by International Development Enterprise (IDE), did not appear very successful because of lack of evidence of commercially sustainable markets for the very small kits. The adoption of LCMH drip irrigation for high value crops to supply urban markets practised on medium size areas of 1-2 hectares however appeared more successful. This was assisted by the problems resulting from large-scale surface and overhead irrigation methods, followed by private and government efforts which were vital in the adoption of low-cost medium head drip irrigation in India. It was found that the potential promotional factors for introducing low-cost drip irrigation are the development by the private sector of low-cost drip irrigation manufacturing and supply, provision of credit facilities, and extension services. In addition, irrigation water development with reasonable charges where necessary, market development and information, rural power supply, and research focussed in low-cost drip irrigation assisted in the promotion of adoption of low head medium drip irrigation in India.

These factors may or may not apply in different conditions or areas in the Kenyan context for the adoption of low-cost drip irrigation. This needs to be further explored through fieldwork of this study. Hence they are used, together with the information from the innovation-decision process (Chapter 2), in formulation of the research needs (Tables 3.7 and 5.1) and the research questionnaire for the phase 1 survey.

Table 3.7 Information needs identified from the literature review of chapter 3

Factor	Literature review findings	Information needs
Irrigation industry role	Role limited to low-cost medium head drip irrigation. Manufacturing and supply of low-cost irrigation low	Sources of equipment and raw materials. Possible constraints of manufacturing such as taxes, providing credit. Increasing market capacity by promotional efforts
Marketing for farm produce	Limited market for agricultural produce in Africa	Reliability of markets, flow of market information, local transport, organisation for marketing
Farmer credit (assistance)	Farmers access to credit limited in Africa	Need for credit for low-cost drip irrigation, credit conditions and interest rates
Government role	Policies on small-scale irrigation not strong in Africa Infrastructure limited in Africa	Policies regarding small-scale irrigation and or irrigation technologies. Role of extension services and research. Irrigation water development, water priority, water control, water reliability, developing rural power
Role of NGOs	In India IDE and local NGOs played role in promotion of both low-cost medium and low head drip irrigation	Role of NGOs, activities and promotion, farmer assistance, problems
Cropping pattern	Horticulture likely to grow in Africa	Types of crops irrigated
Problems of surface irrigation methods in India	Caused flooding, salinity, water scarcity, groundwater overdrawing	Salinity of irrigation water used, problems of large-scale surface or overhead irrigation.
Cultural issues	Experience in irrigation important	Past agricultural practices before taking low-cost drip irrigation

CHAPTER 4

OVERVIEW OF STUDY AREAS AND IRRIGATION IN KENYA

4.1 Chapter Introduction

This chapter presents general information on the study areas and brief outlines of climate, economic status, agriculture and irrigation in Kenya. This is followed by a detailed description of small-scale irrigation and the low-cost low head (LCLH) drip kits currently used in Kenya.

4.2 Kenyan climate

Kenya is administratively divided into 8 regions (Fig 4.1), namely - Western, Nyanza, Rift Valley, Central, Eastern, North Eastern and Coast. The study was carried out in Rift Valley, Central, and Eastern regions.

The country is a semi-arid country characterised by wet and dry seasons, high temperatures, low humidity and erratic rainfall. Only a small area in the Western and Central regions, covering about 17 % of Kenya's 582,600 sq. km, is humid, receiving more than 760 mm of rainfall per annum, sufficient for mono crop rainfed agriculture. Therefore, Kenya's arable farming is severely limited by inadequate and infrequent rainfall. March-June is the wettest and September-February is the hottest period, which is the peak irrigation season when temperatures can rise to over 30 ^{0}C.

For the purpose of this study, the country has been categorised according to annual rainfall from arid to humid as indicated in tables 4.1 and 4.2.

Table 4.1 Main climatic zones of the administrative regions of Kenya

Rainfall p.a. mm	Wet seasons	Climate	Main regions of the country	Main agricultural activity
<300	1	Arid	North and Eastern	Pastoral
300-800	2	Semi arid	Eastern and Southern	Pastoral and some arable farming
800-1200	1	Sub-humid	Western , Southwest, Coast	Arable & livestock
Over 1200	2	Humid	Central	Arable-cash crops

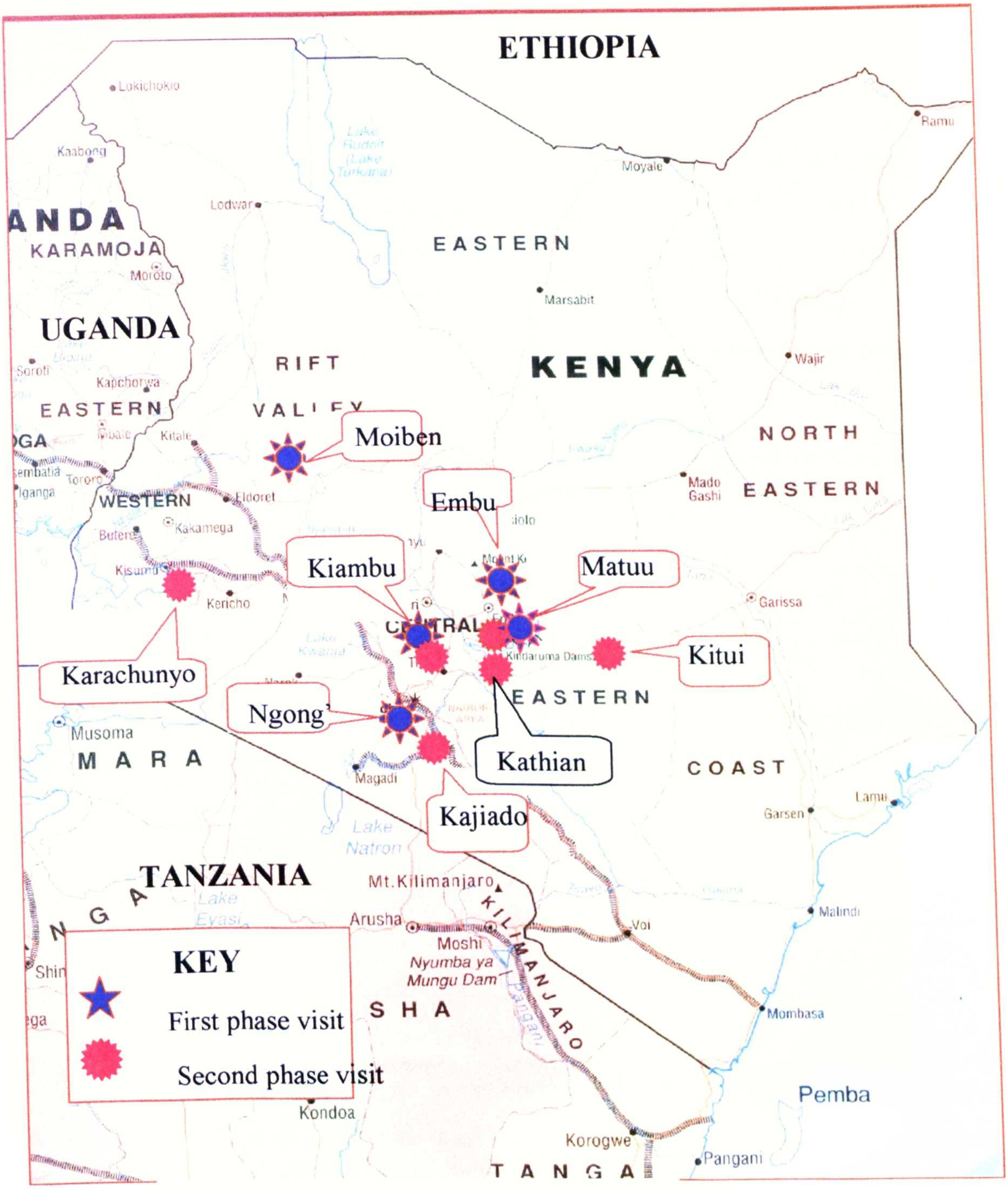


Fig 4.1 Location of study areas in Kenya

4.3 Socio-economic profile

More than 85% of the estimated 26 million people live in the humid or sub-humid 17 % of the country, depending almost entirely on agriculture. The majority of Kenyans live below the United Nation poverty line of less than a dollar a day. Agricultural development is important to the development of the country. Horticulture, under smallholder irrigation, is increasingly becoming important in this development. The development of rural infrastructure, such as roads and power, is necessary for irrigation development especially in the semi-arid areas (Table 4.2). The humid areas are more productive, producing cash crops from which farmers earn income and develop their areas while farmers in the semi-arid areas depend on basic nomadic life-styles and almost entirely on livestock. Therefore, there is less economic activity in the semi-arid areas to encourage the development of a permanent infrastructure such as roads and water supply because the people are usually on the move, yet these regions need development most.

Table 4.2 Profile of study areas

Characteristic	Humid	Sub-humid	Semi arid
Study areas	Kiambu	Ngong, Kathian, Karachuonyo	Kajiado, Kitui, Matuu
Rainfall	Over 1200	800-1200	300-800
Education level	High	Medium	Low
Economic activity	High	Medium	Low
Agricultural activity	Arable	Arable and Livestock	Pastoral
Infrastructure	High	Medium	Low
Major source of income	Arable	Arable/livestock	Livestock

4.4 Agriculture and marketing

Although large-scale farming is significant in commercial crop production in Kenya, small-scale farming supports the majority of the population. While large-scale farming is engaged mainly in coffee, tea, horticulture, cane, pyrethrum and other cash crops, the smallholder farmers' principal crops are staple food crops. These are maize, beans and other vegetables. As these are principally rainfed crops, crop yields are low and failure is not uncommon in many areas. However, in the 1990s, small-scale farmers have increasingly engaged in horticultural production using small-scale irrigation and this is where LCLII drip irrigation could potentially play a role. Horticulture, mainly from smallholders, was the third largest foreign exchange earner in 2000 (Daily Nation 2001), earning over $900 million with a considerable contribution from SSI.

Osoro (1992) observed that agricultural markets are inherently unstable because of:

- The large time lag between production initiation and availability of market; and
- The ease of replicating the produce.

He argues that the problems of African marketing are further exacerbated by the numerous smallholder farmers who have uncoordinated production and deliverance schedules. The market for irrigated produce in Kenya may similarly be characterised by fluctuations between glut, with associated low prices and shortage when prices are very high.

4.5 Water resources development

4.5.1 Sources of irrigation water

Water availability in terms of volume and over time is essential for irrigation practice. Kenya has numerous streams in the humid areas, several rivers and fresh water lakes from which irrigation water can be obtained. In addition, irrigation water can be obtained from ground water, where good aquifers exist, and direct water harvesting.

4.5.2 Irrigation water development

The development of water supply is still very low in the country. Although large dams have been constructed specifically for power generation which have also served irrigation, there are no large regional dams constructed mainly for irrigation. A few private medium to large-scale agricultural farms have constructed farm water reservoirs especially in central Kenya. Apparently, wells are not significant sources of water for small-scale irrigation farmers. The traditional small-scale irrigation is predominantly in valley bottoms and near open water sources for easy accessibility to water, as in the rest of Africa (Chapter 3). Consequently, surface water is apparently the important source of irrigation water for SSI in Kenya.

4.5.3 Water act and water apportionment

Although water is public (government) property, a farmer on private ownership land can have private right provided the source is not outside his property (Achola 1992).

However, irrigation has lower priority than domestic, industrial and hydropower use. Giving a case in Loitoktok, Keoro & Mecheo (1992) observed that irrigation can create water conflict with livestock especially in arid and semi-arid regions, where water supplies are limited.

4.6 Irrigation practices

4.6.1 Irrigation potential

In 1990, it was estimated that Kenya had an irrigation potential of some 390,000 ha, although other estimates put it at about 540,000ha, out of which less than 10% is utilised (Table 4.3). However, the extent to which irrigation can further be expanded is constrained by the lack of reliable water in the semi-arid northern and eastern parts covering about 80% of the country. In view of this, the potential for pressure on the Government to develop and manage its irrigation water resources exists.

Table 4.3 Irrigation potential in Kenya

Catchment area	Irrigation potential (ha)
Tana River Basin	100 000
Athi river basin	40 000
Lake Basin	145 000
Kerio Valley	85 000
Ewaso Nyiro basin and others	20 000
Total	**390 000**

Adopted from Kiragu (1992)

4.6.2 Irrigation methods

Although the government policy is to promote smallholder irrigation projects and LCLII drip kit irrigation, the guidelines on smallholder irrigation projects (MOARD 1993) did not specify details of individual water application methods. The guidelines state:

> *"Since water scarcity occurs in most parts of Kenya, there has to be a restriction on irrigation. It can only be justified where water efficiency is good and high value crops can be grown."*

All the three main irrigation methods - surface, overhead and drip (micro-irrigation) are practised in Kenya, both on large-scale and small scale. As in most African countries, the surface irrigation method is dominant (Appendix 3.0). Large-scale government (rice) irrigation schemes and many traditional small-scale farmers employ this method while commercial farmers both large and small employ sprinkler irrigation. But commercial farmers cultivating flowers and horticultural crops mainly employ medium head drip irrigation. The difference is because overhead and drip require more investment and support than surface systems. The low head drip kit for small-scale farmers, discussed under this study (Section 4.12), is a recent innovation since 1996.

4.6.3 Irrigated crops and area

Irrigation in Kenya is practised for growing coffee, horticultural crops, rice, cotton, and for kitchen gardening (Table 4.4). Although cut flower production is a lucrative venture in Kenya (Daily Nation 2000b) using various types of micro-irrigation, this industry is limited to specialised farms. Purcell (1997) states that the irrigated area for kitchen gardening is variable but he put a reasonable approximation at less than 5,000 ha. This is usually practised on a small fraction of a farm varying from less than 1 acre to over 10 acres; the rest is used for food crops and or livestock.

Table 4.4 Estimate of irrigation areas under different crops in Kenya

Promoting agent	Principle crops	Area (ha)	Scale
National irrigation board	Rice, Cotton, horticulture	9 000	Large
Large Scale Commercial	Coffee, Pineapple, Horticulture	22 6000	Large scale
Group based organisation (MOARD/NGO's)	Rice, Maize, beans, Horticulture	16 700	Large and small
Regional Authorities	Rice, Maize, Horticulture	3 700	Large and small
Individual small holder	Maize, Horticulture	8 000	Small
Total estimated		52,800	Small

Adapted from Osoro (1992)

4.7 Irrigation development agencies

This section discusses the agencies involved in irrigation development to illustrate potential routes through which low-cost, low head drip irrigation could be introduced into Kenya. The following is the existing framework and mode of operation of agencies involved in irrigation in Kenya: -

4.7.1 Smallholder irrigation unit

This unit is under the Irrigation and Drainage Branch (IDB) of the Ministry of Agriculture and Rural Development. It is charged with the responsibility of development of small-scale irrigation projects in the country on scheme or individual basis. It liases with the extension staff of the ministry at the farmer level throughout the country for the extension of irrigation.

4.7.2 Regional development authorities

There are three river catchment based development authorities in Kenya to develop areas under their jurisdiction including irrigation. They are Tana and Athi river development authorities, Lake Basin, and Kerio Valley development authorities. Initially they were established as instruments for planning water and land resources in their respective catchment areas and recommending such plans to existing implementing agencies. Later they diversified and even now promote and or manage some projects, including smallholder irrigation (Gitonga 1991).

4.7.3 District Development Committees (DDC)

The DDC, the political wing of the government, is involved in the administration of irrigation, firstly through the administration of the rural development fund and secondly by vetting irrigation proposals submitted by various agencies.

4.7.4 Non-Governmental Organisations (NGO)

There are over 4000 NGO's in Kenya, registered and unregistered, local and international groupings. They range from charitable organisations (e.g. Oxfam) to a multiplicity of Christian religious denominations (Daily Nation 2000a). In general, African NGOs have either foreign origin or foreign links. Most NGOs tends to be small both in area and funding but with multiplicity of activities.

Daily Nation (2000a) noted that donor funds appear to play a predominant role in the formation and operation of some local NGOs, after noting constant unnecessary squabbling over control of funds. However, this is likely to apply to a very small number of NGOs. While the local NGOs do the groundwork on technical aspects and implementation, the foreign ones take the main responsibility of funding the implementation of the projects.

Non-Governmental Organisations usually aim at short-term solutions, soon handing over the project to the government or farmers and hoping that what the farmers/government officials have learned during the project development is sufficient to see the project succeed. Rarely has this been the case (Daily Nation 2000a). Therefore the IDE approach to promotion of LCLH drip irrigation can applied and tested.

4.7.5 Irrigation research

Agricultural research in Kenya is carried out by the Kenya Agricultural Research Institute (KARI), a government parastatal with its headquarters in Nairobi which has a department of research in irrigation and drainage (NARL). The work by Njoka (1992) on "Irrigation research in historical perspective" and KARI (2000) demonstrates that irrigation research in Kenya was focussed on three key areas: -

- Agronomy;
- Large scale rice production; and
- Cultivation and farm machinery.

The National Irrigation Board (NIB) was delegated to do applied research mainly for large-scale rice schemes while Kenya Agricultural Research Institute (KARI) was delegated to do basic research mainly in water management. Nevertheless, it appears that there is little evidence of research work on smallholder irrigation. Hence, the introduction of a new irrigation technology for small-scale farmers such LCLH drip is likely to lack the research input necessary for its development.

4.8 Small-scale irrigation

4.8.1 Definition of smallholder irrigation

MOARD (1993) Guidelines on Smallholder Irrigation Projects states: "Smallholder irrigation exemplifies a (bottom-up) process that is demand-driven, community-managed and self-sustaining. It is based on small-scale units which are controlled and operated by the local people". This is similar to Cater's (1989) definition (appendix 1.0). However in this process the potential role of government in facilitating the process is important.

4.8.2 History of small-scale irrigation

In Kenya, evidence suggests that local communities such as Marakwet, Iichamus, Turkana and Pokomo may have practised some forms of irrigation as long as 500 years ago (Njoka 1992). Formal irrigation is thought to have started at the beginning of 1900 but large scale irrigation did not commence until mid 1950s during the Mau- Mau emergency period.

In the early 1970s, the Ministry of Agriculture (Irrigation and Drainage Branch IDB) with the assistance of the Dutch Government, and local Non-Governmental Organisations initiated many small-scale irrigation programs with assistance from FAO and the Dutch government (Osoro et al 1992). The objective was to reduce the need for relief food supplies and to provide pastoralists with alternative livelihoods. This had limited success as discussed in chapter 3. During this time "Smallholder Irrigation Scheme Development Organisations" (SISDO), an NGO, was formed focussing on the existing small-scale irrigation methods. Today this NGO is the main promoter of small-scale irrigation in Kenya, although not fully involved in the LCLII drip kit.

4.8.3 Role of smallholder irrigation projects

Mosoti (1992) observed that small-scale irrigation projects were used to supplement food for livestock farmers in semi-arid areas of Kenya as part of poverty reduction through food and nutritional provision. Furthermore, any surplus produce can be put for sale. In producing food where otherwise it would not have been possible, it can be used to solve settlement problems related to nomadic life or land shortage. Since LCLII drip irrigation is used mainly for production of high value crops, its potential for livestock farmers in semi-arid areas appears limited to production of subsistence vegetables rather than cereal production.

4.8.4 Organisation of Water Users Associations

Kimani (1992) observed that although Water Users' Associations were recognised in the Water Act of the Ministry of Water Development, they did not appear to have featured significantly in irrigation development. The Ministry of Agriculture and Rural Development (MOARD 1993) "Guidelines on Smallholder Irrigation Projects" recognises the role of Water Users Associations (Chapter 6). But it does not set up "guiding" rules at the national level for WUA as seen in India (chapter 3) within which rules for different local WUA can be set for better management.

4.8.5 Irrigation methods and water lifting

Purcell (1997) observed that, cheap and simple gravity and pump sprinkler systems for horticulture crops have been very profitable and were growing fast in Kenya. "Appropriate Technologies for Enterprise Creation" (ApproTEC) an NGO, had pioneered the manufacture of treadle pump which later spread to other parts of east Africa. The pump, which cost only $70, was suitable for small plots and could increase the production area by more than 50%.

Although the early version was very popular for domestic water use, the fieldwork revealed (Chapter 6) that these pumps were not popular for direct irrigation water application to the field using hose-pipe or medium head drip irrigation mainly for two reasons. First, the pumps could only suck the water from a depth of up to about 6m and they could not lift pump (pressurise) it. So, the farmer had to carry the water up the field for irrigation. Secondly, they required two people to operate where the topography allowed them to be used, one person to treadle the pump with another to check and direct the hose into the container or field plot for direct irrigation. For these reasons farmers preferred small petrol pump-sets, although considerably more expensive. In 1998, ApproTEC produced a better version that could lift water up to 12 m high. However, this later technology was still at an early stage of diffusion at the time of the study.

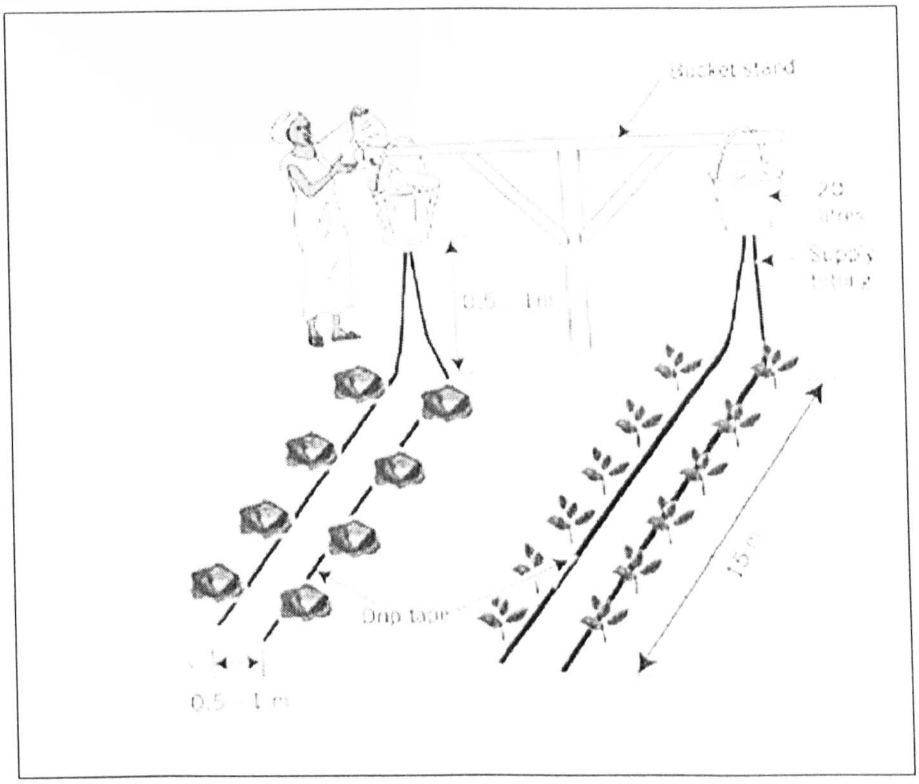
4.9 The drip kit

4.9.1 Introduction

The area under micro-irrigation in Kenya is relatively low compared to other irrigation methods. To put it into perspective, FAO (1995) puts the micro-irrigation area as 1000 ha, sprinkler 21,000 ha and surface 44,600 ha. Most of the area under micro-irrigation is likely to be under pressurised low-cost medium head (LCMH) drip irrigation, and on floriculture farms. This is because this system has been in Kenya long before the drip kit was introduced in late 1996. Although introduced by an innovator, the government has adopted the LCLH drip kit as a way of developing small-scale irrigation for poverty reduction in the country.

The original LCLH drip kit was from Chapin Watermatic of the USA of Chapin Third World Projects, which has kits in 80 countries (Barsito 1999). The drip kit in Kenya is promoted by KARI, the Fresh Produce Exporters of Association of Kenya (FPEAK), Winrock International, the Arid Land Information Network (ALIN), Intermediate Technology Development (IT-Kenya) and several other NGOs (Chapter 6). During the study it was established that KARI had sold over 4000-bucket kits and over 500 one-eighth kits since their introduction (Fig 4.2). Although this number looks impressive, it has a potential to cover only about 31 hectares.

The basic drip kit consists of a water container with a head of about 1 metre from which a manifold is attached. While the smaller kits can be operated manually or



Source: Sijali (2001)

Fig: 4.2 Two Chapin LCLH bucket drip kits

with a simple treadle pump, the larger ones require bigger pumping system. As for any drip irrigation system, it is important to use clean water. The manifold has a filter at the inlet and feeds two or more drip lines. It is recommended that the filter and driplines should be regularly cleaned and flushed respectively.

However, some farmers were not aware of this from the study (Chapter 8) causing problems of clogging. This basic drip kit can be modified and extended to a variety of types according to conditions and needs (Mugwannja & Radiro 1997).

4.9.2 Types of drip kits in Kenya

The following are four main types of LCLH drip irrigation promoted in Kenya, as described by Muganjwa and Radiro (1997). This classification is based on the operational head and irrigated area. The first type is the low head low-cost bucket drip kit that cost $12 (Fig 4.2). It comprises of a standard bucket of about 20 litres, with two 15m long drip lines, a filter screen, two connecting manifold tubes, a rubber washer, male fitting and female fitting. The drip lines have 30 cm spacing emitters, one for each plant position. This gives a maximum of about 50 irrigation plants for one row line and 100 plants for two row lines. It serves a plot of 15-25 m^2 depending on row spacing. The bucket is raised to a head of about 1 m (0.1 bars) and is filled once in the morning and once in the evening. The drip lines are supposed to last for seven years. However, this study found that they last on average about three years (Chapter 6).

The second type is called the low-cost low head drip drum kit system (Plate 2). This is an extension of the bucket kit but instead of the bucket it has a drum water container of about 220 litres, making it capable of irrigating over 400 plants or an area of 75-125 m^2). Each bucket kit costs about $20. Unlike the bucket kit, which is recommended for a small family for subsistence, the drum kit is for a large family and can be used to grow extra crops for cash. It is recommended for farmers with no pressurised water and who want to grow more vegetables.

The third type is called "the one-eighth acre" since it is designed to be used to irrigate an eighth of an acre (0.05 ha). It can irrigate up to 2000 plants with spacing of 30 cm by 75-cm employing about 600 m long drip line. This is sufficient for 20 lines 30 m long. It may have several drums or a large container and is suitable for small-scale farmers who want to produce for marketing. Since it is relatively big, it is more suitable for pressurised water at 0.5 to 1.0 bars. Hence, it has a pressure regulator.

During the fieldwork, the fourth type of drip kit, the Orchard System, was rare to be found. It appeared that most SSI farmers in my study areas do not irrigate fruit trees or bananas yet. As the name suggests, it is designed for abhoriculture.

Plate 2 Successful low-cost low head drum kit irrigation
(Part of 5-customised drum kits)

KARI is also trying another low head drip system called the "Waterboys" manufactured in Sweden while Booth Irrigation Company of Kenya is developing another system.

4.9.3 Performance of drip kit

4.9.3.1 Introduction

According to Lusaka (1998) the low-cost low head drip kits irrigation is thoroughly proven, remarkably flexible and adaptable to local conditions and already showing its potential in the hands of hundreds of creative Kenyan farmers. However, this research found that this irrigation method had a lot of problems in field often forcing farmers to discontinue. Moreover, analysis of a report by Wagner & Lusaka (1999) in evaluation of low-cost low head drip project in Yatta, Kenya indicates that about 70% of drip kits in the field were not working for various problems.

4.9.3.2 Performance tests

Tests carried out by Ngigi et al (2000) on the water distribution of the drip kit for emission uniformity (Eu) and flow variation showed that the Chapin drip tape performed well on flat land and up to 2% slope. It was recommended that the drip kit be used on plots that are as flat as possible for better water distribution efficiency. It was discovered that other locally manufactured tapes could easily be adapted to the drip kit; in fact, some of them out performing the original Chapin tape.

4.9.3.3 Secondary information on field performance

Information from "the evaluation of micro irrigation kit in Kenya workshop" (Winrock 2000) highlighted the following problems on its field performance:

- The breakage and cracking of the filter;
- Filter clogging;
- Attack by rodents;
- Lack of skills in installation, operation, and maintenance;
- Lack of spares and complete kits;
- Technology not feasible where water is expensive; and
- Unaffordable due to poverty.

This information suggests that the workshop:

- Concentrated on problems of farmers who already have and are using them. There is scarce information on the perception of other SSI farmers who do not use the technology or those who may have stopped using them;
- Dealt with the LCLH drip kit promotion efforts in Kenya in isolation of the outside world from which potential useful lessons could be learned; and
- Appeared to have little reflection on the role of the change agents in the adoption process.

4.9.3.4 Economic benefits of low-cost drip irrigation

Nyakwara et al (2000) using a Rapid Rural Appraisal (RRA) worked out gross margins for low-cost low head drip drum kits for three vegetable crops (tomatoes, Cabbage, and *Shuja*) for a farmer in $^1/_4$ of acre, which worked out to be about $8000 per hectare. The gross margin was calculated based on the variable costs incurred and earnings received.

Variable cost gross margin for passion fruits using LCMH drip kit in Uasin Gishu worked out at about $ 41,800 / ha (Chapter 6 and Appendix 4.1). Lusaka (1998) states that a farmer from Kendu Bay (Kenya) had been able to earn an extra $50 (equivalent to $25,000/ha) from her bucket kit in a year.

4.9.4 Manufacture of drip equipment in Kenya

The study revealed that although there were several dealers of drip equipment in Kenya only one actually manufactures drip equipment - Shed Net. The others imported their material from Europe, Israel or America (Table 4.5). This is despite the fact that Kenya has a good plastic industry. These include Amiran Kenya LTD, Beta Engineering, Agro Irrigation and Pumps LTD, Boots Irrigation LTD, Warren & Concrete Irrigation LTD, Irritech Company etc.

Table 4.5 Summary of sources of drip irrigation equipment in Kenya

Type of drip line	Supplier in Kenya	Origin	Remarks
Cheapen turbulent drip tapes	KARI	Chapin Watermatics USA	Low head
T-tapes TSX series	Booth Irrigation Co.	USA	Less clogging
Waterboys	KARI	Sweden	Low head
Netafin integral drip lines	Amirani irrigation Co.	Israel	Less clogging
Naan drip lines	Amirani	Israel	
Victoria drip lines	Shed-Net	Kenya	Spacing can be adjusted

Source adapted from Ngigi et al (2000)

Most of these companies specialise in LCMH drip or conventional high head drip irrigation systems. Two of them, Booth and Shed-Net were in the process of starting to deal in low-cost drip irrigation equipment.

4.10 Chapter 4 Summary

Kenya is semi-arid country with an agrarian society, the majority of who are peasant farmers. The water resources are underdeveloped, with irrigation water getting low priority. Although Water Users Organisations are legally recognised, there are no national guiding rules from the Ministry of Agriculture and Rural Development. Less than 5% of irrigation potential is utilised, mainly for beverage, horticultural, and food crops.

Low-cost low head drip kit was introduced privately in 1996 and most of the equipment for the drip kit is imported. Tests show that it has good water distribution during irrigation. The main promoters of small-scale irrigation are the Government and its agencies, and NGOs, as well as individuals. Irrigation research has focused on large-scale rice and irrigation farm machinery.

CHAPTER 5

PHASE 1 SURVEY: FACTORS INFLUENCING ADOPTION OF LCLH DRIP IRRIGATION - METHODOLOGY

5.1 Chapter introduction

This study was carried out in two phases. Phase 1 examined factors influencing adoption of LCLH drip irrigation. Phase 2 was necessary to determine the factors influencing the discontinuation of LCLH drip irrigation.

This chapter presents the phase 1 survey methodology, and discusses how the data was collected from the field. It starts with the formulation, development, and design of the survey, followed by the data validation procedure. The next section is an outline of the planning and preparation of the fieldwork before describing the actual fieldwork. The chapter ends with a brief methodological critique.

Figure 5.1 shows how the phase 1 fits into the overall research methodology.

5.2 Formulation of the research methods

5.2.1 Field data collection method

The development of research methods has to be based on meeting the research objectives and questions. It is essential that it should endeavour to produce reliable and valid data. Reliable data are from consistent responses over given time, between and among observers and respondents (Fink 1995b). Valid data come from methods that measure what they claim to measure and interpretations that follow from them (Sapsford & Jupp 1996). Furthermore, the objectives and the research questions have to be directly related with the data analysis methods, affecting the choice of each other. Similarly, the research questions determine the data collection methods and vice versa (Murry 1997).

A case study of some individual smallholder farmers was considered because it could describe the smallholder irrigation practice in its real life context that can be useful in identifying factors influencing irrigation and explaining causal links. However, it was realised that the required time for the case study would be much longer than the time available for the study.

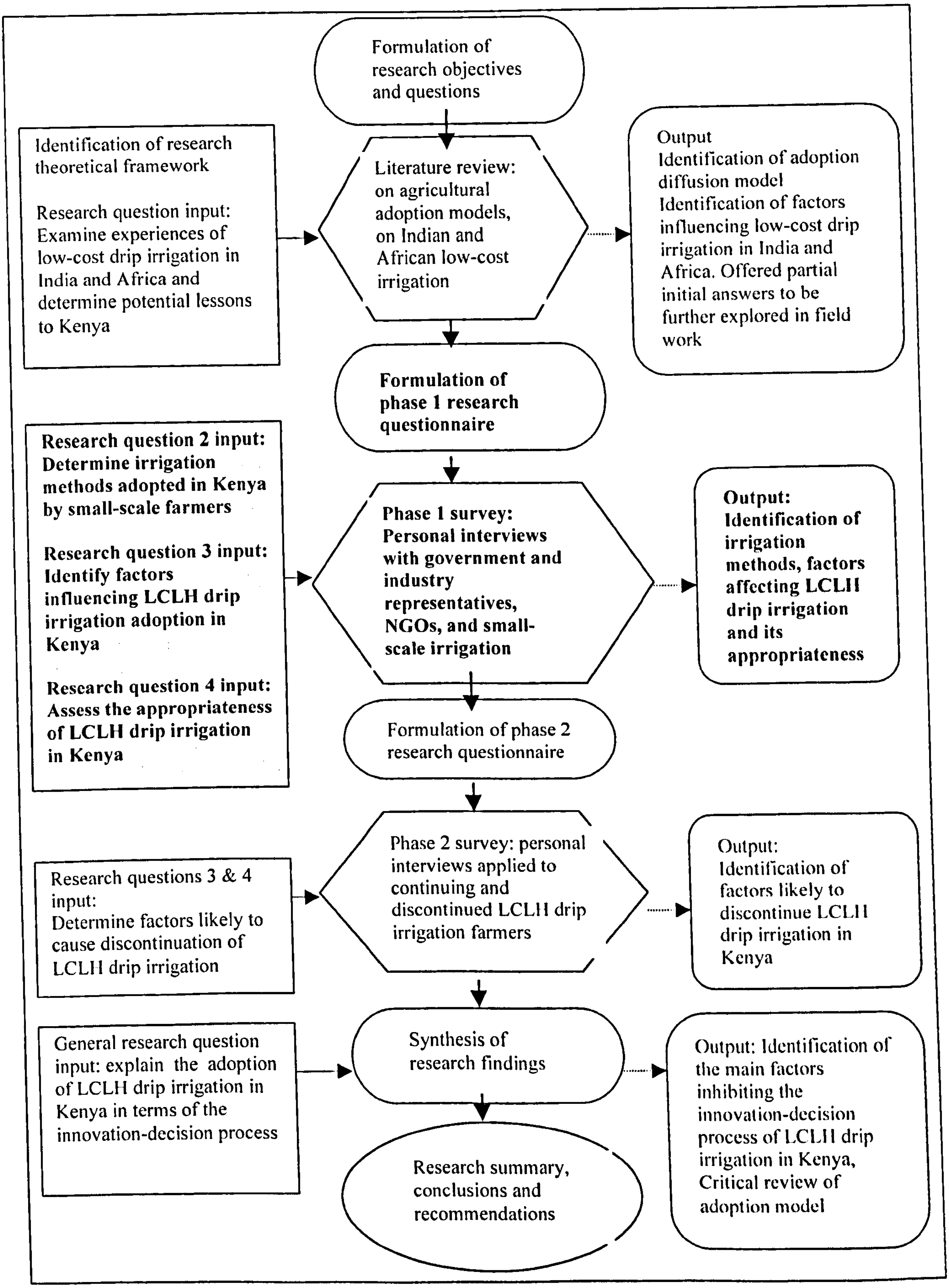


Fig 5.1 Logical flow of research methodology - Phase 1 (shaded)

This is because information was required from smallholder farmers as well as NGOs, Industry and Government representatives. Besides, the growing and irrigation seasons were much longer than the period available for the study. Keeping these factors in mind, it was decided to employ a survey with a questionnaire for data collection. Consequently, four months fieldwork (January to April 2001) was carried out in Kenya. This was followed by data compilation, analysis, and discussion of the results. The results formed a basis for the phase 2 survey.

5.2.2 Research questions and data needs

To begin, the data needs linked to the research questions were formulated (Table 5.1). Data sources and the collection methods were closely linked. Various data collecting methods were employed ranging from informal questionnaire surveys, secondary document sources and direct observation. The major data sources were smallholder irrigation farmers, government officers, irrigation industry and local NGOs.

5.2.3 Data analysis and research method

After data collection, it was necessary to consider the criteria for the analysis. The analysis of research data depends on the type of the survey data available:

- Nominal (categorical) – employs categories/scales with no numerical value;
- Ordinal – uses rating scales e.g. agree to strongly degree; and
- Numerical – produces data in numbers.

It was decided that to answer the research questions the information would have to be in terms of a semi-guided narration from which descriptions, explanations, comparisons and associations would be derived. This implied the use of nominal data, and qualitative analysis would therefore form the principle method of data analysis. This method is useful in providing explanations but limited in terms of the generalisation that can be drawn from it. It was also decided that quantitative data would be necessary to support some of the explanations. Statistical methods for more generalisation of the results were ruled out because of non-random sampling and the low number of low-cost low head drip irrigation farmers planned to be interviewed, as a consequent of the limited resources available (time, funds, means).

Table 5.1 Research questions and data needs

Research question	Data needs from innovation decision process	Data collection technique/source
What is the existing approach to introduction of low-cost drip irrigation in India, Africa and Kenya? •	**Role of major change agents of LCLH drip irrigation:** **Features of micro-irrigation manufacturing and dealer services e.g.** Manufacture of micro irrigation and other irrigation enterprises; Sources of equipment and raw material in country; Problems of manufacturing ; and Promotional and support services. **Features of Government role such as** Policy small-scale irrigation/technologies; Role of extension services- promotional methods and performance; Need and assistance for credit, subsidies, taxation marketing of produce; and Problems with low-cost low head drip irrigation known to government representatives. **Features with NGOs related to irrigation work such as** Their activities/assistance with small-scale irrigation/technologies; Promotion of low-cost low head drip irrigation; Knowledge of LCLH drip kit; Nature of assistance given to farmers; and Problems with LCLH drip irrigation as known by NGO. **Features of research work such as** Role of government research; Smallholder irrigation policy; Research work done on LCLH drip kits; Problems with research and development; Current past research work on LCLH drip irrigation; and Use of demonstration centres in the country.	Data collection: Secondary documented records: research papers, workshops, journals, policy papers, reports, and magazines. For Kenya, in addition to above informal survey using semi-structured interviews. Sources: Irrigation industry, Government officers, government research officers and local NGOs, libraries.

What irrigation systems are being adopted by small-scale farmers and why?	**Features of irrigation practices such as**
	– Current irrigation method; and
	– Previous irrigation method.
	
	Reason for choosing current irrigation methods
	Knowledge
	– Awareness of LCLH drip kits irrigation; and
	– Operational knowledge.
	Persuasion
	– Type and use of promotional methods;
	– Sources of information;
	– Attitude and perception of LCLH drip Irrigation; and
	– Use of demonstrations.
	Decision stage
	– Barriers or problems to acquire LCLH drip kits.
	Implementation
	– Availability of the LCLH drip Irrigation;
	– Sources of LCLH drip Irrigation; and
	– Operation and problems experienced.
	Confirmation
	– Kind of rejection- replacement, disenchantment;
	– Causes of rejection;
	    – Does it meet needs of people;
	    – Past experiences of people who had LCLH drip Irrigation;
	– Lack of availability of spares;
	– Problems of operation; and
	– Reliability or living to expectations.
	
	Relative advantage and disadvantages
	– Indication of benefits e.g. increased yield, water savings, less weeding, cost, profit, reliability, easy of operation, disease control for different irrigation methods; and
	– Relative disadvantages and advantages of alternative irrigation
		Data collection: Direct observation, informal survey using semi-structured interviews.
		
		Sources: smallholder irrigation farmers.

	methods e.g. salinity, water scarcity, ground water overdrawing, flooding etc. Problems of the system. **Compatibility** – Required physical changes to accommodate LCLH drip irrigation; – Conformity with existing cultural practices with farming system, cropping system, farmer values, farmer experience, food consumption preferences; and – Suitability of LCLH drip to local conditions. **Complexity** – In terms of operation; – Complicated to understand, introduce, and maintain; and – Needs for high level management. **Triability** – Indication of increments/expansion in fractions bits or phases; and – In terms of availability for trial. **Observability** – Existence of opportunities to observe LCLH demonstrations, indication of a parent /obvious results easy to communicate to others. **Characteristics of the adopters** – Education; – Social status; and – Age. **Other factors (infrastructure)** – Irrigation water development, sources, ownership/right, water reliability, water control, water priority, developing rural power; and – Marketing - availability of markets, flow of market information, local transport, organisation for marketing.	Sources: smallholder irrigation farmers, government officers, irrigation industry, and local NGOs.
For which small-scale farmer is continued adoption of LCLH drip irrigation applicable and why?	– Problems affecting farmers with low-cost drip irrigation; – Economical viability; – Social responsibility; and – Ecological soundness.	Data collection: secondary documents, informal survey using semi-structured interviews.

		Sources: smallholder irrigation farmers, government offices, and libraries.
What is the appropriateness of the LCLH drip irrigation system on Kenyan market?	**Appropriateness of the system** – Cost of LCLH drip irrigation; – Operation and management (problems); – Reliability- technical and economical; – Durability; – Use of local material and ability to locally manufacture it; – Its independence from use of high energy; – Portability; – Physical compatibility with irrigated plots; – Compatibility with cultural practices- values and preferences; – Image of modernity; and – Triability.	Data collection: Secondary documented records: research papers, workshops, Journal, policy papers, reports, and magazines. Direct observation and informal survey using semi-structured interviews. Sources: small-scale farmers and libraries.

5.3 Methods of data collection

Data and information were collected during the field visits using documented records, interviews, and by attending shows.

5.3.1 Documented records

During the study visits, secondary data were collected from published and unpublished material and individuals. Sources for such information included journals, reports produced periodically, workshop proceedings, pamphlets and brochures, research findings, and daily papers. Other information was obtained by attending agricultural shows and village meetings, as well as observation during fieldwork.

5.3.2 Survey interview

5.3.2.1 Introduction

As noted in the previous section, a survey method was selected to be used in the primary data collection. This is because surveys are suitable systems for collecting information to describe, compare, and predict attitudes, opinions, values, knowledge, and behaviour (Fink 1995c).

While formal interview-surveys are suited for testing a hypothesis or confirming an understanding, an informal interview is more appropriate in revealing new ideas especially if it employs "open-ended" research questions. This may provide better understanding and explanation of the factors involved in the adoption process of LCLH drip irrigation in Kenya. This would put it in line with the research questions that required explanation of the factors involved in low-cost low head drip irrigation adoption.

The interview had to be informal to encourage openness and honesty of the respondents. Therefore, a face-to-face open-ended informal interview with key informants was selected. The discussion was tape recorded, with prior permission of the interviewee, and later transferred to paper for analysis. This allowed the conversation to proceed in a more natural form.

5.3.2.2 *Phase 1 survey informants*

The key informants in the first survey were small-scale irrigation farmers, irrigation equipment manufacturers and suppliers, and NGOs and government departments involved in irrigation.

5.3.2.3 *Questionnaire design*

A different questionnaire (Appendix 5.0) was set for each of the six categories of informants to be interviewed as follows: -

1. Small-scale non drip irrigation farmers;
2. Small-scale low-cost low head drip irrigation farmers;

Representatives from:

3. Government extension service;
4. Smallholder irrigation research department;
5. Irrigation industry; and
6. NGOs.

The aim was to have a questionnaire that would eventually produce a picture of the major factors affecting the adoption of low-cost low head drip irrigation in Kenya. A number of factors guided the formulation of the questionnaire. First, it had to be in line with the aims, the objectives and the research questions of the study. Therefore, each question was matched to the information it would provide to each objective and/or the research question (Table 5.1). Secondly, the literature review suggested the kind of information to look for in the first survey (Chapters 2 & 3.). A semi-structured and open-ended questionnaire was designed to identify the probable issues, problems and links of factors affecting the adoption process of the study area.

The following is an overview of the subject of interest for the questionnaire in the phase 1 survey (Appendix 5.0): -

a) For the farmers' questionnaire, questions on:

- The background of the farm;
- The farm and crops;
- Irrigation technology and practices;
- Water supplies;
- Problems and challenges;

- Farmers' drip kit knowledge;
- Why farmers choose their irrigation method;
- Non-low-cost low head drip irrigation farmers' knowledge of drip.

b) For the government questionnaire, questions on:
- Water sources ;
- Government policy;
- Extension work;
- Research work.

c) For the questionnaire for manufactures and suppliers, questions on:
- Sources of manufacturing materials;
- Manufacturing of micro-irrigation;
- Supply ;
- Problems of manufacturing and supply.

d) For the questionnaire for Non-Governmental Organisation and Smallholder Research Projects, questions on:
- Background of the project;
- Activities and problems;
- Crops;
- Irrigation methods and constraints;
- Knowledge of drip kit;
- Potential for low-cost low head drip irrigation.

5.3.3 Administration of questionnaire

The questions were not exhaustive but the questionnaire was to be used as a guideline for probing questions on specific areas of interest. It was expected that since they were open-ended, the participants would raise specific issues in the course of discussion that would be explored further by questions outside the questionnaire. Afterwards this could occasionally turn into open discussions thus the participants' priorities in other areas would emerge. Consequently, in the end the questionnaire would be very flexible in the set of information that was collected. The information was tape-recorded for complete record keeping and ease of counter checking during compilation, analysis and for later work. (Appendix 6.0)

5.3.4 Pre-test

It is essential that the questionnaire be tested before being employed fully in the field ((Fink 1995b). Before fully employment in the field, the questionnaire was tested on 5 farmers, a civil servant, an NGO, and a micro-irrigation manufacturer cum supplier to identify problems of the questionnaire associated with:

- Incompleteness;
- Wording in questions;
- Question sequence; and
- Unexpected response and clarity of questions problems

5.3.5 Timing of farmer visits

The fieldwork was programmed to take place between January and April 2001. A variety of factors influenced this decision. Firstly, this is the dry season in most parts of Kenya during which most irrigation practises are in operation. Therefore, it was possible to learn about small-scale irrigation by observation as part of the triangulation process (Section 5.4). It was possible to see the crops irrigated, estimate and visualise field sizes and crop production, and observe some of the problems farmers face in the field. Secondly, it could be easier for the farmers to recall answers to some interview questions because the information would still be fresh in their minds.

On the other hand, since this was the busiest period for small-scale irrigation farmers, there was a danger of the farmers disregarding the research work. It was felt that this problem could be minimised by finding the best time during the day when the farmers are not busy. My experience shows that most farmers are busy in their farms in the mornings. They start going home from their farms to attend to other business after 11.00 am and, by 2.00 pm nearly all of them are back home. Therefore the farm visits were planned to start when farmers start going home so that they would not feel most of their precious morning hours are wasted. It was hoped that such timing would make the farmers more co-operative in response to the study.

5.3.6 Selection of study area

The next stage involved selecting the area(s) of study. At first it was thought that it would be possible to do a statistical analysis by employing stratified random sampling at the national level down to the study areas units. From the literature survey, some of the precipitating conditions of rapid adoption in India were related to the ecological zones (Chapter 3). Therefore, it seemed reasonable to take these factors in the selection of the areas of study. In practice however, the logistics (distances, accessibility, and lists of farmers) would be very difficult and the study would be very expensive requiring more resources and time than available. Moreover, the differences between farmers with the same conditions that make them adopt or not adopt is also of primary interest in this study. It is reasonable to assume that most of the relative differences would apply in whichever zone is under consideration and they should feature.

Consequently, four criteria were used for the selection of the study district. First, it was felt that since low-cost low head drip irrigation smallholder farmers were apparently not common, choosing areas with potentially large numbers of eligible respondents who are adopters would simplify the logistics of the survey. The second criterion is related to accessibility and distance from the operational areas. It had been planned that the researcher would be involved in the data collection. For this reason, it would be impossible to complete the work within the required time if vast distances were travelled each day to reach each contact farmers where they are scarce and thinly populated.

The third criterion used was that the area should have farmers who are representative in terms of agricultural practices and practised other irrigation technologies. They should also be willing to co-operate, and there should be an active and friendly extension staff. This was essential to get efficiently reliable data in the shortest possible time. The fourth criterion was to include farmers of different characteristics involved in low-cost low head drip irrigation. It was thought by having a good diversity of farmers' backgrounds, it was more likely to build up a picture of the problems and practices of the area. These are practical problems that were considered in order to conserve resources. It was also impossible to visit farmers who could not be accessed by 2-wheel drive vehicle.

The unit of study area was chosen to be the administrative division of a political District. This decision was taken because first it may be easier to get secondary information specific to that area. Secondly, the use of extension staff in helping with the research work was limited to within a particular unit. It was practical in terms of minimising "red tape" required to reach the farmers. And finally it was easier to locate its position and confines.

5.3.7 Selection of participants

The criterion selection of the key informants was small-scale irrigation farmers and Government staff in charge of irrigation in various localities or department. Similarly, NGOs dealing with small-scale irrigation along with manufacturers and suppliers dealing with micro irrigation were also selected.

The small-scale farmers selected were irrigating less than 3 ha or had had irrigation experience. The informants targeted were in charge and responsible for the irrigation and other farming activities. It was believed that such farmers would have real experience of irrigation, hence would provide information that is more reliable. It was felt that farmers using traditional irrigation from a bucket to sprinkling should be included in order to understand the reasons for them not going for low-cost low head drip irrigation.

After deciding who would participate and who was eligible, the next stage was to decide how to sample the individual participants. The selection of the farmers raised two problems. First the possibility of not getting enough adopters in the district, and secondly, some of the farmers randomly selected could be uncooperative. The latter could be minimised by continued sampling assuming the population was large enough. Nevertheless, it was apparent that low-cost low head drip irrigation adopters were few and far apart.

Two alternatives emerged for sampling - use random sampling to obtain a representative sample to avoid unbiased data, or apply purposeful selection, which would create a bias thus losing wider generalisation of the results. Simple random sampling at Regional/Provincial or District level would allow for a limited generalisation of the results. Getting a representative sample implied obtaining adequate numbers of participants for a statistical analysis. However, the size selected with the resources available, would not be large enough for statistical analysis in relation to Kenya or Africa. For these reasons simple random sampling proved unsatisfactory and purposeful selection was adopted.

This decision had some support from earlier discussion in this chapter. It was stated that qualitative data analysis is useful in providing explanations but limited in terms of the generalisation that can be drawn from it. Since this is the main purpose of analysis adopted in this in this study, statistical methods aimed at generalisation of the results do not apply.

5.3.8 Sample size

The next subject was the determination of the number of individuals to interview. This was not a problem for Government officials, NGOs, and manufacturers as they are few in numbers. However, the difficulty was in choosing an appropriate sample size of small-scale irrigation farmers that can be managed within the resources available. In general, the sample size of a study depends on (Fink 1995d):

- The population – large samples for larger populations giving more representative characteristics;
- The degree of accuracy required; and
- The time and finance available for the study.

There are statistical ways of way of working out the appropriate sample size taking into account some of these factors but paradoxically they rely on knowledge of the standard deviation that is only known after the study has already been done. Schofield (1996) gives a method of how to estimate it, but argues that it is a complex matter and states "Just how big a sample should be is a matter of balancing cost against the level of precision required." However, statistical analysis for this study was overruled in the previous sections.

Table 5.2 Informants interviewed in Phase 1 survey

Group		Number
1	Non drip irrigation farmers	17
2	LCLH drip irrigation farmers	16
3	Government / research officers	11
4	Manufacturers and suppliers of irrigation equipment	4
5	Non-government organisation	4
	Total	**52**

In view of these facts, it was decided to have a small focused sample size, keeping the number of low-cost low head drip irrigation farmers and non low-cost low head drip irrigation farmers approximately the same. This led to a final output interviewing 52 participants (Table 5.2) of the initial plan of 48 for the phase 1 survey, with 16 adopters and 19 non-adopters.

5.4 Psychometrics

It was deemed vital to take into account some precautions that would increase the validity and reliability of the data collection methods. This is the subject of psychometrics. In short, a reliable instrument/ measure is consistent while a valid one is accurate. The following sections discuss measures taken to improve the quality of data collected.

5.4.1 Reliability

This refers to the consistency of results using the same procedure, and the extent to which a measure is free from random error (Fink 1995a). In the sample selection procedure, the potential of a random error was created arising from purposeful selection of participants. This could create a possible prejudice.

5.4.2 Validity

In this research a possible factor that would affect the quality of the data collected, was identified as the way the participants perceived the purpose of the study. It was anticipated that the small-scale farmers would perceive that the interview was about to give them immediate help and solutions to their problems. If this happened then they would not give the true responses to the interview. To minimise this, every respondent was cautioned that although eventually the research will be helpful, the interview was not about giving immediate help. It was also necessary to be aware of possible conflicts. For example during the data collection and analysis, it was essential to be aware of likely conflict of interest for example between Government officials and farmers, Government versus NGOs and manufacturers and farmers as well as groups with common interests.

Bias was a potential source of error during the data collection. It could stem from either the researcher or the respondents. Care was therefore necessary to get valid data by avoiding personal bias and other bias resulting from cultural and assumed knowledge including the literature review. Failure to take care of it could cause some misunderstanding in the observation, responses and interpretation of field information. Despite the steps mentioned in the validation of data, it was important to check the validity of the information collected through triangulation.

5.4.3 Triangulation

The data validity can be determined in two ways. First by means of cross-checking the information from different sources to ensure consistency, and agreements between sources of information (Pratt & Loizos 1992). This is referred to as triangulation. The second technique is by post field validation. It is important in confirming the findings as well as piecing together missing information from different sources. The essentials of triangulation are foremost not taking any data at face value and never to rely on one person's opinion or perception. It was decided to cross check the different perceptions of the same fact. This implied involving all those concerned with issues identified as exemplified by the choice of the different informants.

At the beginning of this section, it was considered to include triangulation in the plan as a part of the data collection validation. This would encompass data collection from at least more than one source- secondary, direct observation and the semi structured interview whenever possible. The five questionnaires set for different categories of respondents had questions sometimes seeking the same information across and within participants' categories, to ascertain the validity of the information in the field. This point was reinforced further during the interview discussions. This was a more direct means of checking on validity of observations by cross-checking them with other sources of data. As part of this process it was planned that secondary data review would be undertaken during fieldwork. In doing this, I was aware of some of the problems that may be associated with some official reports such as officials trying to make impressive records for the sake of safeguarding the good name of their offices for the sake of their jobs. Therefore, corroborative information was essential where available.

5.5 Phase 1 fieldwork

5.5.1 Introduction

The data collection took about four months between the months of January to April 2001 in Kenya. It started with pilot testing in January 2001 followed by secondary data reviewing of documents in Kenya. This involved visiting the ministry headquarters, Nairobi, for civil servant interviewing and secondary data collection. The farmer interviews started in late February in Uasin Gishu. Later I went to Ngon'g then Kiambu in March and April. This period had been punctuated by other visits to the manufacturers and suppliers of irrigation equipment. Afterwards I interviewed the NGOs representatives between late April and early May before finishing off with interviews in Kithmani Division (Fig. 4.1).

5.5.1.1 Pilot testing

The pilot testing was done in the 3rd week of January 2001 in which I visited Beta Engineering, an irrigation equipment manufacturing company in Nairobi, followed by a farm visit in Ngon'g Division where a civil servant and three farmers were interviewed. In this research, I needed the assistance of the local extension officer to locate the farmers to be interviewed who also could provide a cordial entry into the community. It was essential that every extension officer who assisted me during the survey was made familiar and understood the purpose as well as the importance of the research. In view of this, an introductory explanation was given to each extension officer accompanying me to the field prior to the fieldwork on the following issues (appendix 5.1):

- reasons for the survey;
- his role within the survey programme;
- informants' role within the survey programme;
- the relevance of the work to development;
- reminder of importance of good public relationship; and
- the risk of farmers' expectations.

The next step was the testing of the NGO questionnaire, at ApproTEC office, before finally revising all the questionnaires.

The pilot test results revealed a number of issues: First, some of the questions seemed to be repetitive. Consequently, I was able to combine a number of questions. Second, there were four questions that the interviewees seemed not understand. Third, some questions elicited a response that was too general. I therefore revised the questionnaire accordingly.

The pilot testing and subsequent interviews enabled me learn more about the NGOs' operations in Kenya. The original questionnaire had been set up believing that NGOs were involved more directly in irrigation than I later discovered. Consequently, some sections of the questionnaire for the NGOs were revised to reflect their working methods. I was later to discover that the research division of the Ministry of Agriculture and Rural Development (MOARD) has a very similar approach hence the project type questionnaire was suitable to them as well.

It had been difficult to get a small-scale low-cost low head drip irrigation farmer during the pilot testing. This suggested that low-cost low head drip irrigation was apparently not as widely used as had been indicated. This confirmed my earlier fear that I could not get enough low-cost low head drip irrigation farmers for the survey. I therefore targeted areas where they were likely to be more of them during the survey.

5.5.1.2 Establishing fieldwork validity

To obtain accurate data, efforts were made to avoid over reliance on particular informants during the fieldwork. This was because some informants could have their own personal biases, or perceptions, based on their social position in a community (Pratt & Loizos 1992). Consequently, they could state their own views at the expense of others. I therefore occasionally involved the administration and other officers from different offices during the data collection. On the other hand, some informants who may have had several interviews previously with government officials or other researchers could think they knew what I wanted. For instance, in Kiambu an informant started narrating what he thought was the purpose of the study before any question was put to him. In view of such case, it was essential that informants' responses be cross-checked against others or other sources of information.

5.5.1.3 Secondary data review

The original plan was to start the secondary data collection from the beginning of January 2001. The idea was that enough background information would be obtained to give a general picture of low-cost low head drip irrigation in the country. This would also enable the formulation of a programme for the next four months. Nevertheless, after going through several libraries (University of Nairobi, Jommo Kenyatta University of Agriculture and Technology, and Ministry of Agriculture including KARI) it was apparent that documents on low-cost low head drip irrigation in Kenya was scarce. Some information was available on lowland irrigation schemes and as consultant work on furrow irrigation, but all was of little help. It was therefore decided that most of the secondary data would be obtained from the government and other offices I planned to visit in the course of work. It was hoped these would be in the form of agricultural extension annual reports, research reports, and articles in newspapers plus other magazines.

The major information was obtained from Japan International Co-operation Agency (JICA)/Ministry of Agriculture and Livestock Development headquarters. This was on Guidelines on Smallholder Irrigation in Kenya (MOARD 1993), ShedNet Drip Irrigation equipment manufacturing company, Winrock International (Kenya branch) on a workshop on Drip Irrigation in Kenya (Winrock 2000), and the International Water Management Institute (IWMI). This formed the basis of the information in Chapter 4. It was difficult to obtain regular reports and other documents from the Ministry or its library and KARI. The explanation given was lack of funds for publication.

5.5.2 Field data collection

5.5.2.1 Areas visited and number of informants

The phase 1 fieldwork took place from January 2001 and April 2001 in Nairobi, Moiben, Ngon'g, Kiambu, Matuu, and Thika areas of Kenya (Fig 4.1). Data was also collected within the same period from companies and NGOs in Nairobi, Thika and Embu. The details of the fieldwork are shown in appendix 5.1, which also explains how reliability and validity were ensured during the data collection.

There were 52 participants interviewed in phase 1, from five target groups with a different questionnaire for each group (Table 5.3):

5.5.2.2 *Data collection in Nairobi area*

It was intended that the secondary data information would be sufficient to enable the fieldwork to be programmed. However, having failed to get this data the next stage was to visit offices (government or otherwise) and collect this information through the interview. The first visit was the national headquarters of the department of irrigation. I was able to speak to two senior officers. Apart from completing the questionnaire I was able to learn what was being done about low-cost low head drip irrigation, who was involved and where. This was very useful because I was able to produce a tentative programme of my work.

The programme was to start by visiting the National Agricultural Research Laboratories (NARL) under the Kenya Agricultural Research Institute (KARI) in Nairobi, to see a project on "Drip Irrigation for Small Holder Farms". The idea was to get information about this project and at the same time find out which areas in Kenya had the highest proportion of the technology. In that case, this would help me to improve on my plan.

In the meantime, I tried to get any relevant information on this project from both the Ministry of Agriculture and the NARL libraries. I had useful discussion with the officer in charge. He explained the new drip kit that was being introduced in the country and showed some of the demonstration sites. The project had started in 1996 so it was now in its 5th year, but it was still getting some assistance from United States Agency for Development (USAID), without which it would halt.

The drip kits appeared simple and could be adopted and tried in stages. I saw the results on the demonstration site but I needed to get information from actual farmers. I found afterwards some technical evaluation of the kit done by the University of Nairobi (Ngigi et al 2000).

I gathered some information that the project started near Eldoret in Uasin Gishu district and that is where according to NARL there was the highest number of users in the country (Appendix 5.1). Realising that these could be the people who had the longest experience of the kit in the country, I targeted them as my first interviewees. This changed my original plan of working near Nairobi. I was not able to get any sales records although later on I established from farmers in the field that their particulars are taken whenever they obtained this kit. Without such records, I depended on the information given by NARL. The nearest areas to Nairobi were Ngon'g in Kajiado, Kiambu, Thika and Kithmani in Machakos District (Fig 4.1). These areas were selected for the research.

5.5.2.3 *Field visit to other areas*

One issue that arose during the fieldwork was the farmer selection. It was hoped that the local extension officer would draw up a list of all the small-scale irrigation farmers in areas under his jurisdiction. Then individual farmers would be randomly selected from low-cost low head drip irrigation and non low-cost low head drip irrigation farmers groups. Finally, an interview list would be prepared according to locality or nearness and a proper order of interviewing identified. This was not possible because extension staff were unable to come up with such list.

In practise, we visited all "known" LCLH drip irrigation farmers in the study areas. The local extension officer would introduce me to the farmer, explaining the research and purpose and the importance of the survey work. This was crucial to avoid any suspicion from the farmer. He then left for the farmer to be interviewed in his absence for the sake of the farmers' freedom in responding to the questionnaire. This avoided unnecessarily biased responses to some questions. The interview was tape recorded with prior consent of the interviewee.

During the week, it took up to four days on field trips, the rest of the time was spent on compiling / processing so that if there was an anomaly it could be checked while still in the field.

5.6 Critique of the data collection method

5.6.1 Literature review

The main constraint on the literature review methodology was that the data on some aspects of study from the Kenyan, was scant and often missing compared to the information from the Indian case. In other cases, the sources were secondary like workshops rather than primary as in the Indian case. This made it sometimes difficult to make conclusions from such information when relating it to the Indian case. That is why some of the conclusions could be less general in application.

5.6.2 Survey errors

This section deals with the possible sources of errors during the data collection despite these efforts, which is important for the interpretation and application of the results.

The first source of error could have originated from the non-random selection of the participants. This implies that it is difficult to make legitimate and reliable generalisation about the adoption of LCLH drip irrigation. Randomisation reduces possible errors and biases by neutralising some of them. Therefore, there could be systematic sources of errors from the process of selecting individuals. This is because the purposeful selection could coincide with any of the factors under study. This could be for example, selecting farmers from the same project under similar management, with the same factors making it difficult for the individual efforts and factors to be discernible. The closest example in the study would be the passion fruit project in Uasin Gishu. In that case, the result may misrepresent the situation as a whole within the country although describing fully the case under study.

The second source of error could have arisen from the selection of the participants by the local extension officers. They would not tell what criteria were used to select the staff. All that is known is that I interviewed all the low-cost low head drip irrigation small-scale farmers known to them and some non low-cost low head drip irrigation farmers, selected by them. This could have been a major bias, especially if others are unknown to them, which may have given misleading results. This could have been a worse problem if I only interviewed some of them. This was possible because there were large concentrated areas of small-scale irrigation plots.

Other errors could have arisen from farmer expectations despite my effort to minimise these. The participants might have expected some kind of assistance from the study and therefore may have answered question in a way intended to boost the need for this assistance. For example, questions on the need for credit facilities.

Lastly, the drawback with the interview method is that it often relies on farmers' memories, and it is difficult to tell those with good reliable memories. For this reason, questions demanding memory may have suffered most. Of course, it would have been better if I could obtain some of the information from records. But to expect this from small-scale farmers of 0.25 acre with little formal education is perhaps expecting too much. Consequently, I had to amend one question in the field because records proved hard to find or were not available, and farmers could not consistently remember the inputs, yields, and crops under irrigation during different seasons. Apart from these problems some government officers were either new in the offices and others could not respond to some questions preferring to consult the seniors. The latter was especially true with some low-cost low head drip irrigation dealers. Hence, these could also have introduced errors in the data.

The other important limitation of data collected was likely to come from the sample size. Although purposeful selection was used to select the key informants, the number of informants selected was too small to make generalised conclusions about the findings. However, this did not mean that no lessons and conclusions could be made about the study. The information collected is still useful in this regard.

In addition, it is likely that there were errors linked to bias and perception. Despite making efforts in my introduction to limit any suspicion, it is possible that some of respondents still had some suspicion with either the purpose of the study or what I intended to do with the information. I was aware of some of this possible suspicion; the Government officers could be afraid that it could form part of the monitoring of their performance, while manufactures could be anxious that some of this information could be passed to their rivals. This scenario can be observed from some of the responses in the questionnaire e.g. reluctance to answer particular questions. Some NGOs could be concerned with adverse publicity. In fact, one of them refused to give me their brochure unless I got permission from their director. Most of the irrigation in Ngon'g is on rented plots which are under great demand. Therefore, I could sense that some farmers suspected that I could be interested in taking over their plots and that is why I was interviewing them. This is expected in an area where potential irrigation tenants offer high fees to remove the current ones. In one case, a landlady was so convinced that her plot was about to go that, despite all our efforts to explain in order to avoid any suspicion, she became very uncooperative.

Despite having pilot tested the questionnaire some errors were noted in the field. For example, it was difficult to get a meaningful response on information about the yields and crop acres (areas) from the small-scale irrigation farmers. This is because most did inter-cropping and harvested irregularly for over long periods. For some crops, e.g. for Kale, the harvest lasted for more than one season making it difficult for farmers to remember their total harvests. Although from the start of the research project, it had been anticipated that few farmers would have records relying on their memory instead: this was only possible where mono-crops were irrigated on separate plots and harvested in relatively short period. It was for this reason that the questions on this subject and others with similar field problem were either modified in the fields or left out during the data compilation. Consequently, it was difficult to estimate relative advantages of different irrigation methods.

In spite of all these constraints, misunderstanding of the questionnaire by respondents was believed to be minimal. This was because I conducted the interviews, designed the questions, knew the objectives and provided guidance accordingly.

5.7 Chapter 5 Summary

This chapter reports the literature (document) review and survey that were used to collect data in Kenya for phase 1 of the study. The key informants were SSI farmers, government officials, irrigation industry, and non-governmental organisations.

The research method was formulated from the research objectives and questions. This in turn determined the type of data to be collected and the questionnaire.

Fieldwork was done between January and May 2001 in Nairobi, Uasin Gishu, Ngon'g', Kiambu and Matuu. The application of pilot testing showed weakness in the questionnaire that led to modification and improvement of the questions. The weaknesses were ambiguities, irrelevant questions and repetition. The visiting of farmers at the correct time allowed for their co-operation in interviewing. The open-ended questions allowed for probing during interviewing and discussions.

The chapter stressed the need for accuracy as well as the limitations of the data collected. During data collection, efforts were made to improve the quality of the collection by the employment of techniques such as triangulation and to increase validity of the data collected through:

- Reducing farmers expectations of immediate gain from the research;
- Minimising personal biases; and
- Proper briefing and introduction during field work.

The selection of the study areas and sampling was purposeful. This was necessitated by limitations imposed by available resources. However, non-random sampling and small-sample size introduced limitations in the general application of the results. The other likely constraints identified were respondents' suspicions of the interview, local expectations of farmers of how the interview might affect them, and the problem of relying on memory rather than records for some questions. Therefore, the data collected, which is analysed in the next chapter, may or may not apply to other areas.

CHAPTER 6

PHASE 1: FACTORS INFLUENCING ADOPTION OF LCLH DRIP IRRIGATION - RESULTS AND DISCUSSION

6.1 Chapter introduction

The aim of this chapter is to present the results of the phase one survey following the general order of the questionnaires. This is followed by a discussion of appropriateness of the LCLH drip irrigation kit and factors influencing the innovation-decision process.

Figure 6.1 summarises the sequence of analysis of the survey further details of transcribing, categorisation and coding are presented in appendix 6.0.

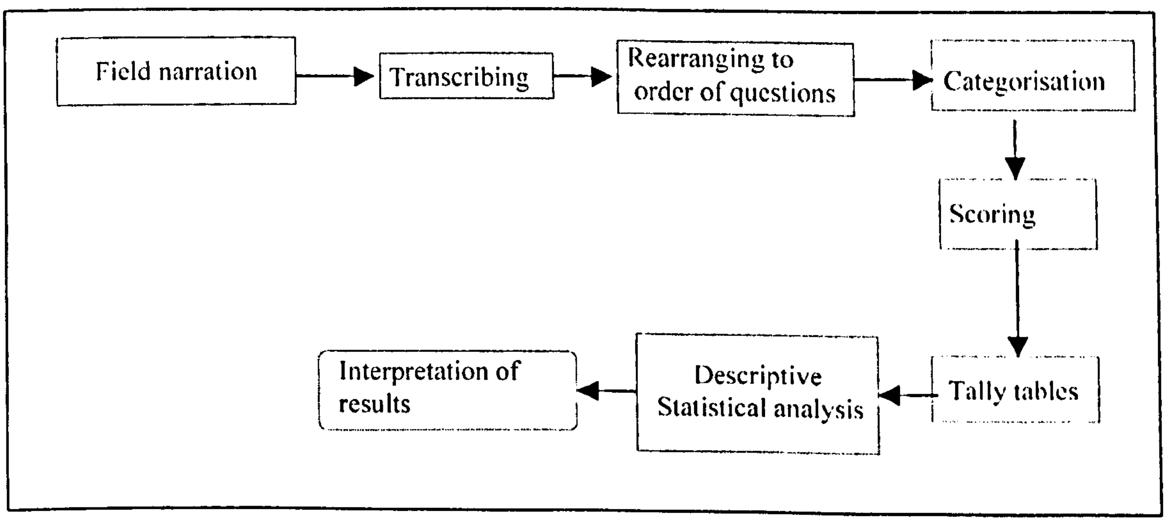


Fig 6.1 Phase 1: The structure of data analysis

6.2 Results of Phase 1 survey

6.2.1 Smallholder irrigation farmer survey

6.2.1.1 Experience of irrigation practice

SSI farmers were asked when they first started irrigation. Non LCLH drip irrigation farmers had practised irrigation for much longer than low-cost low head (LCLH) drip irrigation farmers (Table 6.1). This is despite the fact that some LCLH drip irrigation farmers had previously used other methods. The average LCLH drip irrigation farmer in the study area started irrigation in 1997 while the average non LCLH drip irrigation farmer had started earlier - practising irrigation for over 10 years, extending to over 40 years in some cases. This suggests that the LCLH drip irrigation farmers have less irrigation experience.

Table 6.1 Experience of irrigation practice by small-scale farmers

Qn. When did you start irrigation?				
Type of SSI farmer	**Year**			**Time in years***
	Average	Earliest	Latest	
Non LCLH drip irrigation farmers	1989	1957	2000	12
LCLH drip irrigation farmers	1997	1990	1999	4

* *Survey date 2001*

6.2.1.2 *Irrigation land tenure and sites*

The majority of the farmers (82%) were registered individual owners of their irrigated plots (Table 6.2). More LCLH drip irrigation farmers (94%) owned land than non LCLH drip irrigation farmers (70%). The non LCLH drip irrigation farmers, who tended to be commercial oriented by field observation, were more likely (24%) to rent land than LCLH drip irrigation farmers (6%). The smallholder farmers who went in for commercial production rented and cultivated relatively larger plots (Table 6.4).

Table 6.2 Irrigated land tenure and location

Qn. What is your land ownership?						
Land tenure system	**Total response**	**% total**	**Which participants? (response)**			
			Non LCLH drip irrigation		LCLH drip irrigation	
	Number		Number	%	Number	%
Registered owner	27	82	12	70	15	94
Renting	5	15	4	24	1	6
Other	1	3.0	1	6	0	0
Total	**33**	**100**	**17**	**100**	**16**	**100**
Location						
Upland	24	73	8	47	16	100
Lowland	9	27	9	53	0	0
Total	**33**	**100**		**17**	**16**	**100**

The results show that all the LCLH drip irrigation farmers were from upland irrigation despite valley bottom irrigation for vegetables being the commonest form of smallholder irrigation in Kenya (Appendix 1.0). The non-involvement of such a considerable fraction of smallholder farmers in the country may have a negative effect on the LCLH drip irrigation technology adoption.

6.2.1.3 Objectives of irrigation

73% of irrigation in the study areas was for commercial objectives (Table 6.3). More non LCLH drip irrigation farmers (83%) were commercial than LCLH drip irrigation farmers (63%). There were no non LCLH drip irrigation farmers in subsistence irrigation. It was not surprising that some LCLH drip irrigation farmers practised subsistence farming; the bucket drip kits used by some farmers were designed for subsistence farming.

Table 6.3 Objectives of irrigation by small-scale farmers

Qn. What is your main objective of irrigation?						
Aim of irrigation	**Total response**	**% total**	**Which participants? (response)**			
			Non LCLH drip irrigation		LCLH drip irrigation	
	Number		Number	%	Number	%
Commercial	24	73	14	83	10	**63**
Mixed	6	18	3	18	3	**19**
Subsistence	3	9	0	0	3	**19**
Total	**33**	**100**	**17**	**100**	**16**	**100**

6.2.1.4 Irrigated plot sizes

The majority of the LCLH drip irrigation farmers (58%) cultivated plots of less than 0.1 acres, with an average of 0.15 acres; most of them had LCLH bucket drip irrigation kit (Table 6.4). However, none of the non LCLH drip irrigation farmers cultivated areas this small. The non-LCLH drip irrigation farmers' longer experience, may have shown that very small-plot are not profitable.

Table 6.4 Irrigated plot sizes

Qn. What size is your irrigated area?						
Holding	**Size**	**Total Response**	**Which participants? (response)**			
			Non LCLH drip irrigation		LCLH drip irrigation	
	Acres*		Number	%	Number	%
Marginal	Below 0.10	7	0	0	7	**58**
Small	>0.10-0.25	7	5	26	2	**17**
Semi-medium	>0.25-0.50	5	2	11	3	**25**
Medium	>0.50-1.0	6	6	32	0	**0**
Large	>1.0-3.0	4	4	21	0	**0**
Extra large	>3	2	2	10	0	**0**
Total		**31**	**19**	**100**	**12**	**100**
Mean (acres)			**1.6**		**0.15**	

1 hectare =2.47 acres

6.2.1.5 Irrigated crops

Table 6.5 shows that the most commonly irrigated crop were vegetables, followed by cereals. The two crops accounted for over 60% of all the responses. Of the 33 respondents, 94% of them irrigated vegetables while about half (42%) irrigated cereals. The indication that LCLH drip irrigation farmers seem to grow more fruits may be due to the fact that my first area of survey was predominantly a passion fruit growing area where LCLH drip irrigation was introduced specifically for irrigating fruit trees.

Table 6.5 Irrigated crops of study areas*

Qn. What crops do you irrigate on your farm?						
Crop	**Total response**	**% total**	**Which participants? (response)**			
			non LCLH drip irrigation		LCLH drip irrigation	
			Number	%	Number	%
Vegetables	31	43	16	50	15	38
Fruits	11	15	2	6	9	23
Cereals	14	19	6	19	8	20
Potatoes**	9	13	4	13	5	13
Flowers	2	3	1	3	1	3
Bananas	5	7	3	9	2	5
Total	**72**	**100**	**32**	**100**	**40**	**100**

* Note many farmers irrigate more than one crop

* * Sweet & Irish

6.2.1.6 *Effect of irrigation on farm income*

When farmers were asked what had been the effect of irrigation on farm income, over 88% of non LCLH drip irrigation and 69% of LCLH drip irrigation farmers stated that it was profitable (Table 6.6). This implies that more non LCLH drip irrigation farmers found it profitable than did LCLH drip irrigation farmers. This difference indicates that profitability alone was an unlikely factor to persuade non-irrigation farmers to adopt LCLH drip irrigation from surface or sprinkler irrigation.

Table 6.6 Irrigation effects

Qn. What has been the effect of irrigation on your farm benefit?						
Effect of irrigation	**Participants**		**Which participants?**			
			Non LCLH drip irrigation		LCLH drip irrigation	
	Total	**%**	Number	%	Number	%
More profitable	26	79	15	88	11	69
No effect	3	9	1	6	2	13
Less profitable	1	3	0	0	1	6
Don't know	3	9	1	6	2	12
Total	**33**	**100**	**17**	**100**	**16**	**100**
Qn. Why?						
Reasons why profitable or not						
Helps food production & domestic expenditure	17	52	9	53	8	50
Grow more frequently	10	30	7	41	3	19
Only way for arable farming/ increased yield	5	15	1	6	4	25
Cannot support me/no market	3	9	1	6	2	13
Irrigation system problems	3	9	1	6	2	13
Don't know	2	6	2	12	0	0

In explaining why they considered irrigation more profitable, most defined profitability in terms of what they were able to do after starting irrigation, as shown in table 6.6. Most farmers were unable to remember or estimate figures for their inputs and outputs. The most important factor was the effect of irrigation on food production and its positive contribution to reducing domestic expenditure, which was stated by about half (52%) of participants and contributed 43% of all responses. This applied mainly to farmers who had no irrigation before, used traditional method, and/or hose-pipe to sprinkle (hose-spray) the water onto the crops.

Closely related to this was the fact that SSI farmers were able to grow crops more frequently. However, 41% of the non-LCLH drip SSI farmers reported this as compared to only 19% for the LCLH drip irrigation kit farmers. This difference arose from the fact that non LCLH drip irrigation farmers tended to be in low valley bottoms near water where water supply was more reliable, making it possible to irrigate for longer periods in a year.

The results demonstrate that most LCLH drip irrigation farmers practised irrigation as their only means of arable farming in contrast to non LCLH drip irrigation farmers. This was generally the case in the semi arid areas such as Kajiado area. It was not surprising to find that it was difficult to get some representative gross margins from the field. NARL information was that no such evaluation tests had been done for lack of funds. Indeed the 2000 KARI (2000) report on small-scale LCLH drip irrigation development does not have this information.

However, I obtained secondary data (Nyakwara et al 2000) and, secondly made some estimates of variable costs gross margin for passion fruits from a farmer who was able to remember the necessary data (Chapter 4 and Appendix 4.0). The two sources indicated that low-cost irrigation was profitable for farmers cultivating (0.25 acres) (0.1 ha) using larger pressurised low-cost medium-head drip irrigation units.

During the survey, most farmers could remember very little information on their farm inputs and yields making it generally difficult to compute variable cost gross margins. Some of them had good reasons why they did not find it necessary to remember past information on farming activities as this farmer from Kiambu explains when asked about the input output in formation:

> "I *have been able to get extra income from it (farming) but I think the retail person gets most of the profit. I get enough and sell the extra. It is not advisable for me to remember figures (data) of farming activity to know if the business is viable or not, because you (one) will be discouraged very soon and drop out of farming. But the following season things may change the better".*

6.2.1.7 Irrigation methods adopted

The farmers were asked what irrigation method they had now and what irrigation method they had had before moving to the current one. The results are presented in fig 6.2. The main irrigation methods of those interviewed were LCLH drip irrigation kit, sprinkler, and motorised hose-pipe accounting for 91% (Table 6.7).

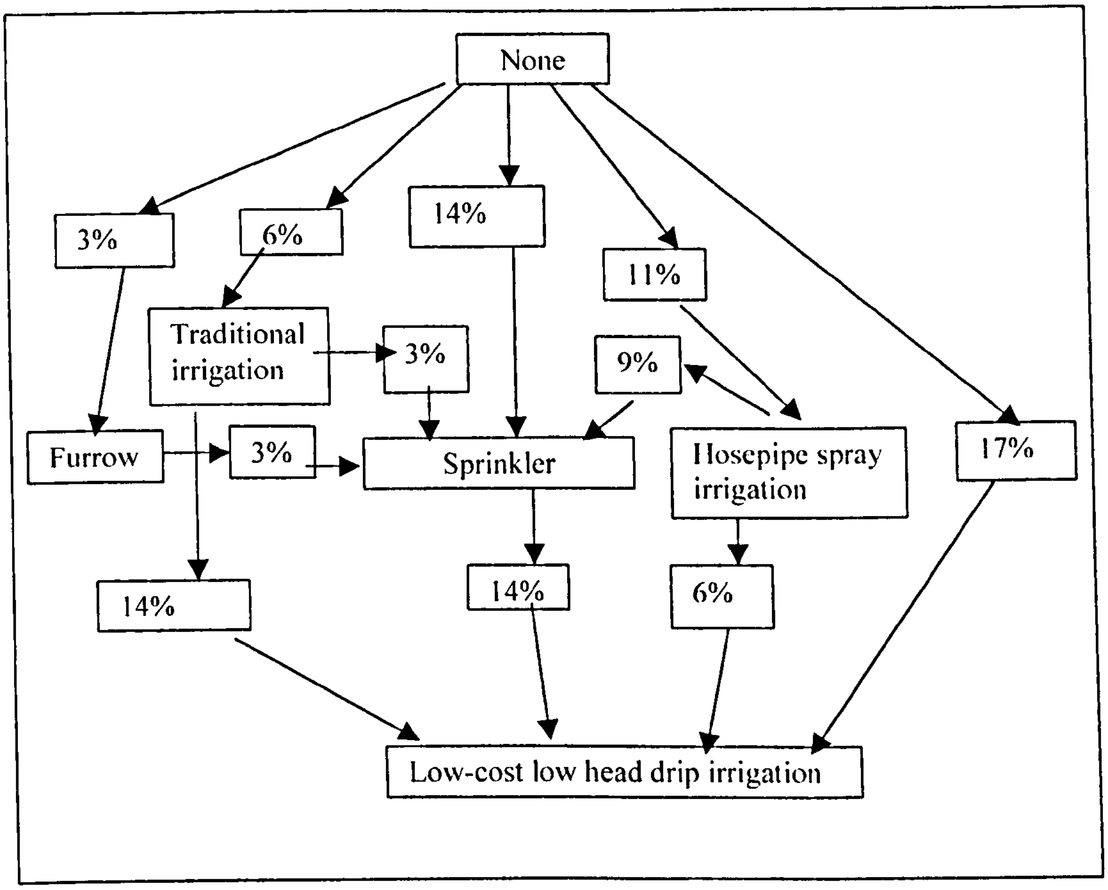


Fig 6.2 Last movement in adoption of irrigation methods (% responses)

However, the interviewee selection had aimed at interviewing about half drip and half non drip irrigation farmers.

The figure shows that no farmer dropped LCLH drip irrigation for any other method. A few had stopped using it temporarily, since they stated that they would continue using it if they solved the problems why they had stopped. The most frequent changes were from none to sprinkler, or traditional to LCLH drip irrigation (Appendix 1.0). About 31% of farmers who took LCLH drip irrigation had no previous experience of advanced irrigation methods because they came from traditional bucket irrigation or had no irrigation practice before.

Table 6.7 Main irrigation methods by small-scale farmers

Factor	Number of SSI farmers	%	Cumulative %
LCLH drip irrigation	18	51	51
Sprinkler	10	29	80
Motorised pump hose	4	11	91
Others	3	9	100
Total	**35**	**100**	

A bias in selection could have created an apparent disproportionate number of farmers going in for LCLH drip irrigation. It should also be noted that those who dropped from LCLH drip irrigation altogether were not interviewed in the phase one of the survey.

6.2.1.8 Reasons for choosing LCLH drip irrigation

Low-cost low head drip irrigation farmers were *asked* why they chose the LCLH drip irrigation kit irrigation method (Table 6.8). 56% of the farmers revealed choosing the irrigation partly due to persuasion from the change agents and peer pressure. A similar fraction was due to water saving. These two reasons were the main responses.

Table 6.8 Reasons for choosing low-cost low head drip irrigation kit

Qn. Why did you choose low-cost low head drip irrigation?		
Reasons for choosing LCLH drip irrigation kit	**Number responses**	**% total responses**
Role of change agents/peer pressure	9	56
Water saving	9	56
Given as a demonstration	2	13
Other reasons	2	13

6.2.1.9 Why smallholder farmers prefer different irrigation methods

Table 6.9a displays five major categories of relative advantage attributes given by the farmers for both LCLH drip irrigation and non LCLH drip irrigation. The majority of non LCLH drip irrigation farmers thought that their irrigation methods were profitable and less laborious. On the other hand, LCLH drip irrigation kit irrigation farmers saw their methods as economical and profitable. Further details outlining concepts of economical, convenient, labour, and safety variables as obtained from the rural farmers' knowledge are outlined in table 6.9b. These factors of relative advantage are discussed later in this chapter with respect to the innovation-decision process.

Table 6.9a Benefits of irrigation methods

Qn. Does it have benefits compared to other irrigation methods? If yes, what are they?					
Non LCLH drip irrigation			**LCLH drip irrigation**		
Benefit	Response	% participant	Benefit	Response	% participants
Profitable	14	73	Economical	14	88
Less laborious	10	52	Profitable	12	75
Convenient	9	47	Less laborious	9	56
Safety	8	42	Convenient	8	50
Economical	3	16	Safety	3	19
Don't know	0	0	Don't know	3	19

- **Economical factor**

Most non LCLH drip irrigation farmers (88%) considered their systems more economical compared to only 16% of non LCLH drip irrigation farmers. This was the main difference in benefits as stated by farmers. These responses referred to energy saving, water saving and cost (Table 6.9b)

Table 6.9b. Why farmers prefer different irrigation methods

Qn. Does it have benefits compared to other irrigation methods? If yes, what are they?			
Attributes	Variable	Sprinkler	LCLH drip irrigation
Economical	Energy saving	No	Yes
	Water saving	No	Yes
	Cost	No	Low
Convenient	Types of crops	Most	Limited
	Shifting	Easy at end of season	No periodic shifts
	Supervision	Periodic shifts required	Little
	Soil in the root zone/field	Soil remains moist for short periods	Soil remains moist for long periods
	Clogging	No problem	Is problem
	No muddy conditions	Is problem	Dry working conditions
Labour requirements	Saving	Saves at the end of the season	Saved on daily shifts
Safety of system	Pest control	Is problem	Ok
	Disease control	Is problem	Ok
	Theft	Not problem	Is problem
	Soil erosion	Could be problem	Not a problem
	Accidental cutting	No	Is problem
	Soil erosion	May be a problem	Not a problem
	Damage to crops when shifting	Not a problem	Is a problem

There were two distinctive views of economical factor of energy saving by the two groups. Motorised hose irrigation farmers saw the method of irrigation as saving fuel in comparison to using sprinklers and the traditional LCLII drip irrigation system. In contrast, those using LCLII drip irrigation stated they saved fuel in terms of less amount of water pumped. For instance, a farmer in Kiambu had decided to use LCLII drip irrigation because his land was very sloping and he was incurring a high fuel costs with sprinkler irrigation. When he bought LCLII drip irrigation and modified/expanded to serve the one acre he used for sprinkler irrigation, he started using half the amount of water he previously used. Therefore both water and energy saving were 50% compared to the sprinkler system.

- **Profitability of irrigation system**

About 75% of both LCLII drip irrigation and non LCLII drip irrigation farmers saw profitability as a major factor. However, information on costs and benefits of different irrigation methods practised by small-scale farmers useful for computation of comparison of relative advantage for LCLII drip irrigation was scarce from promoters. In the field, most small-scale farmers in the study areas could not remember the costs and yields as most of the crops were harvested several times over period of three to five months. Farm records were rare. This was further complicated by the fact that most irrigation farmers not using drip irrigation practised mixed crop farming making it difficult to get farmers using different irrigation methods with the same crops for comparison. Therefore, to come up with realistic cost and benefits for analysis of relative advantages would need detailed case studies, extensive search for farmers with records or good memory or experiments. This was beyond the resources available for this study.

- **Labour requirement of the irrigation systems**

About half of both LCLII drip irrigation and non LCLII drip irrigation farmers thought their irrigation methods were less laborious. The LCLII drip irrigation farmers reported that the LCLII drip irrigation kit saved labour, as it required no shifting during the day. In contrast, motorised hose irrigators argued that their system as having the advantage of shifting easily when their tenancy ended. A proportion (31%) of the non-

LCLH drip farmers rented land for short terms of up to a season or a year. However, this period is not secured. That is why this factor was important to them.

- **Safety of the system**

It is interesting no note how the two groups of farmers regard safety. Although this is not viewed as major (24%) factor relative to others by the small-scale farmers, the drip irrigation farmers see it as least important (19%). While they view this factor in terms of pest-control of weed and disease the non-micro look at in terms of theft of the equipment, accidental field tubes cuttings, and soil erosion.

A small group (18%) of non-drip irrigation could not perceive any benefits as to why they us the system. This could be attributed to the illiteracy level, peer pressure or the lack of effective persuasion process by the change agents.

6.2.1.10 Communication channels

Both LCLH drip irrigation and non LCLH drip irrigation farmers were asked how they became aware of LCLH drip irrigation kit irrigation. From table 6.10, the highest number of the SSI farmers became aware of the drip irrigation through friends and relatives. However, the main communication channels of the LCLH drip irrigation kit for adopters were change agents and friends accounting for 63% of participants.

Table 6.10 Communication methods for LCLH drip irrigation kit by small-scale irrigation farmers

Qn. How did you hear about it?						
	Total response	**% total**	**Which participants? (response)**			
Communication channel			Non LCLH drip irrigation farmers		LCLH drip irrigation farmers	
			Number	%	Number	%
Change agents	7	21	0	0	7	44
Friends/relatives	8	24	5	30	3	19
Don't know	10	30	7	41	3	19
Govt. extension or NARL	2	7	0	0	2	12
Media	1	3	0		1	6
Self/show/exhibition	5	15	5	29	0	0
Total	**33**	**100**	**17**	**100**	**16**	**100**

It is surprising to note the minimal role played by the government extension service (12%). At a local level, no Government extension staff admitted having an awareness program for LCLH drip irrigation during the interview despite the government having a LCLH drip irrigation kit programme.

6.2.1.11 Awareness of low-cost low head drip irrigation kit

When non LCLH drip irrigation farmers were asked whether they had heard of LCLH drip irrigation kit irrigation, 59% of them were aware (Table 6.11). Of those who were aware of the existence of LCLH drip irrigation in general, half (50%) knew very little about it while a third (30%) that it was very expensive. During the discussions, it was found that the latter response was associated with the expensive conventional high head drip irrigation system. This implied that these farmers were still ignorant of the low-cost drip kit being promoted by NARL. This suggests that only about 10%, of all the farmers who responded to this question, knew about the LCLH drip irrigation kit. These results indicate that awareness of the LCLH drip irrigation kit was apparently low; although 59% were aware of the kit over 80% of them did not appear to have operational and understanding knowledge.

Table 6.11 Awareness knowledge

Qn. Have you heard of low-cost low head drip irrigation kit?				
	(responses)			% aware
Which participants? Non LCLH drip irrigation farmers	yes 10	No 7	total 17	% yes 59
Qn. What do you know about the low-cost low head drip irrigation kit				
	Little	**Expensive**	**Other**	
Number of non LCLH drip irrigation	5	3	2	10
Percentage total	50	30	20	100

6.2.1.12 Problems and delay in starting irrigation methods

In general, most SSI farmers (69%) obtained the LCLH drip irrigation kit soon after deciding to do so (Table 6.12). Only 15% of LCLH drip irrigation farmers had delay problems related to lack of funds. More LCLH drip irrigation farmers (69%) stated that they had no delay, compared to non LCLH drip irrigation farmers (50%). The table shows that there had been no major problem preventing the LCLH drip irrigation farmers adopting it as fast as they wanted. Informal discussions confirmed that the question of credit was not raised by any farmer during introductory meetings or induction courses.

Table 6.12 Adoption delay problems

Qn. Did anything prevent you from adopting low head drip kit faster than you would have wanted?						
Attribute	**Total**	**%**	**Which participants?**			
	Response	Total	Non LCLH drip irrigation farmers		Number of LCLH drip irrigation farmers	
Delay problem			Number	%	Number	%
No	19	58	10	50	9	69
Yes	6	18	4	20	2	15
Don't know	5	15	4	20	1	8
N/a	3	9	2	10	1	8
Total	**33**	**100**	**20**	**100**	**13**	**100**
Qn. If yes, explain?						
Cash problem	4	67	2	50	2	100
Land problem	2	33	2	50	0	0
Total	**6**	**100**	**4**	**100**	**2**	**100**

6.2.1.13 Method of purchasing irrigation equipment

To confirm whether the LCLH drip irrigation equipment was affordable, SSI farmers were asked if they bought their equipment on credit or cash.

Table 6.13 Method of purchasing irrigation equipment

Qn. Did you buy it cash or on loan?				
Attribute	**% responses**	**Which participants?**		**% LCLH drip irrigation**
		Non LCLH drip irrigation	LCLH drip irrigation	
Buy cash	60	12	10	63
Not cash (credit)	20	3	0	0
Don't know	20	4	3	19
Given as demonstration	0	0	3	19
Total		**19**	**16**	**100**

The results in table 6.13 shows that the majority (60%) bought their irrigation systems on cash payments, with similar percentages for LCLH drip irrigation kit farmers (63%) and non LCLH drip irrigation kit farmers (60%). It is possible that the farmers who bought and were interviewed were the ones who were capable and ready to buy. Those who needed credit but failed to get it could not be in the sample interviewed.

6.2.1.14 Cost of low-cost low head drip irrigation equipment

The majority of non LCLH drip irrigation farmers (63%) did not remember the cost or where they obtained their equipment (Tables 6.14). This was because most of them had obtained them over several years and usually in bits while others were traditional irrigation methods not requiring major equipment.

The highest number of SSI (27%), had irrigation systems costing between Ksh 1000 to 10,000 ($ 12-128) with an average cost of Ksh 4629 ($59) for LCLH drip irrigation kit farmers and Ksh 2400 ($31) for non LCLH drip irrigation kit farmers (Table 6.14). A quarter of LCLH drip irrigation farmers did not know the cost of the kit.

Table 6.14 Cost of irrigation equipment by farmers

Qn. What was the cost of the system?					
Cost range (Ksh)**	**Total response**	**% total responses**	**Which participants? (Number responses)**		**LCLH drip responses (%)**
			Non LCLH drip irrigation farmers	LCLH drip irrigation farmers	
Donation	3	9	0	3	19
Up to 1000	6	18	5*	1	6
1,000-10,000	9	27	2	7	44
>10,000	6	19	5	1	6
Don't know	9	27	5	4	25
Total	**33**	**100**	**17**	**16**	

* For traditional irrigation

** 1US$ = Ksh 78

These - were mainly employed respondents or wives - who were not involved in the purchase of the system. There were no non LCLH drip irrigation kit farmers with a donated irrigation system, while only a small fraction (19%) of LCLH drip irrigation farmers had.

Table 6.15 shows that the drip kit is the most expensive per hectare, but it is affordable because it can be obtained on small-scale and extended when necessary.

The prices of the various types of drip kit were also discussed in chapter 4

Table 6.15 Estimated equipment and installation costs of irrigation systems*

Source(S/n)	System	Cost/ ha US$	Information available Ksh.	Crop
28	Convention drip	6,300	200,000/= less 80,00/= for pumping and storage per acre	Tomatoes 30cm by 60cm
29	Convention drip	4650	150,000/= per acre less pumping	Typical horticultural
30	Green house drip	19,000		
32	Convention drip	6,900	16,000 for 1000m	Tomatoes 30cm by 60cm
26	Conventional	6000	192,000 for 1 acre	Tomatoes
27	Sprinkler	2000	750,000/= for 12 acres	Bananas
34	Sprinkler	4000	95,000/= for 0.75 acres	Mixed
2	Bucket drip kit	81000	950/=per kit	Tomatoes

* *Excluding water supply, 1 US$ = 78 Ksh*

6.2.1.15 Farmers experiences of dealers' services

When LCLH drip irrigation farmers were asked whether they were satisfied with dealers' services of their equipment, the majority (63%) were dissatisfied; most (60%) never saw technical support staff (Table 6.16). This fits the findings in the previous section in which few farmers knew the dealers for their irrigation equipment.

Table 6.16 Dealer services to low-cost low head drip irrigation kit farmers

Qn. Are you satisfied with dealers' services?		
Attribute	**Number LCLH drip irrigation farmers responses**	**% LCLH drip irrigation responses**
Satisfied with dealers		
No	10	63
Yes	5	31
Don't know	1	6
Total	**16**	**100**
If no, Why not?		
Never saw them	6	60
No initial help	4	40
Total	**10**	**100**

6.2.1.16 Problems with smallholder irrigation method and practice-1

The irrigation farmers were then asked to explain if they had any difficulties with their irrigation methods. Their responses are discussed in section 6.2.5 alongside responses from other categories of participants.

6.2.1.17 Sources of irrigation water

Water supplies from streams were an important water source for small-scale farmers, accounting for over 40% of the cases (Table 6.17). This was followed by irrigation water from community dams. However a point of precaution; a large number of farmers in Uasin Gishu district depended on a large community dam but this was not common in other areas.

The role of government water supply was minimal, contributing less than 5% of sources. One might have expected the government to take a leading role in small-scale irrigation water supply in country where over 70% is semi arid and agriculture is the main industry. But it is possible that other factors could be in play.

Table 6.17 Irrigation water sources for small-scale irrigation farmers

Qn. What is the source of irrigation water?				
Source	**Non LCLII drip irrigation**	**LCLII drip irrigation**	**Total**	**% total**
Stream	13	2	15	**44**
Community Dam	1	10	11	**32**
Private bore-hole	1	3	4	**12**
Well	2	1	3	**9**
Government bore-hole	0	1	1	**3**
Total	**17**	**17**	**34**	**100**

The survey results (Table 6.18) show that most of the farmers interviewed (48%) stated that their irrigation water was of good quality

Table 6.18 Irrigation water quality

Qn. How would you describe the irrigation water quality?				
Attribute	**Number of total responses**	**Which participants? (Number responses)**		**% total**
		Non LCLII drip irrigation	LCLII drip irrigation	
Water quality				
Good quality water *(fresh & clear)*	17	8	9	**48**
Poor quality water *(saline)*	10	6	4	**32**
Don't know quality *(never tasted)*	6	2	4	**19**
Total	**33**	**16**	**17**	**100**
Qn. Do you know effects of using saline irrigation water?				
Yes	6	5	1	**21**
No	23	10	13	**79**
Total	**29**	**15**	**16**	**100**

However, the terms "good" or "poor" in the interview were in terms of salinity and clearness. Over three-quarters (79%) did not know the effect of using poor irrigation saline water quality in the long run which may have a direct implication on the method of irrigation used.

6.2.1.18 Irrigation water control and charging

The fraction of SSI farmers who were being charged directly for using irrigation water was small (10 %) (Table 6.19). However, about a third paid indirectly through water permits and maintenance irrespective of the area irrigated.

Table 6.19 Irrigation water control and charges

Qn. Is the irrigation water charged?						
	Responses		**Non LCLH drip irrigation**		**LCLH drip irrigation**	
Attribute	**Total**	%	Number	%	Number	%
Water charged						
No	17	59	14	93	3	**21**
Yes-Indirectly	9	31	0	0	9	**65**
Yes –directly	3	10	1	7	2	**14**
Total	**29**	**100**	**15**	**100**	**14**	**100**
Qn. Is the irrigation water controlled?						
Water						
Not regulated	22	73	8	54	14	**93**
Regulated during drought	6	20	5	33	1	**7**
Water regulated	2	7	2	13	0	**0**
Total	**30**	**100**	**15**	**100**	**15**	**100**
Qn. If yes, does it limit irrigation?						
No	32	97	17	100	15	**97**
Yes	1	3	0	0	1	**3**
Total	**33**	**100**	**17**	**100**	**16**	**100**

When asked further if the irrigation water use was controlled in any way, only 27% reported it was restricted during drought and only two admitted having ever seen the scouts in charge of enforcing the regulation during the dry seasons. This was understood to mean that there was no noteworthy constraint for SSI farmers in terms of irrigation water charges or regulation in the study areas. This was confirmed by 97% of SSI farmers who stated that they were not limited in their irrigation by water charges or restrictions.

6.2.1.19 *Farmers' characteristics*

Table 6.20a indicates that the majority of SSI farmers (55%) had only reached primary level education, compared to 63% of LCLH drip irrigation farmers and 47% of non LCLH drip irrigation farmers. The fraction of the level having at least secondary education for both categories of farmers was similar.

The farmers were asked whether they had any agricultural training and what it was if any. The majority (91%) of SSI farmers had no agricultural training; comprising 88% of LCLH drip irrigation farmers and 94 % of non LCLH drip irrigation.

Table 6.20a Educational and agricultural training

Qn. What is your level of education?						
Attributes	**Response**	**% total**	**Non LCLH drip irrigation**		**LCLH drip irrigation**	
			Number	%	Number	%
Education						
Primary	18	55	8	47	10	63
Secondary	9	27	5	29	4	25
University	2	6	1	6	1	6
None	4	12	3	18	1	6
Total	**33**	**100**	**17**	**100**	**16**	**100**
Qn. Do you have any agricultural training?						
Agricultural training						
Yes	3	9	2	1	2	13
No training	30	91	14	16	14	88
Total	**33**	**100**	**16**	**17**	**16**	**100**

The social status of the adopters of LCLH drip kit irrigation were noted during the conversation of the interview (Table 20b). In general, most people in Kenya do not have access to land until in the early thirties of the age because of culture and traditions.

Table 6.20b Adopter characteristics of LCLH drip kit farmers

Characteristics	Response	% total	Cumulative %
Social status			
Employed/retired	8	50	50
Businessman	4	25	75
Peasant farmer	3	19	94
Local leader	1	6	100
Total	**16**	**100**	
Age			
Under 40 years	10	62	62
Over 40 years	6	38	10
Total		**100**	

Therefore, a 40-year-old farmer is relatively young. The majority (75%) of the adopters in phase one survey was either employed or retired employees or businessmen. This suggests they were likely to be of high social status, cosmopolitan, exposed to wide communication avenues, and of relatively high economic status. The majority were "young" under the ages of 40 years. The social status and age together, suggest that a typical adopter of LCLH drip kit in the study area was also employed (e.g. a teacher) or a businessman under the age of 40. This may partly explain why the issue of the need for credit was not important. The application of these factors on the adopter categories and introduction stages of LCLH are discussed later in the chapter.

6.2.2 Irrigation industry survey

6.2.2.1 Irrigation equipment enterprises in Kenya

The survey of six main irrigation companies in Kenya revealed that most of them had been distributing and installing irrigation equipment for at least 10 years (Table 6.21). However only one company manufactured LCLH drip irrigation equipment - Shed-Net Company. The majority (67%) of the companies dealt in LCLH drip irrigation equipment by importing parts for local assembly. This demonstrated the extent to which the LCLH drip irrigation kit depended on foreign material.

Table 6.21 Activities of major irrigation industry in Kenya

Qn. How long have you been in the irrigation industry?		
Attributes	**Response**	**% total participants**
Age of business		
At least 10 years	5	83
Less than 10 years	1	17
Total	6	
Qn. What irrigation equipment do you deal in?		
Manufacture/assembly		
All sprinkler parts	5	83
Import LCLH drip irrigation equipment	4	67
Pumps	2	13
All LCLH drip irrigation parts	1	17
Mini sprayers /jets	1	17
Manufacture LCLH drip irrigation parts	1	17

6.2.2.2 *Sources of raw material and equipment for irrigation*

The main sources of irrigation equipment and materials were Europe (50%) (mainly Italy, Spain, Austria, and Britain) and Israel (36%) (Table 6.22). The companies were then asked if they had tried alternative cheaper sources as India or South Africa. Most of them (80%) stated they had not, and gave quality standards as the main reason.

Table 6.22 Source of irrigation equipment and raw material

Qn Where do you get most of your raw material and equipment?		
Attributes	**Response**	**% total response**
Source of raw material and equipment		
Europe*	7	50
Israel	5	36
Kenya/local	1	7
Africa (Egypt)	1	7
Asia (India)	0	0
Total	**14**	**100**
Qn. Have you tried to import from India?		
Tried India or other cheaper sources		
Yes	1	20
No	5	80
Qn. If no, why not?		
Why not?		
Problems of Standard	4	67
We get from our original country of company	2	33

* Italy, Spain, Austria, Germany, Britain

6.2.2.3 *Problems of manufacturing low-cost low head drip irrigation kit*

The only company manufacturing micro-irrigation equipment reported that it had no serious manufacturing problems. This suggests the production of components of LCLH drip was unlikely to have manufacturing problems if started.

6.2.2.4 *Industrial research on irrigation equipment*

It was not surprising when the survey showed that only one company out of 6 companies interviewed did not use foreign quality standards (Table 6.23) although local companies could generate their own research information for the design and manufacture of equipment suitable to the local standards and conditions.

Table 6.23 Research and Irrigation information

Qn. Where do you get your research information (standards) for manufacturing?		
Attributes	**Number response**	**% response**
Research information		
Parent foreign company	5	71
South Africa	1	14
Experience/none	1	14
Local sources	0	0
Total	**7**	**100**

6.2.2.5 Private supply and promotion of low-cost low head drip irrigation kit

Most manufactures (60%) did not promote LCLH drip irrigation kit (Table 6.24). Only one sold the kits while the others did not report clear intentions to start. This was not surprising given that the Indian case was similar, and only 50% of them were aware of the kit. All of those that promoted micro-irrigation in general concentrated on shows and exhibitions for their promotions. However, shows tend to be far away and are likely to be expensive for small-scale farmers to attend. None of them had demonstration sites in rural areas.

Table 6.24 Private supply and promotion of the LCLH drip irrigation kit

Attributes	**Response**	**% total response**
Qn. Do you promote low-cost low head drip irrigation (kit) irrigation?		
Yes	2	40
No	3	60
Qn .How do you promote low-cost low head drip irrigation (kit) irrigation?		
Shows, exhibitions and news print	2	40
None (we are established)	3	60
Total	**5**	**100**
Qn Do you have demonstration sites in country?		
Yes	0	0
No	5	100
Total	**5**	**100**

6.2.3 Government survey

This section focuses on the phase one survey on government representatives. The key respondents included officers at the national level down to grassroots level who were:

- Senior officers in Irrigation and Drainage Branch at the Ministry of Agriculture and Rural Development;
- Research officers at National level in-charge of smallholder irrigation Unit; and
- Agricultural extension officers at District, Divisional and grassroots location level.

6.2.3.1 Government policy on irrigation technology for smallholders

Table (6.25) on government extension policy suggests that the extension policy on small-scale irrigation technologies was apparently lacking, not clear, or not emphasised (67%). This was consistent with the findings in chapter 4 on Small Holder Irrigation Guidelines by MOARD (1993).

Table 6.25 Government policy on smallholder irrigation

Qn. Is there a current government extension policy on irrigation technology development for small-scale farmers?		
Attributes	**Response**	**% total response**
Yes	0	0.0
No	2	33
Not clear, not emphasised	4	67
Total	**6**	
Qn. Is government facilitating introduction of low-cost low head drip irrigation kit?		
Yes	1	20
No	4	80
Qn. If no, are there plans do so in the future?		
Yes	4	67
No	2	33
Total	**6**	

6.2.3.2 Strategies for creating awareness of low-cost low head drip irrigation

Government representatives were asked if their ministry or departments had small demonstration sites (awareness programme) for small-scale LCLH drip irrigation technology. Of the six government officers surveyed, none had awareness programmes and/or demonstration sites for the LCLH drip irrigation kit, except NARL. The apparent lack of wide-spread government persuasion or extension efforts for adoption of the drip kit demonstrates the monopoly by NARL, and the state of the approach to introduction of the LCLH drip irrigation kit in Kenya, which is unlikely to help its adoption.

6.2.3.3 Assistance for marketing of SSI agricultural produce

When asked if the ministry assisted the smallholder irrigation farmers in marketing, including into foreign markets, 67% of government staff said no (Table 6.26). There was a whole government department in charge of this service. However, the problem was inadequate funding of the department which, when funds are available, targeted groups and not individuals.

Table 6.26 Assistance for marketing of SSI agricultural produce

Qn. Does the ministry assists small-scale irrigation farmers in marketing including foreign?		
Attributes	**Response**	**% total response**
Government assistance for marketing		
No	4	67
Yes	1	17
Only for certain groups	1	17
Total	**6**	**100**

6.2.3.4 Small-scale irrigation research problems

The main government problem for research was under-funding as explained by a senior officer in charge of National Research. He stated:

> "Even *this project (low-cost low head drip irrigation kit) could not have started without the support of USAID*".

This problem confirms the general inadequate funding by African governments on agricultural projects as discussed in chapter 3.

6.2.4 Non-Governmental Organisation survey

Representatives from four local NGOs were interviewed whose activities involved working with smallholder farmers in irrigation at the field level rather than national co-ordination. These were:

- Smallholder Irrigation Scheme Development Organisation (SISDO);
- Sustainable Agricultural Community Development Program (SACDP);

- ApproTEC; and
- Plan International.

In addition marketing information on horticultural produce was obtained from Fresh Producers and Exporters Association of Agricultural of Kenya (FPEAK)

6.2.4.1 Promotion of irrigation technology

Only one of the four NGOs interviewed directly promoted the use of the LCLH drip irrigation kit technology. This is despite 50% of them being aware of the drip kit (Section 6.2.5). Table 6.27 shows the great variation of reasons given by NGOs for not engaging in non LCLH drip irrigation methods. Most NGOs did or would not promote the LCLH drip irrigation kit for reasons ranging from lack of awareness, how busy they were, market problems, and possible credit problems. However, during the informal discussions the most important factor accounting for these different reasons (given above) was the apparent fear of the risks involved in irrigation in general. It was apparent that most NGOs, as well as for the Government extension service, went by whatever irrigation methods the farmers already used.

Table 6.27 Some reasons why NGOs do not promote irrigation technologies

*Qn. Do/would you promote the use of low-cost low head drip irrigation kits? If no, why not? **		
Reasons for not supporting LCLH drip irrigation kit irrigation	**Response**	**% total response**
Farmers not aware of the LCLH drip irrigation kit	1	20
Our resources- finances/personnel stretched	1	20
Farmers don't service credit	1	20
Market problems	1	20
A non-profit NGO is more suitable	1	20
Total	**5**	**100**

* *NGOs not limited to only one response*

6.2.4.2 Extension service by NGOs

Three quarters of the NGOs surveyed had an organised extension service unlike the government services and the manufacturers (Table 6.28). Furthermore, the NGOs seemed to have better communication channels to reach the smallholder farmers. Unlike the manufacture that used shows and exhibition and government extension service that hardly had any promotional services for the LCLH drip irrigation kit, the NGOs employed inter-personal methods, including courses, demonstrations and samples, and they operated at grass root level. However, relatively few were involved in the promotion of LCLH drip irrigation.

Table 6.28 Extension work by NGOs

Qn. Do you do agricultural extension work?		
Attributes	**Response**	**% total response**
Yes	3	75
No	1	25
Total	**4**	**100**
Qn. How do you create awareness of the irrigation technology to small-scale farmers?		
Local newspapers	1	13
Training courses	4	50
Demonstrations and free samples	3	38
Total	**8**	**100**

6.2.4.3 NGOs farmer assistance

Half of the four NGOs interviewed stated that they helped farmers in training of better crop husbandry, provision of credit, and marketing (Table 6.29). While there were few NGOs supporting farmers by giving them direct finance and the development of water harvesting, there were no NGOs concentrated on LCLH drip irrigation kit irrigation project alone. Most NGOs were multidisciplinary; a typical NGO described its activities as follows:

> *"We have a programme of upgrading goats, we construct water tanks for rural communities, and we train rural communities in agro forestry and soil and water conservation. We also assist communities in small-scale water project as farm ponds for domestic and agricultural use and this is where (low-cost low head drip irrigation kit) irrigation comes in."*

With so many activities, there may be a tendency for some NGOs to over-stretch their resources, so that LCLH drip irrigation was likely to receive little attention.

6.2.4.4 NGOs criteria for the credit

Table 6.29 shows that the important criteria to get credit were on groupings and possession of bank account. The grouping was necessary for administration and the peer security of the credit. A bank account was necessary for control and proper accounting of the finances.

While most NGOs helped SSI farmers in marketing as shown (Table 6.29) a few did not because their programmes were geared to subsistence farming. The majority (75%) assisted farmers by training including the organisation into groups for marketing and advising them where they can sell the crops. They also advised them where they can get market information. None of the NGOs was involved in direct marketing for the farmers. In general, NGOs appeared more active in helping SSI farmers in marketing of their produce than their government counter-parts.

Table 6.29 NGOs assistance to smallholder farmers

Questions	Response	% of participants	% of responses
How do you help SSI farmers?			
Crop husbandry	2	50	22
Credit facilities	2	50	22
Marketing	2	50	22
Indirectly (low Tec pump)	1	25	11
Water harvesting	1	25	11
Direct finance	1	25	11
Total	**9**		**100**
What is the criterion for the credit?			
Must be group	2	50	40
Must have bank account	2	50	40
An individual	1	25	20
Total	**5**		**100**
How do you help farmers in the marketing of their farm produce?			
Training how to market	3	75	50
Advertise their produce	1	25	17
Provide market information	1	25	17
Organising for marketing group	1	25	16
Total	**6**		**100**

6.2.5 Questions general to all groups

This section outlines the results of the main factors influencing the adoption of LCLH drip irrigation arising from questions to all the respondent groups. These results are discussed later showing how they are linked to the Rogers (1995) Innovation-decision model with respect to this study later.

6.2.5.1 Problems with smallholder irrigation method and practice

The irrigation farmers were asked to explain if they had any difficulties with their irrigation methods. In addition, Government officers including research (NARL), the manufacturing companies and NGOs were asked what they considered as the main problems for LCLH drip irrigation kit in Kenya (Table 6.30). The table shows that the highest number and percentages of LCLH drip kit irrigation participants responses were on the problem of LCLH drip irrigation kit maintenance, followed by water supply problems. These two constituted almost half of all the responses When the problems of marketing and operation are included, this covers the main problems of LCLH drip irrigation kit irrigation as seen by the farmers themselves accounting for more than 75% of the responses. The fourth problem was from the government respondents who cited the lack of proper policy on small-scale irrigation as a main (22%) problem. The focus of the following discussion on problems of LCLH drip kit irrigation is on these four top factors namely: maintenance, water supply, marketing and government policy in that order.

- **Maintenance problem**

Technical support appeared to be the drip kits biggest disadvantage accounting for 24% of all responses (Table 6.30). The drip kit seemed to have more mechanical and maintenance problems than other methods. Maintenance was a larger problem than water supply and marketing for LCLH drip irrigation farmers, whereas it was not for non-LCLH drip farmers. This implied that farmers were likely to be tempted to avoid adoption of the drip kit.

Although all the major problems were generic, the drip kit appeared to be more sensitive to lack of maintenance than non-drip irrigation methods. There were two main categories of maintenance problems:

- Related to lack of technical staff, spares, and other materials, including new kits, due to there being very few dealers in the areas; and
- Related to mechanical problems such as clogging, leaks and breakage.

Table 6.30 Summary of main problems of small scale irrigation farming (% of total responses)

Non LCLH drip farmers	%	LCLH drip farmers	%	Government/NARL	%	Manufacturing	%	NGOs	%
Marketing Lack of market / information 22%, Market organisation 3%.	25	**Maintenance** Personnel, source of kits, distance 11%. Mechanical – clogging, leaks and breakage 13%.	24	**Government policy** More consideration from Govt. 13%, Method of project initiation 3%, NARL dealing direct with farmers 6%.	22	**Introductory stage** SSI too few to keep business running 33%.	33	**Marketing** Market problems 25%	25
Water supply Unreliable water supply/ during drought 20%. Poor water organisation problem 3%.	23	**Water supply** Unreliable water supply/shortage in drought 15%. Poor water use organisation problem 7%.	22	**Water supply** Cost of water development 8%. Lack/Irregular water supply 6%, and Management irrigation water 3%.	17	**Finance and credit** High interest rates 17%.	17	**Water supply:** Lack of water 20%. Poor quality of harvested water for LCLH drip irrigation 5%.	25
Environment damage Soil erosion runoff 14%. Water logging 2.0%.	16	**Marketing** Lack of market / information 12%. Market organisation 3%.	15	**Maintenance** Information lack of kits 7%. Availability of LCLH drip irrigation kits 3%, and Operational technical problems 3%.	14	**Raw materials** Lack of raw material and information on sources abroad 9%.	9	**Environment:** Adverse weather/draught 15%	15
Maintenance Mechanical –clogging, leaks, breakage 6%. Maintenance – personnel, source, distance 4%.	10	**Operational** Unable to install 5%. Expensive laborious to fetch water 8%.	13	**Crop husbandry**	14	**Farmer features** Farmers miss maintenance instruction 8%.	8	**Farmer features** Poverty draws farmers to immediate problems 5%. Illiteracy & low exposure to irrigation agronomy 5%	10
Energy Fuel cost 8%	8	**Incompatible** use on seed bed 9%	9	**Marketing** Marketing & organisation	9	**Communication** Poor rural roads 8%.	8	**Politics 5%**	5

This implies that in the general development of agriculture based on the drip kit the aspect of repairs must be better planned for, to avoid maintenance problems. For instance, provision should be made for sufficient technical personnel and dealers making sure that they are accessible within reasonably short distances from the farmers. Alternatively, the market approach could be tried (chapter 3). Although this may be obvious, it seems to be easy to forget. Alternatively, do not promote drip where there is no support.

On the other hand, the main concern for manufacturers and suppliers of irrigation equipment was that the market was too small to keep LCLH drip irrigation business running (33%). For instance, one company respondent explained why they have not seriously considered LCLH drip irrigation in small-scale farms as follows:

> *"We are still dealing with sprinkler irrigation both small scale and large scale. There are a few small-scale (drip) farmers but they are too few to keep the business running. I think in Kenya no company can survive on small-scale drip irrigation only. It has to have other business. The main problem with small-scale drip irrigation is the water resources. The water has to be available to the farmer for him to use. This has not happened in most parts of this country. Getting water to the farmer including dams, bore-holes and treatment is very expensive but not necessarily the drip system itself."*

The statement also brings out the problem of irrigation water supply in Kenya. It suggests that some manufactures could be waiting for the government or other agents, to create enabling conditions by constructing infrastructure before the manufactures have the confidence of investing heavily in LCLH drip irrigation.

The Kenyan manufacturers seem to be detached from the small-scale farmers because their responses are very different from the other 4 categories of informants. They do not for example, mention the problems of maintenance or marketing as other groups of participants.

- **Water supply problem**

Water supply problem was a generic and the main problem (Appendix 6.1). It was more recurrent among the respondent categories than maintenance. While it carried similar weight in terms of response by non-LCLH drip farmers (23%) it was the second major factor mentioned by government officers and NGOs as a problem to LCLH drip irrigation. Overall, it was the first major problem cited by all participants contributing 68% of all responses. Although the four categories of respondents agree on this problem, they differ in terms of the details of water contribution to water supply problems.

The LCLH drip kit had alleviated some water scarcity problems especially for farmers who had previously practised other forms of irrigation. This was one of the relative advantages discussed earlier in this chapter. However, some drip kit irrigation farmers experienced the problem of water supply due to unreliability caused by shortage or unexpected long drought. This constituted 15% of the response. Other factors such as poor management and poor water users' organisations also contributed. These were the same two causes expressed by non LCLH drip irrigation farmers; with the former having more response (20%) while the latter less (2%). Although the government extension officers stated similar problem, their main concern was the cost of water development, which constituted about half of all responses on this subject.

The quality of harvested water for drip irrigation was a factor expressed by NGOs. The water harvesting was mainly from surface runoff, which affected its physical quality. This problem appears minor because there was low water harvesting activities in the study areas. Nevertheless, it is likely that as LCLH drip irrigation grows more farmers will turn to water harvesting, increasing the problem significantly.

- **Marketing problems**

The problem of marketing was recurrent at the top of most respondent categories but features low under the government responses (Appendix 6.1). The problem ranked third from the LCLH drip irrigation farmers' point of view. The LCLH drip irrigation farmers appeared relatively less sensitive to it than non-drip farmers. However, this could have been an indication that the production levels in drip kit areas were at rudimentary stage.

The main problems of marketing were lack of market information (13%) and poor market organisation (3%). To illustrate the importance of latter SSI farmers in Ngon'g valley bottoms had an opportunity to export vegetables to China. However, they were unable due to lack of organisation, as this farmer explained:

"We *are over 35 members."*

***Qn:** Do you have an organisation?*

"No. We have never had a meeting of the project area... We have had government officials visiting us...they know our problems. One of our problems is shortage of land. That is why you can see very many small pieces of land... Because of this, even if we formed a co-operative it will be useless.... for marketing purpose. We had a Japanese company buying "Chinese" cabbage for export... However, they were unable to continue because we were producing small quantities.... It was very helpful and profitable to us. The problem was our lands are small and also because some members were reluctant to grow the commercial crop to meet (increase) required output.".

***Qn:** If it was profitable how come, some members were reluctant to grow the crops?*

"Some people have no other place they can get food. This is the only place. Therefore, they have no choice. So each person does his own things. This people (Japanese) were very good because they used to tell us how many acres of tomatoes, cabbage, onions etc we should plant at a given time".

- **Government policy**

It is astonishing that the top three problems by SSI farmers and NGOs do not feature at the top of the government list. Does this mean the government has lost touch with the problems of SSI farmers? This would appear to be partly the case. This view was supported by the fact that the main concern for most government officers was lack of emphasis or consideration (policy) for SSI irrigation technologies (14%). Furthermore, the original idea of the introduction of the drip kit in Kenya was not from the government. Information from agricultural extension officer when answering a question on irrigation development for small -scale farmers explains why there is a problem of government promotion of the drip kit:

"I have not seen any (policy). I do not think the ministry has put serious extension work in small-scale irrigation at least at the Divisional level. There is no vote (money) for the extension irrigation for small-scale farmers or for irrigation technology. Perhaps this money is at the District level. I have not seen any policy on both of them."

This case shows that some technical staff at the grassroots do not know or understand the Government policy. However, while at the ministry headquarters I was able to get Guidelines on Smallholder Irrigation Projects for Implementing Agencies and Donors (MOARD 1993). This was mainly for non-governmental organisations rather than government extension staff. In view of this, it may not be surprising that 14% of government responses recommended that SSI in general and drip kit in particular should get more consideration from the government. It should be emphasised here that the government has already recognised the importance of smallholder irrigation by creating a unit in charge of this sector. However, what these study findings seem to indicate is that its effects are not felt at the grassroots by the technical staff on the ground. The lack of guiding principle for the drip kit extension was exemplified by the fact that a number of technical extension staff (6%) complained that NARL was dealing directly with SSI farmers although it was officially they who were required to promote new agricultural technologies in the areas. I later learned that finance was the main cause for this. That was why several of these officers had problems knowing the drip kit farmers under their jurisdiction during the survey. This created problems because whenever farmers had a problem with the kit they were inclined to look for NARL staff. However, they were often several hundreds of kilometres away centralised in Nairobi. This made them generally inaccessible to SSI drip kit farmers.

6.2.5.2 Awareness of low-cost low head drip irrigation

Only half of the NGOs and 40% of manufacturers interviewed were aware of the NARL LCLH drip kit programme (Table 6.31). What was surprising was the response from the only NGO officially dealing with smallholder irrigation in the country. When asked if aware of the LCLH drip irrigation kits NARL was promoting in the country:

"No. How do they look like? Where are they from? ...I come from a semi arid area, but I know very little about the low-cost low head drip irrigation or low-cost low head drip irrigation. So it (programme) will need a lot of education for people to know what it is and have any prospects".

Table 6.31 Knowledge by groups of respondents

Qn. Have you heard of low-cost low head drip irrigation kit?				
	(Number responses)			% aware
Which participants?	yes	No	Total	% yes
Non LCLH drip irrigation farmers	10	7	17	59
Government & research	6	0	6	100
Manufacturers	2	5	7	40
NGOs	2	2	4	50
Total	**20**	**14**	**34**	**59**
% total	**58**	**42**		
Qn. What do you know about the low-cost low head drip irrigation kit				
	Little	**Expensive**	**Other**	
Non LCLH drip irrigation	5	3	2	10
% total	**50**	**30**	**20**	**100**

6.2.5.3 Prospects of low-cost low head drip irrigation in Kenya

Although the results on appropriateness showed that half the farmers thought that the LCLH drip irrigation kit was suitable, these results did not include those who had discontinued the adoption this is the subject of the next phase of the survey. The results obtained from the irrigation industry, government officers and NGOs in this section indicate that the majority (59%) thought its prospects were high (Table 6.32).

Table 6.32 Responses on prospects of low-cost low head drip irrigation in Kenya

Qn. From your experience, what are the prospects of low-cost low head drip irrigation in Kenya?					
Factor	Government & NARL	Manufactures & Suppliers	NGOs	**Total**	**% total**
High	4	4	2	**10**	**59**
Low	1	2	0	**3**	**18**
Don't know	2	0	2	**4**	**24**
Total	**7**	**6**	**4**	**17**	

Most respondents thought the LCLH drip irrigation kit has prospects in Kenya because it could play a major role in eradication of poverty in the country. The manufactures and suppliers noted that it was a fast growing market hence had better prospects. However, the future of LCLH drip irrigation kit appears to depend on resolving the identified problems and conditions that emerged during the course of this study.

6.2.6 Appropriateness of low-cost low head drip irrigation kit

A half of LCLH drip irrigation farmers interviewed responded that LCLH drip irrigation was appropriate (Table 6.33), mostly in terms of rural farmers' knowledge of its benefits. The other half thought it was not appropriate mainly due difficulties with its management (80%) and the risk of theft (20%). Most non LCLH drip irrigation kit irrigation farmers were unaware of the drip kit so their responses were generally associated with the conventional high head drip irrigation. For example, they thought (wrongly) that it was expensive in terms of capital cost and operational energy and or appropriate only for large-scale farms (20%). Others thought it was only appropriate for specialised green-houses. Such responses suggested they were unaware of the low-priced small LCLH drip irrigation kit under promotion.

Table 6.33 Low-cost low head drip irrigation kit appropriateness

Qn. Is low-cost low head drip irrigation appropriate to your farming system?				
Attribute	**Which participants?** (Number responses)			
	Non LCLH drip irrigation		LCLH drip irrigation	
	Number	%	number	%
Is appropriate				
No	5	29	5	31
Yes	2	12	8	50
N/a	7	41	3	19
Don't know/	3	18	0	0
Total	**17**	**100**	**16**	**100**
Why not?				
Expensive (cost or energy)	3	30	0	0
Appropriate for large farms	2	20	0	0
Land tenure/already invested	2	20	0	0
Theft	1	10	1	20
No water problem	1	10	0	0
Difficult to manage	1	10	4	80
Total	**10**	**100**	**5**	**100**

A number of SSI farmers (20%) had seasonal tenancy and so thought the LCLH drip irrigation kit was not appropriate to them because of the possible danger of theft of the kit. Although the LCLH drip irrigation kit could be used where there was short tenancy, the danger was that it could be easily stolen in some areas because most hired land tended to be several kilometres away from the homestead. Other farmers thought they had invested so much in their irrigation system it was too late and unnecessary to switch to another one. Others had no water problems, so they saw no need to go in for the LCLII drip irrigation.

6.2.7 Summary of phase one survey results

This section and appendix 6.2 summarise the phase 1 results by giving a brief outline and a table (6.34). This is followed by the second section of the chapter on discussion of these results mainly with respect to innovation-decision process in Kenya.

The results in this chapter showed that the majority of LCLII drip irrigation farmers irrigated both high value crops and subsistence crops on field plots averaging 0.15 acres, much smaller than non LCLII drip irrigation farmers away from water courses, using irrigation water mainly from streams and reservoirs.

The majority of non LCLII drip irrigation farmers irrigated high value crops on the field plots averaging 1.6 acres, near stream water courses, with objective of commercial farming. There were no major barriers (credit problems) reported, preventing farmers implementing LCLII drip irrigation kit fast. LCLII drip irrigation and sprinkler irrigation were the main methods under adoption.

Persuasion for LCLII drip irrigation kit adoption was mainly face-to-face by change agents and friends but promotional strategies were limited; hence, the awareness of LCLII drip irrigation kit appeared low.

Although the kit had some good relative advantages and compatibility, it appeared to have more maintenance problems during the implementation stage than other irrigation methods, which impaired the adoption process.

Maintenance was a major problem of the drip kit - in terms of availability of personnel, spares, and mechanical problems in terms of clogging, leaks, and breakage. Other problems affecting LCLII drip kit were water supply, inadequate marketing of produce, and operational requirements in terms of installation and fetching water.

Table 6.34 Phase 1 Survey results of factors influencing adoption of LCLH drip irrigation in Kenya

Factors	Direction of association*	Comments
Irrigated crops	+ve	High value horticultural crops grown followed by cereals
Knowledge	-ve	Awareness (operational and understanding) knowledge apparently low
Communication channels	- ve	Limited, mostly personal, few demonstrations, unlikely to access most farmers. Few mass communication methods employed
Change agents	- ve	Limited. Government extension and manufacturers had no promotion programmes. Only NARL had. Most NGOs assisted in marketing of farm produce for small-scale farmers but few were in LCLH drip irrigation kit irrigation. Extension staff had no programmes on LCLH drip irrigation
Relative advantages	+ ve	Most farmers thought main benefits were economical in energy, water, and cost. Others had benefits of food security and available income for domestic expenditure. The kit is apparently affordable, portable, water saving, and profitable. No major financial problem preventing farmers adopting fast was reported. Farmers who had shifted from bucket irrigation thought the kit was less laborious. It produced no muddy working conditions on the farm and apparently produced relatively longer moist soil times for better performance of crop. It is safe for soil erosion
Compatibility	+ ve	Farmers considered the kit convenient in terms of type of crops, shifting, less supervision. The system is compatible with size and shapes of farming plots.
Triability (divisibility)	+ ve	The kit is expandable. Farmers were uncertain of financial return on the smallest kits
Observability	-ve	Limited demonstrations available to farmers.
Adopter attributes		
– Education	+ ve	Most adopters had some education
– High social status	+ ve	Majority of adopters were employed or businessmen
– Young age	+ ve	Majority of adopters were under 40 years
Dealer services	-ve	Most farmers dissatisfied with dealers services of the LCLH drip-irrigation kit
Maintenance	-ve	Lacking. The system has relatively more maintenance problems increasing the risk of adopting it. Most farmers never saw the technical staff and or did not know their location.
Water supply	-ve	Irrigation water mainly from streams or rivers. Unreliable and expensive to fetch, poor organisation for water community use
Market	-ve	Unreliable, poor organisation for marketing. Role of assistance in marketing. Lacking due to funding

Crop husbandry	- ve	Problem was farmers knowledge of crop protection practise as when and what chemical to apply and importance of getting disease free seedlings
Security requirements	-ve	In terms of theft and from wild or domestic animals
Government policy	-ve	Lacking or not clear on smallholder irrigation technologies. All the extension officers stated they are not aware of any such guidelines.
Research	-ve	Government research on irrigation limited due to funding. Industrial research foreign
Manufacturing	-ve	Scale of manufacturing of LCLH drip kits locally low but No major problem found

* + ve denotes promotes or facilitates the adoption process
* -ve denotes inhibits the adoption process

Irrigation water was generally neither regulated nor charged and its quality was not considered in irrigation practice. However most irrigation water sources appeared to have fresh water suitable for irrigation. The majority of non LCLH drip irrigation farmers who were aware of the LCLH drip irrigation kit, seemed to have low operational and understanding knowledge about it. Besides, most farmers were dissatisfied with dealer services as most dealers were rarely seen.

Although most NGOs assisted smallholder farmers in agricultural marketing, few of them were involved significantly in LCLH drip irrigation. The government extension staff stated policy on irrigation technologies was not clear and government smallholder irrigation research and assistance for marketing were limited due to funding.

The majority of informants thought the prospects for LCLH drip irrigation were good. However, although no major problem of manufacturing LCLH drip irrigation equipment was found, the scale of manufacturing was low due to the present small market.

6.3 Discussion of phase 1 survey results: factors influencing innovation-decision process in Kenya

6.3.1 Introduction

The purpose of this section is to examine the results in the context of the Rogers (1995) Innovation-Decision (I-D) process (Chapter 2), to identify the factors likely to influence LCLH drip irrigation adoption. The section focuses on adoption of LCLH drip irrigation as a function of farmer and technology characteristics and an outline of the limiting factors of the adoption process. Table 6.35 presents the main findings of farmers' progress along stages of the Innovation-Decision process of this study. The suitability of the Rogers (1995) model is examined at the end of the chapter.

6.3.2 Adoption as a function of characteristics of small-scale farmers

In chapter 2, it was noted that the majority of people in less developed countries (LDC) are poor and practising agriculture. The LCLH drip kit in Kenya was introduced in the study areas under this condition. The phase 1 survey revealed that the majority of the small-scale farmers adopting LCLH drip kit (knowledge stage) had no experience in irrigation or their experience was based on traditional irrigation methods which required relatively less managerial skills than the new LCLH drip technology. Moreover, other farmers did not have any experience in arable farming. These factors were likely to inhibit the adoption of LCLH drip irrigation.

Three criteria were introduced in chapter 2 for adopter categories to investigate adopter characteristics on which adoption depends and find out at what stage of introduction the adoption process in Kenya was. These were education, social status and age. The study indicated that majority of farmers who had adopted LCLH drip irrigation had some education, were of relatively high social status and were less than 40 years old. These characteristics are associated with innovators and early. This suggests that the introduction of LCLH drip irrigation in the introductory and growth stages (Appendix 2.1). These findings also create a paradox in that although the drip kit is supposed to be affordable to the poor it appears that this technology is not reaching them. Instead, the relatively well off are the ones who can access it. This is consistent of the findings of DFID (2003) as discussed in chapter 3.

Tables 6.35 Summary evidence of innovation-decision stages from phase 1 survey

Stage	Main study findings
Knowledge	
	Awareness of drip kit low. Most farmers not aware of the LCLH drip kit. Operational knowledge among LCLH drip irrigation farmers was apparently low.
Communication channels	Promoting: channels-trade shows and publications (but likely to have limited coverage. NARL main change agent. Inhibiting: limited mass communication, limited demonstrations available.
Persuasion	
Promotional agents	Generally limited among the three key informants groups. Government extension, NGOs, and manufactures had no effective programmes. NARL main change agent.
Communication channels	Promoting factors: Mainly face-to-face communication channels from friends and change agents.
LCLH drip perception factors	LCLH drip had good perception factors as perceived by adopters (Table 6.36) but seemed to be limited in performance by the conditions under which it was working.
Decision	
	No barriers at the decision stage to implement. Most farmers obtained the LCLH drip kit as soon as they decided to.
Implementation	
	Most farmers dissatisfied with dealer services. Kits and parts generally not available. Most farmers never saw technical support service and did not know where to locate them or source the kit parts. Most LCLH drip irrigation kits have maintenance problems and external problems. These problems posed high risk to LCLH drip irrigation.
Confirmation	
	More LCLH drip kits have problems than those non-drip methods. Marketing seems the main constraint at this stage. Apparent limited follow-up after implementation. N/B Causes of rejection are the subject of next phase of the study

Other approaches including credit could be looked into if the aim is to assist the poor smallholder farmers to have access to the technology where it is appropriate. It has already been stated that there is usually high rate of defaulting on credit (Gakundi 1997; it may be possible that the extreme poverty may force farmers to use the funds to service credit on their immediate problems. This suggests that the market approach as promoted by IDE may be unlikely to benefit the poorest farmers.

6.3.3 Adoption as a function of characteristics of LCLH technology

6.3.3.1 Perceived positive characteristics

In general, the LCLH drip irrigation kit had suitable physical characteristics for SSI in terms of size and irregular shapes of the irrigated land. However, the size of the bucket drip kit appeared unsuitable to some farmers. Indication from the technical performance test by the University of Nairobi had showed it was reliable. In addition, evidence from this research demonstrated that the LCLH drip irrigation kit had good relative advantages (Table 6.36), although it was inappropriate to some farmers. The majority of farmers using it were certain of its water saving and financial return, except for small kits, and none required credit facility. Farmers reported that it was convenient in terms of the range of types of crops to grow and, the fact that it did not require supervision unlike other irrigation methods. However, if the scale of farming were to increase, it would be too small. The point about portability was both its strength and weakness. It was best for temporary land tenure systems where the time for renting of an irrigation of plot was as short as one season. Then one could easily shift to another plot at the end of tenure-ship. However, this also meant that the LCLH drip irrigation kit could easily be stolen.

For the majority of farmers interviewed, LCLH drip irrigation was profitable in terms of increased food production and domestic expenditure. While this benefit was important to farmers who depended on rain fed agriculture or irrigated as the only way of life, it was less important for farmers who had other forms of irrigation. In fact, there were more non LCLH drip irrigation farmers who thought their systems were profitable than LCLH drip irrigation farmers. This meant that on the basis of perceived profitability alone non LCLH drip farmers were unlikely to decide to adopt LCLH drip irrigation.

Table 6.36 Perceived characteristics of LCLH drip irrigation technology

LCLH characteristics	Main study findings
Relative advantage:	
Economical factor	
Low-cost	No barriers to adoption in terms of cost. Other studies indicated this was a problem in other areas. (Cost per hectare expensive)
Profitability	Farmers stated it was profitable (except for small kits). Other studies and this study estimate showed LCLH profitable. However, relative profitability with alternative irrigation methods uncertain.
Water saving	Farmers reported that LCLH could save up to 50% of water compared to sprinkler
Food production	Increased vegetable food production by growing more frequently or growing in new areas where it was only method for arable farming
Domestic income	Farmers found that LCLH increased income which was used on domestic expenditure and school fees
Labour requirements	Labour was saved on daily shifts compared to sprinkler. Laborious to some farmers
Convenient factor	
	The technology was convenient in terms of having little supervision, lack of frequent shifts, and keeping the soil moisture in the root zone for longer period thus improving crop performance and quality. Besides the system did not produce muddy working conditions which is a problem especially in clay soils
Safety of the system	The system controlled reduced pest diseases associated with moist/ damp conditions in the field.
Relative/ disadvantage	**(to other irrigation methods)**
Limited role	Inability of LCLH to use on seedbed was a major disadvantage compared to other methods
Maintenance	Clogging was found to be a problem compared to

	alternative methods. The system appeared to have more maintenance problems relative to others.
Theft	Unlike other methods the small drip kits had a danger of being stolen especially if far away from homesteads
Damage	Accidental damage to drip line during working was a problem. For larger units damage to crops when shifting driplines was a major disadvantage to LCLH drip irrigation
Compatibility	
With Cropping system	Similar crops irrigated before LCLH in humid and semi - humid areas. This may not apply in some dry areas where livestock is dominant. But not cited as reasons for adoption or rejection of the technology
With farmer values and consumption	Farmers seem to prefer growing and consuming vegetables except in the semi-arid and arid areas. But not cited as reasons for adoption or rejection of the technology
With farmer experience	Most farmers adopting LCLH drip irrigation had no previous irrigation experience or from traditional irrigation methods. But not cited by respondents as reasons for adoption or rejection of the technology
With farm management	Concerns over additional labour requirements for fetching water in places where irrigation never existed before. But not cited by respondents as reasons for adoption or rejection of the technology
With farm physical characteristics	Technology suitable for the small irregular plot sizes of most smallholder farmers. Bucket drip kit size was unsuitable to some farmers. Cited by respondents as reasons for adoption or rejection of the technology
Complexity	
	Evidence that some farmers did not follow management instructions, and technology may be complex for some farmers to understand, especially those with low or no previous experience.
Triability	
	Technology potentially suitable for expansion in phases or bits. However, there was evidence of limited opportunity to

	try because of lack of availability of the kit and parts.
Observability	Evidence of limited demonstration plots especially closer the farmers at the village level. Lack of opportunities to observe the practical management and performance of LCLH drip kit

The main problem with economic benefit seemed to be with the single bucket kit; some farmers thought the effort of irrigation using the single bucket was not worth the efforts. But larger irrigated areas using several kits combined to suit individual needs were appeared profitable. It offered them security in food production and domestic expenditure.

The irrigation of large areas by low-cost drip irrigation of at least a quarter of an acre (1000 m^2)), but generally 1 acre (4050 m^2) or above appeared to meet farmers needs (Plate 2, Nyakwara 2001, and my estimates for passion fruits in chapter 4). There was scarce evidence in the field of successful farmers who irrigated areas less than these areas. In a similar research, DFID (2003) found that the small unit kits did not offer much incentive in terms of livelihood impact to poor farmers. However, they suggest minimum larger areas of 1-2 hectares for irrigation to meet farmers' livelihood. The difference size of areas may be due local economical conditions of farming.

The fact that that larger irrigated areas may be more viable than the area small kits can irrigate raises a paradox. The LCLH are meant to use less energy, but the small kits which can be operated by a family to fetch water do not appear to be profitable. The larger viable units might be so demanding in water supply that a family is unlikely to be able to fetch water to supply it necessitating the use of pumps. This is an added cost, which may make the system no longer low-cost to establish and run. Therefore, it may be no longer available to many smallholder farmers for who it was meant.

6.3.3.2 Perceived negative characteristics

The results of the first phase survey found that LCLH drip irrigation kit appeared to have more maintenance problems than other irrigation methods causing a negative attitude in potential adopters. Unless this problem was reduced, it could be compounded by perceived advantages of other non LCLH drip irrigation systems, leading to rejection of the LCLH drip irrigation technology.

An old farmer who had stopped using the LCLH drip irrigation kit because of this problem disagreed that the LCLH drip irrigation kit was unsuitable for her but then added:

> *"It is unsuitable as you can see I am unable to fetch water for my domestic use. How can I then fetch for crops? If water supply is in place anybody of any age can practise (low-cost low head drip irrigation kit irrigation) farming..."*

The adopter and technology characteristics with respect to the innovation-decision process on adoption of LCLH drip irrigation in Kenya are presented in figure 8.1 in chapter 8.

6.4 Conceptual model of factors limiting implementation LCLH drip irrigation adoption at the farm level

Farmers who had gone through knowledge, persuasion and decision stages found that they could not proceed with the adoption process because of several determining factors in the implementation stages. In contrast to IDE statements that the LCLH drip kit is suitable (appropriate) for all farmers, this suggests that there are apparent basic conditions for each area that should be met during the implementation stage for the LCLH drip irrigation innovation-decision process to be successful (IDE & WI 2000). Fig 6.3 illustrates conditions for implementation of low-cost low head drip irrigation at farm level using a conceptual model. (The numbers indicated in each of the concepts are for identification only and do not necessarily follow any particular order). Such a model could be of assistance in assessing and advising farmers who may wish to adopt LCLH drip kit by going through the main factors systematically to assess whether their conditions are favourable for drip kit irrigation or not or whether they need specialised advice. However, these factors also form the basis of phase 2 survey to confirm which ones are important in continued/discontinued adoption of LCLH drip irrigation.

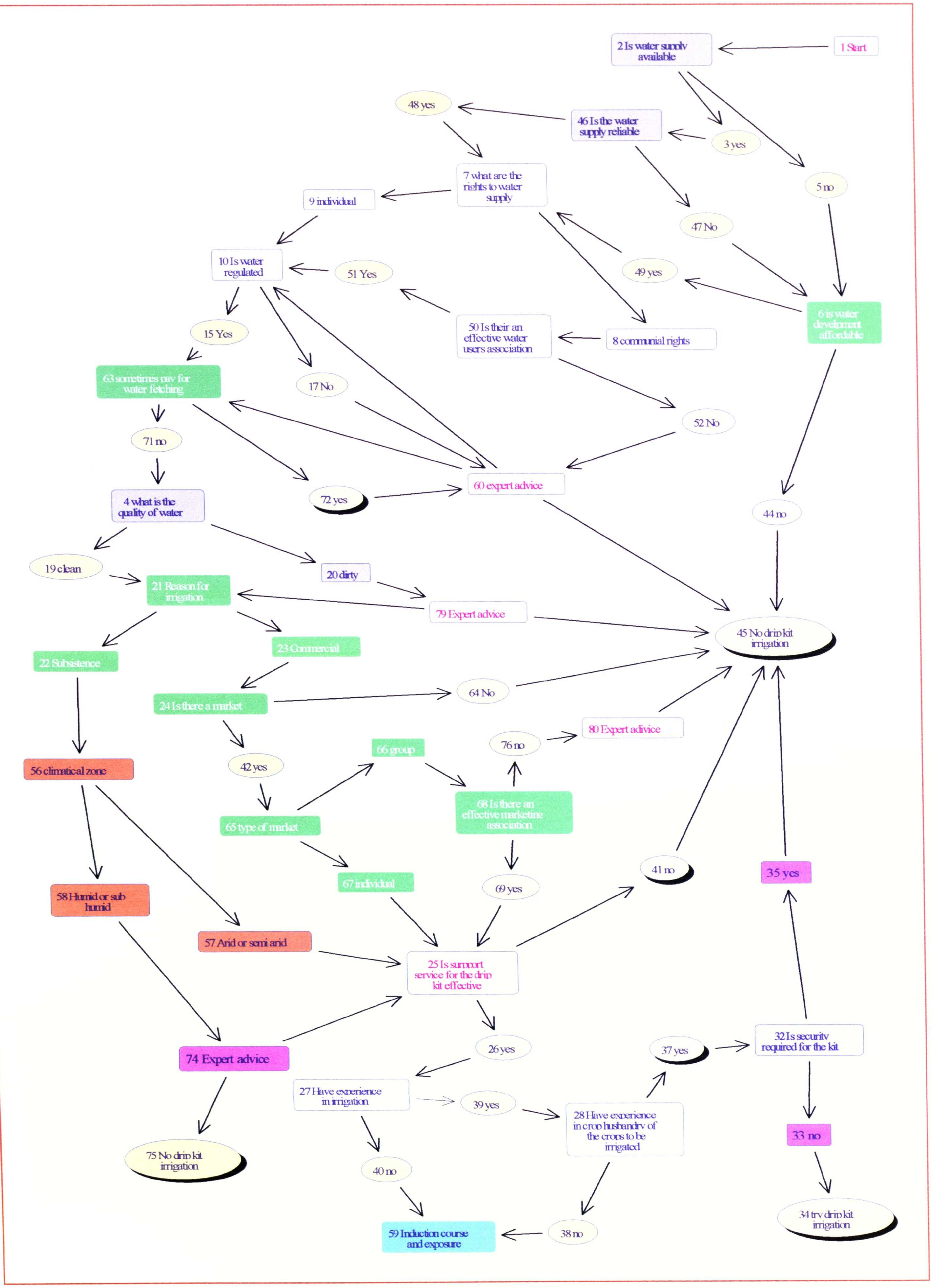


Fig 6.3 Conceptual model of conditions for adopting LCLH drip kit at implementation stage

A technical expert, referred to in the model, may be useful in deciding if there is some other overriding factors or other methods of solving a particular problem and advice accordingly. This could be an expert in irrigation, agriculture, or water resources. The following is a brief outline of the factors in the model. (Figure 6.3):

(i) Availability of reliable water

The reliability of irrigation water was found to be one of the main factors influencing the implementation of LCLH drip irrigation. Farmers with individual water rights, in effective water users associations, or who do not have to fetch or pay expensively for fetching irrigation water from long distances may be advised to try drip irrigation. Farmers with uncontrolled irrigation water may not see perceived water scarcity hence they may not see the need for drip irrigation and are likely to neglect it later with when faced with minor problems. How expensive or laborious the fetching of water will depend on the distance and the mode of conveyance-manual, animal, or power. Informal discussions revealed that farmers who had water sources further this distances appeared to have problems of fetching water with their respective means of water conveyance. Besides, the irrigation water quality should not cause frequent clogging.

(ii) Reason for irrigation

LCLH drip irrigation for subsistence may be possible for vegetable growing in semi-arid regions where conditions may not favour other forms of vegetable production. However, it was found to be inappropriate for some smallholder farmers.

(iii) Availability of reliable market

It was found that lack of market was an important factor in the collapse of LCLH irrigation projects. During the informal discussions with farmers it was evident that most farmers eventually wanted to sell their farm produce irrespective whether the initial reasons for going in for irrigation was for subsistence or commercial. Therefore, a reliable market for the produce is important for any farmer who is considering LCLH drip kit. This is an important factor in the market approach (chapter 3) which could be tried. Where a market group exists or has a potential its effectiveness or potential effectiveness in organisation and reliability should be assessed accordingly.

(iv) Support service

Technical support service was found to be a major problem. Therefore, the availability or the potential to create an effective support service is important when a farmer wants to implement LCLH drip irrigation. The availability of effective technical support service for at least three years may be necessary.

(v) Farmers experience

Experience in the crops irrigated and irrigation is also necessary. This may be important in agronomic aspects of farming. However, where an effective extension service or induction course exists it may be less important.

(vi) Security for the drip kit

Some farmers had problems of domestic or wild animals destroying the kits and crops. In some areas, theft of the drip kit was also known. Farmers who wish to implement LCLH should be aware and take the necessary precautions.

6.5 Suitability of the Rogers (1995) innovation-decision model from the study

The innovation decision process identified factors affecting the adoption process of LCLH drip irrigation. This can help to recommend suitable measures that may encourage the adoption of LCLH where appropriate.

The phase one survey found that many of the factors which influence the innovation-decision process of the LCLH drip irrigation were institutional and political (e.g. policies) factors during the implementation stages (Fig 6.3). Farmers who had moved along the process from knowledge, persuasion, and decision found that they could not proceed in the process because of these factors. Morris et al (2000) stated that the Rogers (1995) model was criticised for being less useful in explaining external factors associated with political and institutional factors as confirmed by findings of this study. These factors include lack of infrastructure such as water development, research, manufacturing and reliable markets.

The role of government policy and extension services appeared to influence the adoption process of LCLH drip irrigation in Kenya. In the case of Kenya and LCLH drip irrigation, at the present stage of development the political and institutional factors appear to be more as inhibitors rather than promoters. This contrasts with the Indian case in which these factors appeared as promoters partly due to a relatively more advanced development stage.

The adopter characteristics during the knowledge stage and perception factors during the persuasion stage of the Rogers model of innovation-decision process applied in influencing acceptance of LCLH drip kit but appeared to be less relevant. The implementation and hence, the adoption of the drip kit had more to do with institutional and government policy than acceptance of the LCLH drip kit technology. These barriers appeared more important than even the communication methods or role of change agents.

This discussion is continued in chapter 8.

6.6 Chapter 6 summary

The phase 1 survey results were summarised in section 6.2.7. The discussion in the rest of this chapter employed the Rogers model of the Adoption Process of Technology as a useful tool in understanding the factors influencing the adoption of the LCLH drip kit in Kenya. It was found that farmer and LCLH drip technology perception characteristics conformed to the process. However, political and institutional factors played a more important role in limiting the innovation-decision process of LCLH drip irrigation adoption in Kenya.

The next phase of the survey will investigate the effect of these factors at the farm level, on discontinuation of the LCLH drip irrigation.

CHAPTER 7

PHASE 2: FACTORS AFFECTING DISCONTINUATION OF LCLH DRIP IRRIGATION- METHODOLOGY, RESULTS AND DISCUSSION

7.1 Chapter introduction

The purpose of this chapter is to describe the procedure, results and discussion of results of the phase 2 survey. It starts by linking this to the previous phase. Then, it states the objective of the survey and the key informants, and locates the study areas in Kenya. This is followed by an explanation of how the data was analysed using homogeneity analysis, before presenting and discussing the results.

Figure 7.1 shows how the phase 2 fits into the research methodology.

7.2 Background

The findings in the previous study on small-scale irrigation farmers suggested that some key factors influenced the adoption of drip kit irrigation in Kenya. These factors were:

- Provision of reliable water;
- Availability of efficient support and technical service;
- Size of the drip kit;
- Technical problems;
- Adoption of drip kit with commercial interest as the primary aim;
- Possession of training or experience knowledge; and
- Security in terms of theft, vandalism, and animals - both wild and domesticated.

From these factors, a flow diagram of possible steps to drip kit adoption was formulated (Fig 6.3). This was used as a basis of this study to investigate why some farmers fail in the adoption of the drip kit irrigation.

7.3 Objective of phase 2 survey

To investigate factors associated with discontinuation of LCLH drip irrigation.

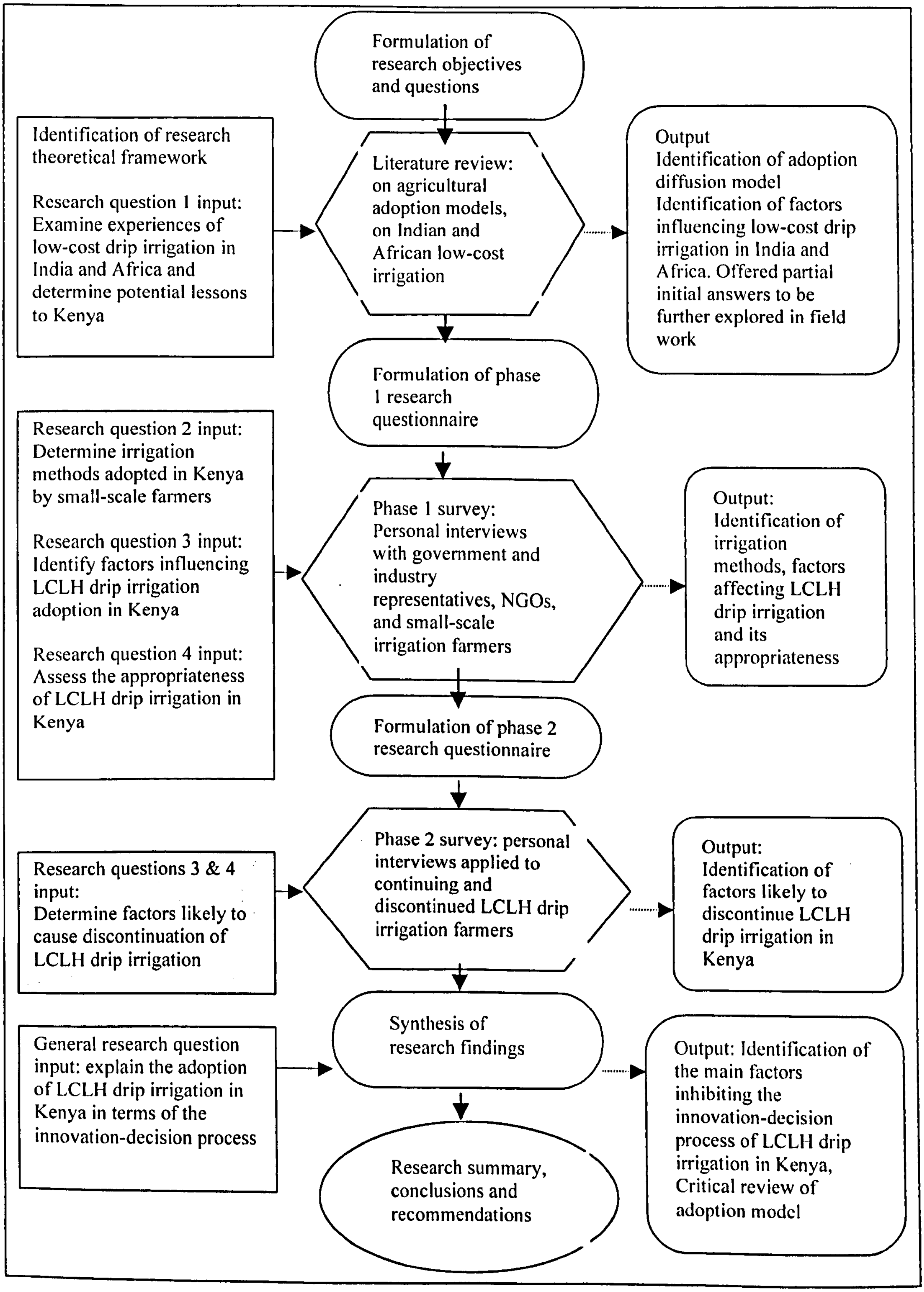


Fig 7.1 Logical flow of research methodology - Phase 2 (shaded)

7.4 Key informants

The key categories of informants were continued adopters and discontinued rejecters of the drip kit irrigation. A total of 16 continued adopters and 19 discontinued rejecters were interviewed. For the purpose of this study, a continued adopter was a farmer who had used it continuously for at least six month to the time of the interview. But a discontinued rejecter was defined as a farmer who had stopped using the kit for six months continuously to the time of the interview.

7.5 Methods and survey areas

The survey used a semi structured open-ended questionnaire (Appendix 7.0). It was carried out in Western Central and parts of Eastern Kenya using a similar approach as the phase one of the study. New survey areas were used to find out if the data they generated was consistent with the areas previously studied (Table 7.1 and Fig 4.1).

Table 7.1 Phase 2 survey areas in Kenya

Zone	Study areas
Semi arid	Rachuonyo, Kajiado central, and Kitui, Matuu
Sub-humid	Kathiani
Humid	Kiambu

7.6 Data processing and analysis

The objective of the analysis was to differentiate between factors associated with continued adopters and factors associated with discontinued rejecters. A data processing procedure similar to that in phase one was adopted. However, SPSS Homogeneity Analysis (HA), a form of Corresponding Analysis (CA), was selected for data analysis, since the data was nominal and with several variables. Discriminant analysis was considered but discarded on the basis of the nature of this data.

7.6.1 Selection of variables for the analysis

In considering which factors to include in the homogeneity analysis, it would have been helpful to carry out Chi-squared statistics to identify the variables with significant influence upon continued adoption. This was not possible, since most of the variables were below the sensitivity limit of the chi square test, due to small sample size and the large variation in responses. Besides, the chi tests cannot be applied to the non-frequency data, although the descriptive use of such data is very useful. For these reasons, the chi-squared test was not applied.

Instead, all the survey responses applying to both continued adopters and discontinued rejecters (37 respondents) were entered into SPSS Homogeneity Analysis. On the basis of this, the input table for homogeneity analysis (Appendix 7.1) was formulated. Homogeneity analysis describes deviations from independence, whether that deviation is statistically significant or not (Weller & Romney 1990).

7.6.2 Homogeneity Analysis

Homogeneity Analysis tries to produce a solution in which objects (farmers) in the same category (e.g. continued adopters) are graphically plotted close together, and the farmers in different categories are plotted and grouped far apart. In this way the farmers are divided into two subgroups, (continued adopters A and discontinued rejecters N, Fig 7.2).

HA can compute a solution in multiple "dimensions". Ideally as few dimensions as possible should be used for clarity to give a meaningful interpretation to the plot. It is rare to use more than two dimensions (Benzecri' 2002), as used here. For a one-dimensional solution (i.e. one attempt to discriminate) HA finds a single set of quantification of the survey responses which best group the farmers. For a two-dimensional solution, HA finds a second set of quantifications unrelated to the first, and so on. In this way HA produces a visual "picture" of responses based on their scores (co-ordinates) which can be used to visually separate them into groups (Fig 7.2). The dimensions themselves do not have a consistent physical meaning, other than that of the quantifications imputed by the HA procedure (and which thus depend on the responses) (Meulman & Heiser 1999). In this analysis, the scores (or weightings) of individual factors chosen by HA are those shown in table 7.2. Since each dimension thus includes 27 different factors, they are referred to as dimension1 and dimension 2 as used in available literature.

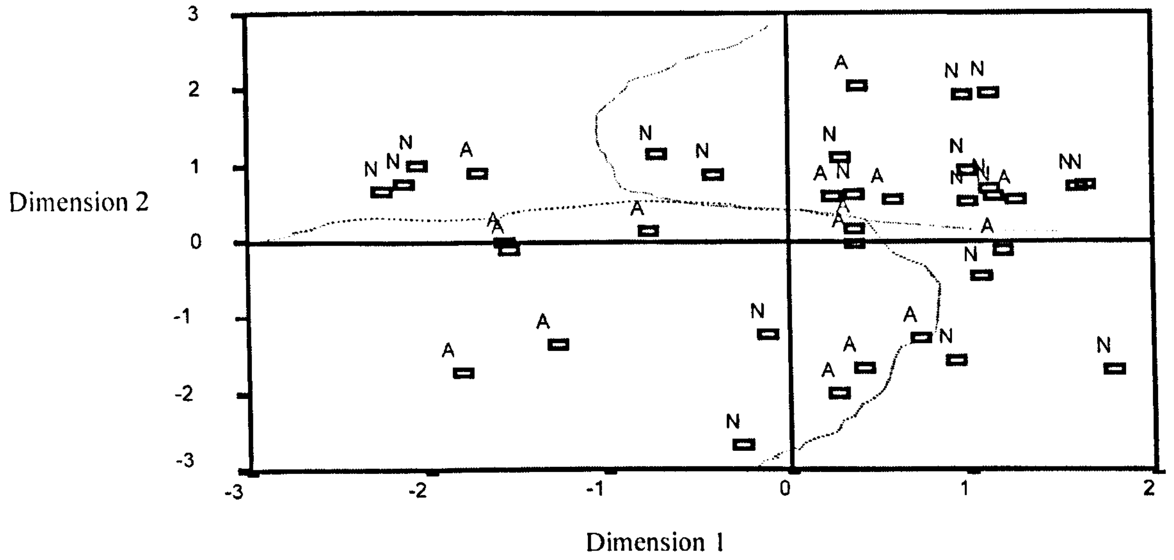


Fig 7.2 Plot of spread of rejecters (N) and continued adopters (A)

Figure 7.2 shows the HA plot of the farmers scores by displaying them as A (continued adopters) and N (discontinued rejecters). The scores are obtained by assigning numerical values to questionnaire responses, which are then transformed into co-ordinates for defined dimension.

By visual examination of the figure (7.2), the region strongly represented by A has been separated (by the author) from that strongly represented by N, using the dotted lines. It can be seen that the N region is mostly in the upper right quadrant, while the (A) region is mostly in the left lower quadrant. The other two quadrants show farmers who were correctly discriminated by only one of the dimensions, and are hence termed "marginal" or not true representatives (Meulman & Heiser 1999).

Using this classification we can now determine which responses (factors) are associated with A or N. This is done by plotting the "scores" (co-ordinates values) of the factors (shown in Table 7.2) as assigned by the homogeneity analysis. The result (Figure 7.3) is then compared with figure 7.2. The responses that fall in the previously defined region A, i.e. the left lower quadrant, are those associated with farmers likely to continue adoption. Conversely, those that fall in the region N i.e. the right upper quadrant are associated with farmers more likely to discontinue. In figure 7.3 for example we see that seasonal water problem (No. 1) is strongly related to farmers who are mostly likely to discontinue drip with irrigation, while reliable water supply (No. 16) is strongly related to farmers likely to continue.

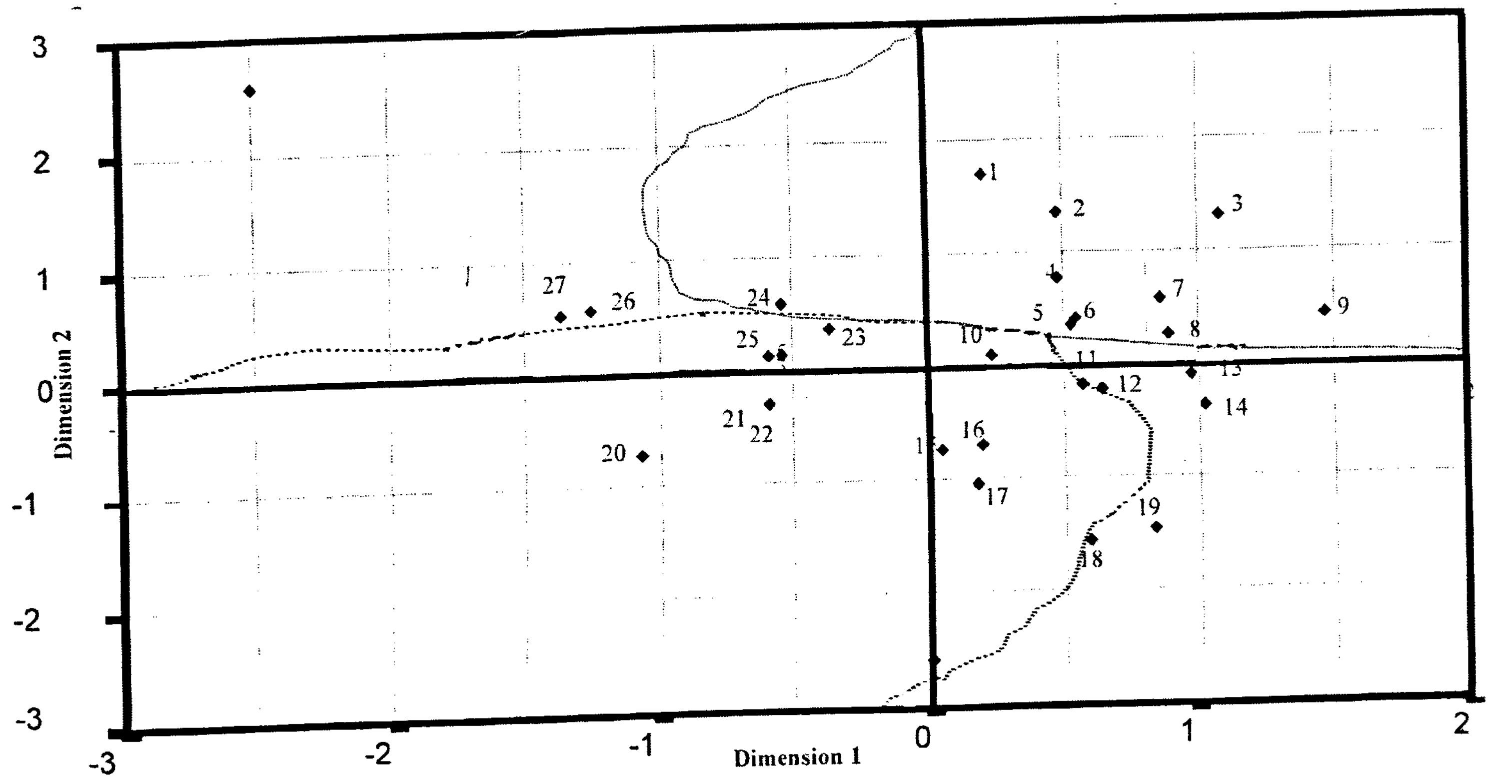


Fig 7.3 Plot of the HA scores of the survey factors

Table 7.2 Response scores of homogeneity analysis on factors associated with continued and discontinued adoption

Factor	Dim-1	Dim-2	Quadrant	No (Fig 7.3)
Factors strongly associated with farmers who discontinued/rejected (region N)				
Buying food as only other source of food	1.08	1.31	Upper right	3
Long seasonal water problems	0.20	1.70	Upper right	1
Inadequate irrigation water in volume	1.47	0.43	Upper right	9
Poor irrigation water quality	0.48	1.35	Upper right	2
Acquisition of drip kit by subsidies with NGOs	0.86	0.58	Upper right	7
Lack of spares	0.48	0.77	Upper right	4
Use of bucket kit	0.55	0.41	Upper right	5
Factors marginally associated with either group				
Had drip kit security problems	0.53	0.35	Borderline	6
Mixed farming as aim of drip kit irrigation	0.89	0.26	Borderline	8
Lack of extension staff	0.97	-0.10	Lower right	13
Buying LCLH drip kit for cash	1.02	-0.38	Lower right	14
Farmer had no irrigation experience	0.57	-0.18	Borderline	11
Farmers also obtain food from rainfed agriculture	0.64	-0.22	Lower right	12
Farmer had previous experience in arable farming	0.23	0.10	Borderline	10
Starting drip irrigation for commercial purpose	0.59	-1.57	Borderline	18
Theft of drip kits problem	0.83	-1.47	Lower right	19
Starting drip irrigation for subsistence farming	-0.54	0.59	Borderline	24
Use of single drum kit	-1.25	0.57	Borderline	26
Farmer without previous arable experience	-0.36	0.36	Borderline	23
Depending on animal as food source	-1.36	0.53	Borderline	27
Factors strongly associated with farmers who continued adoption (region A)				
Getting food donations	-1.07	-0.73	Lower left	20
Donated drip kit	-0.54	0.14	Upper left	25
Farmer has reliable water	0.19	-0.70	Lower right	16
Animal security problem	-0.59	-0.30	Lower left	21
Use of lager units or several drum kits	0.04	-0.74	Lower right	15
Use of communal water supply	-0.59	0.13	Upper left	22
Agents cannot repair drip kits	0.17	-1.05	Lower right	17

7.7 Discussion of factors strongly associated with farmers who discontinued and continued adoption

7.7.1 Food production

The variables referring to food acquisition by the farmer suggest that SSI farmers who received food donations as their main food source were more likely to be continued adopters than those who had to buy food occasionally or those who depended on animals. This was possibly because the latter groups tended to use drip irrigation as secondary source of living when the weather was not right. They were therefore likely to abandon it when the weather improved. On the other hand, farmers who received food donations tended to be those from semi arid areas, where the climate was constantly not favourable for other means of food production than irrigation. Hence drip irrigation was their primary source of subsistence vegetable production and that is why they were likely to be continued adopters.

7.7.2 Water supply

Farmers subjected to prolonged irrigation water (long seasonal water problems) or inadequate volumes, were more likely to discontinue the use of the drip kit irrigation than those with reliable irrigation water. Both factors resulted in shortage of water, caused by prolonged droughts, poor management of water supply and/or low priority for irrigation water.

Those affected by poor water quality problems were strongly associated rejecters. The quality affected irrigation in two ways. First, SSI farmers reported that saline water corroded the metal parts of the drip kit. Secondly, in regions where water was harvested, such as Matuu, physical substances in water caused clogging, in spite of advice to filter irrigation water when filling the kit container. Although irrigation water quality was not a major issue in the study areas, this problem is likely to grow as drip kit irrigation matured.

The results show that farmers who used communal water supply were likely to continue with LCLH drip irrigation. This result appears to be erroneous, possibly biased because of the disproportionately large number of farmers who used communal water supply. Alternative other overriding factors may be in place.

There were several cases where communal water use was a real problem. Discussions during the survey revealed that conflict between irrigation and other uses was a major issue, as well as lack of commitment to maintain and operate the irrigation water supply.

7.7.3 Method of acquisition

Farmers who discontinued were more likely to have received their drip kits through subsidies than those buying with cash. This point appears to indicate the importance of the original need and commitment at the point of acquisition. Donated drip kits were mostly given to farmers whose primary source of arable farming was irrigation, and most of them tended to continue because they apparently had limited options.

7.7.4 Technical support service

The main problem of farmers who discontinued LCLH drip irrigation was the lack of spares. This is consistent with the discussion on causes of incomplete adoption in chapter 2 (Oliver 1990). It was evident that the level of support service was higher in phase 2 areas than in the areas of the first phase of study. However, there were still cases where farmers had stopped irrigation for lack of spares, suggesting that this was still a critical factor. Table 7.2 shows that the main problem for farmers who continued adoption was that the agents could not fix repairs, breakage, leaks, and clogging. For example, a headmaster in Central Kajiado had struggled to get the necessary parts from Nairobi for three broken down bucket kits for 3 months. He stated that he had been to the District Headquarters for help from the technical support service. However, every time they promised to come they never did. When asked, "Why?" in my presence, I do not think he got a satisfactory answer from the very technical officer who was taking me around. I later learned that the problem was lack of transport. This example illustrates that some farmers who continued with LCLH drip irrigation still had problems of inadequate technical support service.

7.7.5 Size of drip kit

The bucket drip kit is strongly associated with farmers who discontinued adoption; reflecting the issue, raised in the earlier study by SSI farmers, that it was too small. Farmers using larger units, e.g. several drum kits, were less likely to discontinue adoption. This indicates the need for viable unit size. Indeed, from my experience as Kenya with rural agricultural background, it is rare to find smallholder farmers cultivating such small plot in Kenya as the bucket kit is designed for.

During the informal discussions of the survey, it was evident that most SSI farmers eventually wanted to get extra income from drip kit irrigation, including those who were motivated to adopt the bucket kit for subsistence vegetable production (Fig 7.4). However, farmers were discouraged to continue with irrigation by the route " subsistence vegetable production → increase in vegetable production for sale" (Fig 7.4) by increasing the size of their irrigation units, from (bucket kit) subsistence vegetable production to increased (commercial) vegetable production for sale.

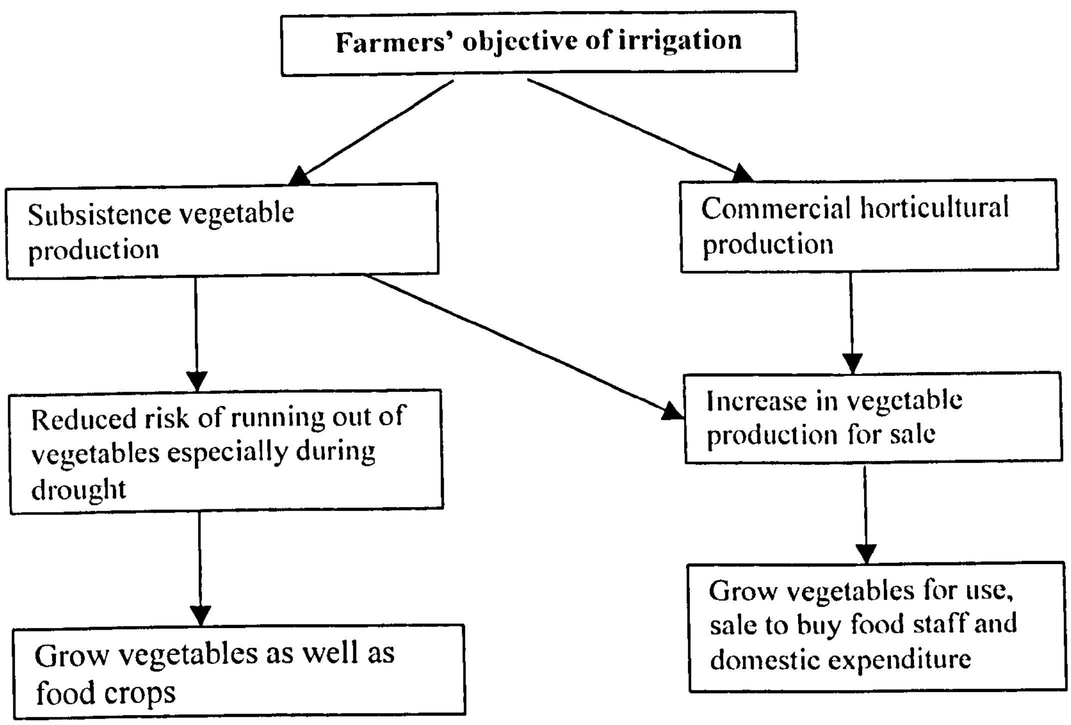


Fig 7.4 Typical motivation for adoption of low-cost low head drip in Kenya

This route appeared hampered by:

- The small size of the kits;
- High costs to expand and customise the small kits;
- Unavailable spares or additional kits; and
- Technical management problems.

In addition, those who went in for subsistence farming using the bucket kit tended to be on short-term food shortage crisis management; LCLH drip irrigation was unlikely to be the primary source of food. Therefore, as soon as the weather improved, they were able to subsist without the use of "laborious" irrigation farming.

7.7.6 Security problems of the drip kit

Surprisingly, farmers who discontinued using drip kit irrigation had no drip kit security problems, unlike those who continued using it, suggesting that this was not a critical factor. Indeed, farmers stated that they reduced this problem by fencing against livestock or wild animals, and where theft was a problem by using the drip kit close to the homestead (Plate 3). This contrasted with the phase one survey in which some farmers were unable or unwilling to fence off their farms.

Plate 3 Neglected drum kits- Kajiado*

** Note the security fence and broken driplines*

Mr Arap Kigen is an educated and employed farmer and a teacher in Uasin Gishu district of Kenya, an area with a sub-humid climate. He has 8 acres (3.3 ha) of land on which he grows wheat and maize as well keeping some cattle.

He first heard of LCLH drip irrigation from a relative in 1997 who informed him it was being promoted locally by a progressive farmer. He decided to attend a promotional seminar at the farm of the farmer promoting the technology. After the seminar, he was persuaded it was a good technology for him to start a small-commercial vegetable farming. He had no previous experience in irrigation or the crops he was going to irrigate- vegetables and passion fruits. However, he attended an induction course on these subjects organised by the change agents at the home of the progressive farmer.

Mr. Arap Kigen bought four drum kits, by cash, immediately after deciding to start the irrigation. For three years, the irrigation of the passion fruits and vegetables did very well despite frequent maintenance problems. This included clogging, breakage and leaks. He was often forced to improvise since he was far from Nairobi, did not know where to get spares, and agents who had introduced the system had vanished. The passion fruits were profitable because he made more than double his civil servant salary from them. He therefor decided to expand the irrigated area from $500m^2$ to $1000m^2$. Before he could do it, he started experiencing problems of marketing of his fruits. There was no ready market for them and the price dropped from Ksh. 50 per Kg (US$ 0.64) to Ksh 10 per Kg (US$ 0.13). He kept on irrigating hoping the conditions would change.

Then the problem of water reliability came in. His source of water was a shared community dam where members had to pay for the running costs of the water supply. However, some members could not pay for the power supply for the water pump. This was presumably because of the market problems they were also facing. Besides there was no effective Water Users Organisation to enforce rules so that those who were reluctant to pay paid. So the power supply to the water supply pump was disconnected and Mr Arap Kigen found himself with no irrigation water. Therefore, he discontinued his LCLH drip irrigation. After a year without any sign of improvement, he sold it. Recently the dam was washed away by floods.

During the three years, he practised the drip irrigation; no change agent had visited his farm. He however, had heard rumours once they had been around in the area.

Box 1 Experience of a discontinued rejecter

7.8 Operational (durability) period and constraints of LCLH drip irrigation kit

The study showed that more LCLH drip irrigation kits had failed (57%) than still operated. This is because all continuing adopters and discontinued rejecters in the study areas were interviewed, without preference for a particular group in selection. Discontinued rejecters were asked when they had stopped drip kit irrigation. Figure 7.5 illustrates the response. This indicates the operational durability of the drip kit in the field. It shows that the majority (78%) of those that discontinued irrigation did so within a period of less than two years. The short operational period of the drip kit suggests it had problems with continued adoption. This could be attributed to the low quality of materials and manufacture of the kit. Since no test were done to this effect, it is not possible to confirm this. The other reason was likely due to ineffective orientation courses. However, the level of orientation in the second phase areas appeared much higher than in the first phase areas. Most of the NGOs made sure farmers who received the kits had orientation course on how to handle the drip kit. However, the level of education is important as to how much the farmers can gain from such courses. Therefore, this could have been another important factor as well as the level and effectiveness of the support service. This is discussed below together with other factors obtained from the interview.

The discontinued farmers were then asked why they discontinued with LCLH drip irrigation. Table 7.3 summarises the responses to this question.

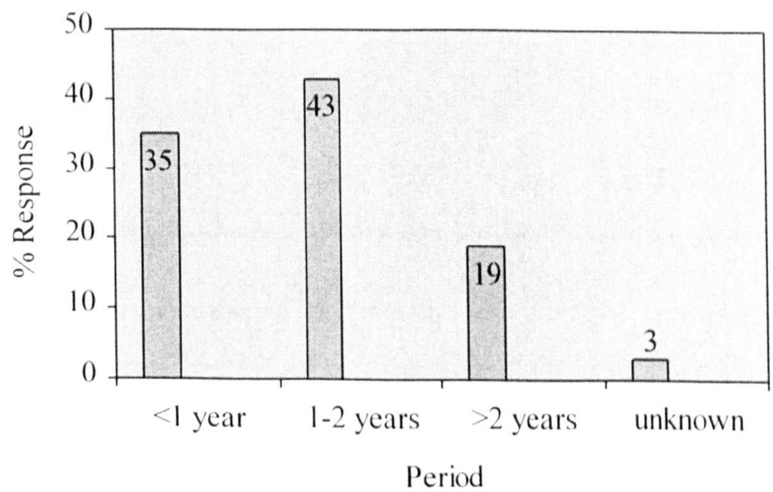


Fig 7.5 Operational period of drip kit irrigation of discontinued farmers

In order to understand if certain problems were specific to certain regions, the areas covered by the problem have been included as follows:

A Participants from Karachuonyo areas;

B Participants from Kajiado area;

C Participants from Kathiani areas;

D Participants from Kitui areas;

E Participants from Matuu areas; and

F Participants from Kiambu areas.

The high number of farmers who cited lack of spares and repair problem with their drip kit were from all areas except Kajiado reflecting the wide spread of the problem. However, Kajiado had an active NGO promoting the use of drip kit. Most farmers who were not used to arable farming, and hence found drip kit irrigation laborious, were from central Kajiado, reflecting the pastoral life style of the participants in this region. This lifestyle was also reflected in the problem of lack of security, usually from animals.

Table 7.3 Reasons for discontinuing smallholder LCLII drip irrigation

Summary of question	Respondent	Which participants?	% responses
Is your drip irrigation kit working?			
No	19	A, B, C, D, E, F	54
Yes	16	A, B, C, D, E	46
Total	35		100
If you stopped drip kit irrigation, Why did you stop?			
Lack of spares of spares and or repairs	7	A, B, E	37
Farmers not used to arable farming (laborious)	4	B, F	21
LCLII drip kit size too small for farmers needs	3	D, E	16
Unreliable water supply	2	A	11
Lack of market for produce	2	F	11
Lack of security	1	D	5
Total	**19**		**100**

The main observation (37%) was on the lack of spares followed by cultural practice being incompatible with the "laborious" LCLII drip irrigation (21% response). The former illustrates the weakness of technical support staff and confirms the findings in the earlier study while the latter reflects the cultural background in which the drip kit was introduced. These factors suggest that LCLII drip irrigation is not appropriate to the farmers. A large part of the second phase of study covered pastoral life-style areas mainly in Kajiado.

Earlier, it was found that SSI farmers who had initial irrigation experience were associated with discontinuance of LCLH drip irrigation kit. This suggested that other reasons were responsible for this and table 7.3 indicates that lack of spares was likely the main constrain.

There appeared to be a market problem in areas where irrigation was relatively more mature or successful. This was demonstrated by fact that the majority (75%) of all the farmers from areas of central Kajiado, Kiambu, and Isinya, where drip irrigation was very productive, reported having market problems with their produce.

A notable constraint was the lack of ability to install the drip kit. On the surface, it appeared as if this constraint was due to lack of understanding-knowledge but during the discussion, it was evident that the real reason was often due to farmers finding later that the small-bucket drip kits would not meet their irrigation needs. For example, a farmer in Kitui who had not installed her drip kit for over a year showed us where she had intended to install her kit. The plot was next to a watercourse where she practised irrigation by aspersion (traditional bucket sprinkling). Water did not seem to be a problem in terms of availability over time and the labour required for fetching it. However, the drip kit could only irrigate a small fraction of what she was already irrigating implying that it was probably incompatible with the existing irrigation plot size. Although farmers could extend the kit, they found this probably too expensive for them. Therefore, it was understandable why she had not installed.

A similar example was found in Kathian. In this case, two issues were likely discouraging the installation of the drip kit i.e. water availability and the area the drip kit was able to irrigate. The notion of expansion of the small LCLH bucket drip kit according to needs appeared more theoretical than practical.

Mr Ole Chege is an educated farmer and employed by local NGO. He comes from Kajiad district, which is a semi-arid region. He has 15 acres and practises mixed farming of arable and livestock. He irrigates 2 acres (0.8 ha) using LCMH drip irrigation, growing vegetables, tomatoes, potatoes and citrus fruits. He has not attended any course on irrigation or agriculture.

In 1993, he realised that he was the only one in the area with reliable water for irrigation while the area suffered from vegetable shortages. He decided to develop his 48 ft (14.5m) deep shallow well with assistance of an NGO under cost-sharing aid. He installed a 1000 litre water tank and started furrow irrigation on one acre (0.4 ha). He also bought a 5-hp pump. The water was sufficient for his and neighbours domestic use, and his livestock.

He first became aware of the LCLH drip irrigation from a friend in 1997 who informed him that KARI was selling an irrigation water saving system. He decided to visit KARI in Nairobi and after talking to the staff and seeing the LCLH drip irrigation equipment he was persuaded it may save water hence the pumping costs used in furrow irrigation. Soon after he bought and installed a unit for one acre (0.4 ha).

Mr Ole Chege realised a lot of benefits from the LCLH drip irrigation. Instead of using about 100 litre of petrol a month on pumping irrigation water under furrow irrigation now he was using 40 litres only. Whereas he needs labour to make furrows, direct water hoses into furrows, and to attend to the pump for furrow irrigation, the LCLH drip irrigation could be operated by a single person. Moreover, he does not necessarily have to be present all the time during irrigation, saving time for other activities. Later he expanded his irrigation area to two acres (0.8 ha)

He has never run short of irrigation water even after the expansion. Neighbours depend on him for vegetables, fulfilling his original objective of starting irrigation. They come to buy from his farm but occasionally during the wet season, he has to go out to look for a market for his vegetables. The market for his three-quarter acre (0.3 ha) fruits is huge. Sometimes, he does not even have enough fruits for the traders who come to buy from his farm. This is because he irrigated a good variety of sweet seedless citrus.

Mr Ole Chege has not been visited by anybody from KARI since he bought the low-cost drip irrigation equipment. He does not expect them to come because he says, "I buy so many other different equipment where the dealers do not follow up to see how it is doing". Because of his long experience in irrigation, Mr Ole Chege had no maintenance problems with his equipment. He knows where to get spares in Nairobi and can fix most problems. He knows what chemicals to apply to his crops when necessary. If in doubt, he seeks advice from the dealers that sell the chemicals. The farmer had no problems with theft of his equipment, but occasional minor crop damage by wild animals occurred which he is able to put up with.

He does not intend to expand his irrigation because he thinks the 2 acres are sufficient for his labour, management ability, and the available water.

Box 2 Experience of a continued adopter

7.9 Limitation of findings of phase two survey

Although, it would have been helpful to test for statistical differences between the factors associated with continued adopter and discontinued rejecters before the homogeneity analysis, this was not possible because of the small sample size and the numerous different responses to each questionnaire. In any case, the participants had not been appropriately selected for such a test.

In spite of these difficulties, the homogeneity analysis is able to discriminate factors associated with discontinuation. Weller & Romney (1990) state that we may not always formally test for independence, it should always be kept in mind that homogeneity analysis describes only deviations from independence, whether that deviation is statistically significant or not. Benzecri' (2002) asserts that, " the profile map is the most important part of homogeneity analysis because most researchers using this technique usually publish only a chart formed by the first two axes (dimensions). This is justifiable because the graph is the most information rich part of the output, and the main interest of the data analysis appears here if at all".

7.10 Chapter 7 Summary and link to next chapter

This chapter found that LCLH drip irrigation farmers who bought their kits with cash and with the aim of commercial irrigation were less likely to discontinue irrigation. But those who bought only one bucket kit, went in for drip irrigation to alleviate short-term problems, or had security problems, were likely to stop LCLH drip irrigation.

The Phase 2 survey confirmed the importance of most of the factors found in phase 1 to be influencing the adoption process. These factors included irrigation water supply, method of acquisition of drip kit, maintenance, and size of the drip kit. These factors were strongly associated with continued adoption.

However, in some areas where the technology was generally compatible with farming practices, it appeared to be incompatible with the existing irrigation plot sizes .For this reason, some farmers who had acquired the drip kits technology could not install it.

It was observed that a marketing problem that was a major problem in phase 1 survey appeared as problem in a few areas where the drip irrigation had relatively been successful. This suggested that the factors identified in this study might vary among the different areas, reflecting the different conditions.

The innovation-decision process with respect to the adoption of LCLH drip irrigation in Kenya, derived from the results of phase 1 and phase 2 survey, is the focus of the synthesis in the next chapter.

CHAPTER 8

SYNTHESIS: APPROACHES AND STRATEGIES FOR PROMOTING LCLH DRIP IRRIGATION

8.1 Chapter introduction

This chapter brings together the findings of the study on India, Africa and Kenyan. It starts by discussing the innovation-decision process in terms of the study findings in Kenya, followed by a review of the appropriateness of the technology. This leads to the development of a generalised modified Rogers innovation-decision process model. Lastly, the chapter discusses the findings in terms of the research questions and then reviews critically the Rogers model with respect to this research.

8.2 The innovation-decision model with respect to low-cost low head drip irrigation adoption in Kenya

The factors influencing the innovation-decision process of LCLH drip in Kenya were presented in Chapters 6 and 7. This section examines their role in the context of the stages of the Rogers model. Figure (8.1) shows the factors linked to the relevant stages; these are now discussed in turn.

8.2.1 Prior conditions

The prior conditions are the existing factors into which the LCLH drip irrigation was introduced, which may influence and have an effect on the adoption of the irrigation system. Such conditions include whether there were felt needs for LCLH drip irrigation system at the time of its introduction as well as compatible social norms or cultural practice for irrigation or arable farming. The policy framework to facilitate the adoption of irrigation technologies through control, incentives and extension or advice at the farm level is also an important prior condition. Figure 8.2 shows some of the negative prior conditions identified in this study.

The prior conditions are discussed below in terms of cultural practice, felt needs and government policy.

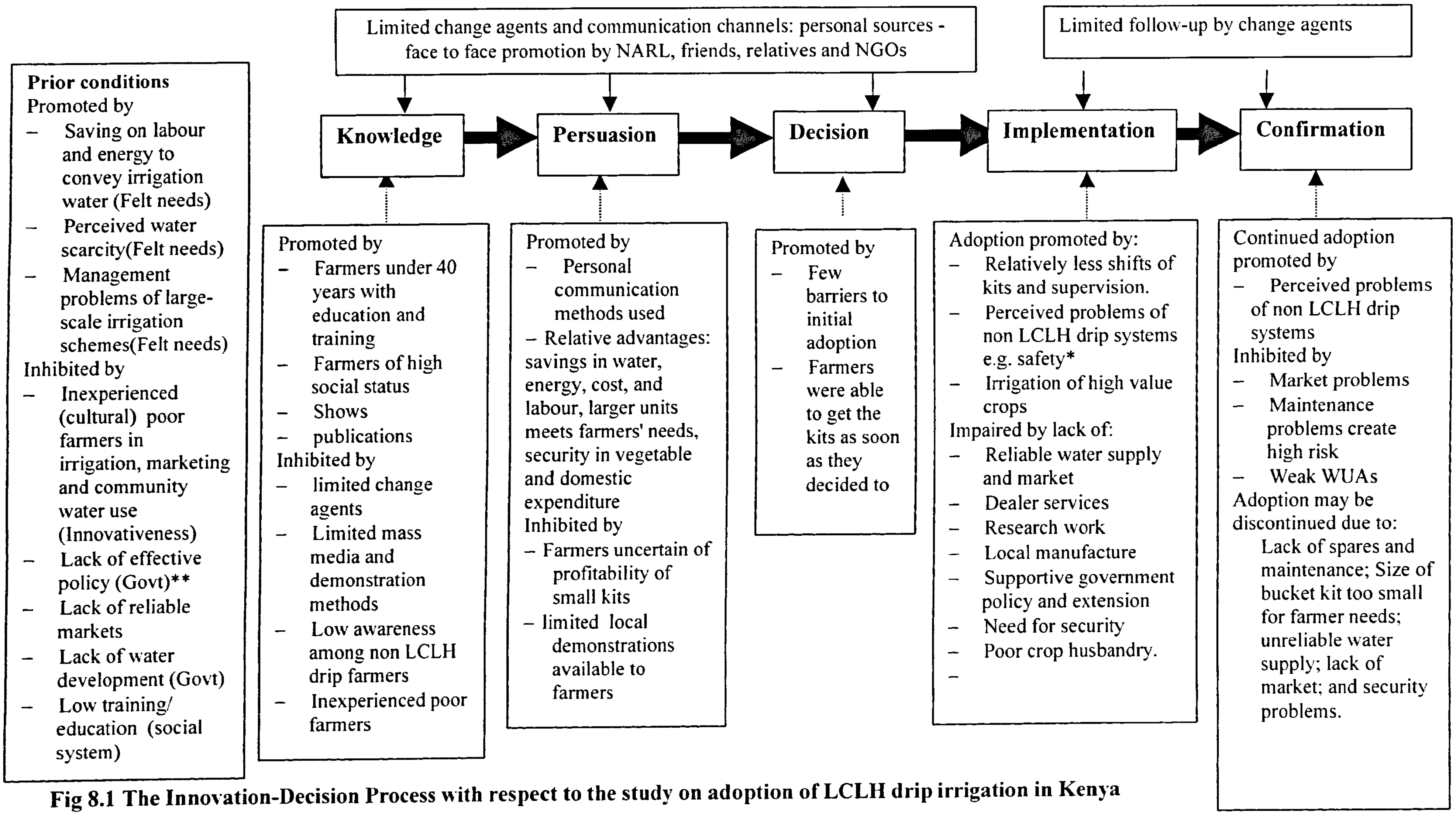


Fig 8.1 The Innovation-Decision Process with respect to the study on adoption of LCLH drip irrigation in Kenya

* Safety in terms of pest control, disease and soil erosion, **Govt denotes government

8.2.1.1 Cultural practice of small-scale farmers

Traditional African irrigation was limited to areas near the water sources such as river valleys, valley bottoms and swamps. However, it was found that most farmers who adopted LCLH drip irrigation in study areas were from upland areas. Although these are potential areas for the introduction of irrigation, the farmers are likely to lack historical irrigation experience, unlike the equivalent farmers in India. Therefore, the average Kenyan farmer being introduced to low-cost irrigation is likely to be inexperienced in irrigation practice, and consequently lacks the necessary experience in community irrigation water use organisation and in marketing of the irrigation produce (Fig 8.2). The results showed farmers who had no experience in areas such as Kajiado tended to discontinue with the LCLH drip irrigation, consistent with findings by Hogg (1988).

It is important that farmers have experience of the husbandry of the crop to be irrigated. It was found that many irrigated passion fruits plots in Uasin Gishu, for example, had been infested by diseases that led to late abortion. During the discussions it was evident that the farmers did not understand what crop protection chemicals to apply and when, and did not appear to understand the importance of using screened clean seedlings despite the "extension advice". Consequently, some of them were not continuing with LCLH drip irrigation. However, the case of Kitui was different because farmers were able to have good crop husbandry because of the combined forces of effective extension service from the NGOs and Ministry of Agriculture. Consequently, this was not a problem for them to continue with the LCLH drip irrigation. This case suggests that good extension service could breach this gap of lack of experience.

Farmers who may have been exposed to irrigation are likely to have favourable attitudes as well as having gotten used to the nature of the work involved. Therefore, it may be important to concentrate on areas where farmers are experienced. Alternatively, good training and extension service are needed where farmers are not experienced with irrigation practice. The training and extension should include agronomy, water management, and marketing. Where water use is communal, an existing group organisation should be used to train and build an effective Water Users' Organisation (WUO) as discussed in chapter 3.

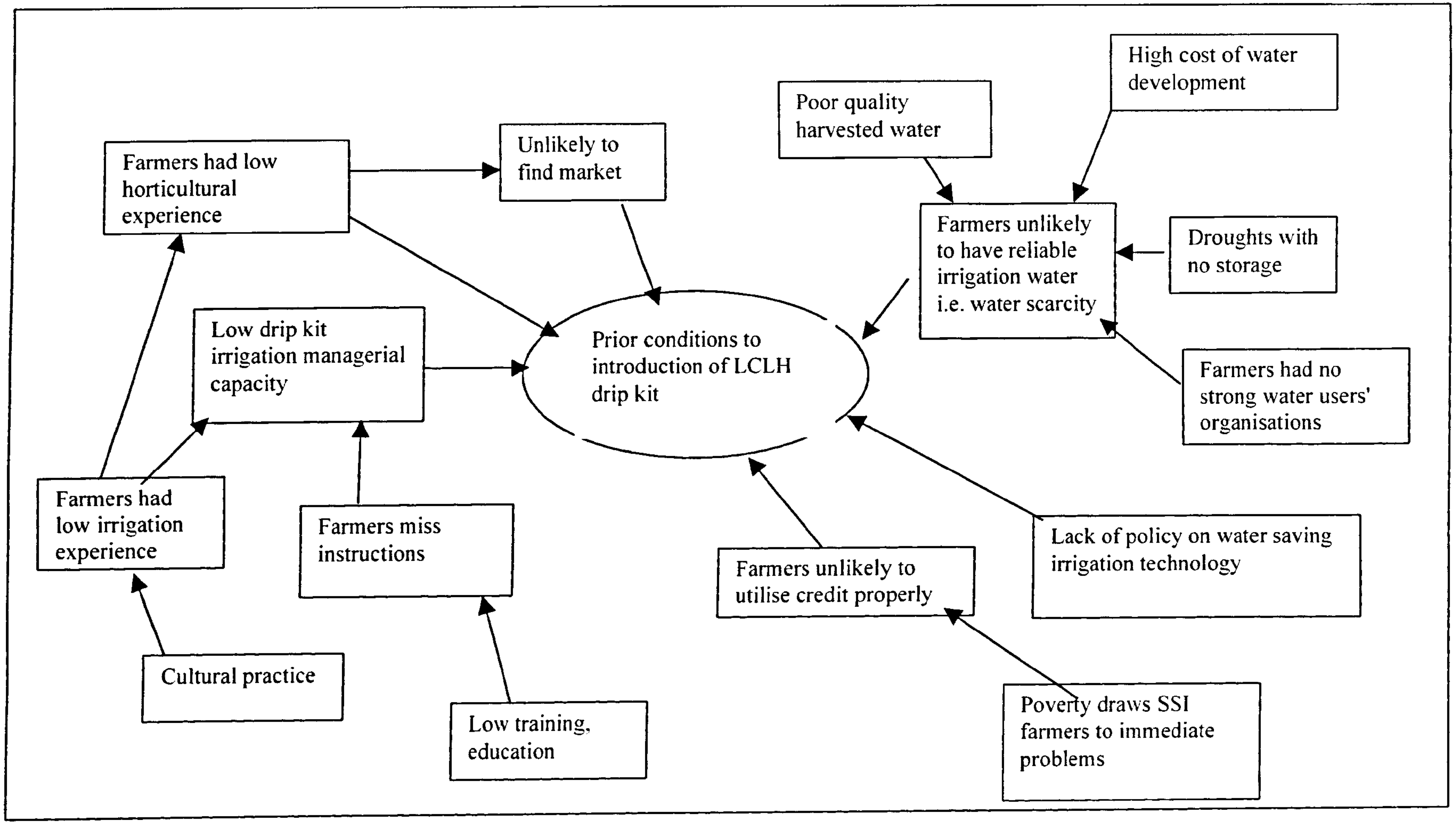


Fig 8.2 Conceptual model of some conditions prior to LCLH drip kit introduction

8.2.1.2 *Felt needs and problems*

The survey results showed that water scarcity was a perceived problem in areas where LCLH drip irrigation was introduced, which created a felt need for water saving irrigation technology such as LCLH drip irrigation. Socially, the farmers were generally poor creating the need for a low-cost drip irrigation system.

The water was unreliable over time i.e. being deficient during prolonged droughts. However, in some areas it was insufficient in volume at any given time and in others some water sources were too far from the irrigated areas. This made it laborious or expensive to fetch enough volume of irrigation water. This problem arose from the fact water development in the study areas was generally low.

Sometimes technological change is necessitated by operational conditions making the use of the current technology difficulty to operate, thereby creating conditions favourable for change. In India for example, large-scale non micro-irrigation irrigation was sometimes resulting in the depletion of ground water due to over drawing and water logging of fields. These were favourable conditions for the introduction of farmers to shift to low-cost drip irrigation (Suryawanshi 1995). The combination of these factors, supported by enabling conditions of relevant irrigation experience, established infrastructure and good markets, and hence enabled faster adoption of LCMH drip irrigation.

Many African countries seem to be lacking compelling factors arising from problems of large-scale irrigation methods, except Egypt (El Kadi et al 1997) and Sudan (Adeep 1999). These two countries practice surface irrigation on very large scale. The presence of low-cost drip irrigation on a significant scale in the Nile delta in Egypt (Merret 2003) suggests that they are important factors in the adoption of the technology. However, with the present population growth and development in Africa, these problems are likely to become more significant in other African countries where large-scale irrigation exists. There may be need in places where large scale irrigation problems are likely to occur to plan for alternative preventative irrigation methods to avoid water logging and wastage.

Evidence in chapter 3 suggests that the need for water saving irrigation technology in India arose from the need for conservation of water resources that were being depleted rapidly by non-drip irrigation methods. This is because most farmers obtained irrigation water from developed sources such as their own tube-wells. In

Kenya however, water resources are not well developed. It was found that most smallholder farmers obtained their irrigation from running rivers. Here, the need to reduce labour and energy to convey irrigation water to farm plots seems the principle reason favouring the introduction of LCLH drip kit. In semi arid areas where water was obtained from storage reservoir, water depletion was likely to create water scarcity, favouring the introduction of low-cost drip irrigation. The lack of water resource development in Kenya is an unfavourable prior condition for the development of any form of irrigation.

In chapter 2, it was stated that the African smallholder farmer often operated under conditions of poverty. For this reason, a low-cost water saving technology such LCLH drip irrigation was preferable so as to be affordable by the poor farmers. In practice, it was found that it was still not affordable by the very poor farmers. On the other hand, the relatively affluent Indian farmers were more successful in adopting the more expensive medium head drip irrigation; though with great assistance from the government and irrigation industry.

8.2.1.3 Government policy

Government policy can set an environmental framework that can influence the nature and development of the adoption of the irrigation technologies. It was found that the majority of Government staff expressed the view that there was need for more emphasis from the government if the LCLH drip irrigation were to succeed. Moreover, the survey revealed that the policy on LCLH drip irrigation promotion was not clearly spelt out. This was likely to lead to inadequate extension service from government department on the LCLH drip irrigation. The ultimate effect of this was that some farmers were unable to adopt the LCLH drip irrigation kit, resulting in a slow adoption process (Fig 8.2). In view of this it was not surprising that the majority of commercial dealers complained that the LCLH drip irrigation kit was not sufficient to form a viable business and for them to promote it in the field. This may form a self-propagating loop.

The apparent weakness of the link between the extension work and farmers is consistent with findings by De Lange (1997). This weakness seemed to hinder communication of the technology, indicating that LCLH drip irrigation should be introduced only where there was a clear policy on promoting it. The apparent lack of research information on LCLH drip in Kenyan agricultural research publication indicated that agricultural research appeared to be skewed towards rainfed agriculture, agronomy and economics, supporting similar findings by Rukuni (1984b).

These findings for Kenya are similar for many African governments, which lacked policy on types of irrigation technologies and its extension (Chapter 3). Besides, they provided limited credit for the development of smallholder irrigation farming and, imposed high taxes on irrigation equipment and raw materials. In contrast, although the Indian government was not actively involved in the promotion of LCLH drip irrigation, its effective policy for promotion of low-cost medium head (LCMH) drip included subsidies, credit, extension work and research.

8.2.2 Knowledge stage

This research found that there was an apparent low awareness of LCLH drip irrigation method among the non LCLH drip irrigation small-scale farmers in Kenya. This was apparently caused by the limited use of mass communication methods and local demonstration sites during the introduction stage and the limited quantity of change agents involved in its promotion. Moreover, most of the extension staff who were supposed to promote it lacked information about the system. Prominent communication channels employed were shows and publications that were not accessible to most farmers because of the cost and time involved.

In India however, the promotion of low-cost medium head drip irrigation was effectively by use of demonstrations on farmers' plots as well as village level seminars. These, together with fact that drip irrigation was available on commercial farms, created high awareness among small-scale farmers about low-cost medium head drip irrigation.

The survey revealed that the farmers who were likely to become adopters of LCLH drip kit in Kenya were relatively young, educated and of high economic social status. This type of adopter profile implies that the poorer farmers may require credit assistance to access the technology and that LCLH drip kit is not suitable for them. This contrast with the Indian case in which the farmers were generally from an experienced and a progressive farming community in which the poorer farmers received assistance from irrigation industry and government for a LCMH drip type of irrigation technology.

The discussion in this section suggest that for awareness to be improved in the study areas then the right communication channel at each stage of the innovation decision process should be employed. This may also be achieved by increasing the quantity of change agents.

8.2.3 Persuasion stage

The main promoting agent for LCLH drip irrigation in the study areas was NARL. A few NGOs were involved in promotion but most avoided engaging in irrigation because it was considered a risky business. The role of government extension in LCLH drip irrigation was limited by lack of policy and information. Consequently, there was insufficient communication of the technology to smallholder farmers in the study areas. This contrasted very much with the Indian case in which the leading promoting agents were the local NGOs (DFID 2003).

The study showed that personal communication was used at the persuasion stage to create farmers' interest in LCLH drip irrigation in Kenya. However, due to the limited number of change agents involved, the impact was apparently limited. For example when a farmer in Kiambu was asked during the informal discussion of the interview whether he intended to continue using sprinkler irrigation, he gave a reply common among smallholder farmers:

> *"Yes, since I started using this (sprinkler), I have not thought of changing because I do not know any other one to change to. Nobody has mentioned to me of another (irrigation method) that I can go for. You are the first visitor I have seen talking about irrigation on my farm. Most visitors (government agents) here talk about crops and not irrigation".*

This statement indicates that personal communication was required to encourage smallholder farmers to look for more information about LCLH drip irrigation in Kenya. It also demonstrates that agricultural extension staff are biased towards rainfed agriculture and not irrigation in general. This contrasts with the Indian government extension staff who actively promoted low-cost medium head drip irrigation.

However, smallholder farmers in Kenya were persuaded by LCLH drip irrigation because they believed it would save water, and hence labour or energy to convey it. Micro-irrigation can supply the necessary amount of water very accurately and efficiently to the desired root zone at the required time. Moreover, it supplies water only to localised area around the root zone of the crop. Therefore, it can reduce water losses in comparison to other non-drip irrigation methods. Another incentive of creating interest in LCLH drip irrigation was the reported increased yields due to more frequent growing of crops by small-scale farmers during the study.

In India the need for saving of groundwater and to reduce problems caused by other irrigation methods as discussed in chapter 3, persuaded farmers to adopt similar system to LCLH drip irrigation of low-cost medium head (LCMH) drip irrigation system. In addition, there were reported increased yields associated the LCMH drip irrigation system in India.

In general, the positive perception factors that influenced the adoption of low-cost drip irrigation in India are similar to those likely to create farmers' interest in LCLH drip in Kenya, but described in terms of the people 's (farmers') knowledge. However, the compelling factors and the promotional methods appear to be dissimilar. The importance of personal communication methods with a large involvement of different change agents and the availability of demonstrations at the farmer level are important factors during the persuasion stage, as evidence from the effective promotion of LCMH drip irrigation in India shows.

To break the barriers at the persuasion stage it would be beneficial to provide LCLH drip irrigation demonstrations at the farm level and for government extension to be actively involved in promotion of irrigation in general and LCLH drip irrigation in particular.

8.2.4 Decision stage

In deciding whether to implement the LCLH drip irrigation, small-scale farmers may consider the feasibility and practicability of low-cost low head drip irrigation on their farms. The LCLH drip kit was physically suitable for irregularly shaped plots although it appeared unsuitable to some plot sizes. For the majority of farmers interviewed there were no apparent barriers inhibiting the initial decision to implementation of the drip kit. Most of the farmers interviewed were able to buy or obtain the LCLH drip kit as soon as they decided to: most of them bought for cash. There were no apparent barriers related to lack of finance or the need for credit facilities. Most thought it was affordable. However, inevitably only farmers who were able to buy were interviewed. But during the interview, farmers were asked if there were other farmers who raised the issue of the need for credit during the early introductory meetings to LCLH where everybody in the village was invited to discus the introduction of the project of LCLH drip irrigation. None of them reported such issue being raised.

However, the analysis of adopter characteristics in this study and evidence from other sources suggest that lack of credit was a likely barrier during this stage (Winrock 2000). In the Indian case, any such barriers had been reduced by the promotional efforts of irrigation industry and the government for LCMH drip irrigation by providing credit.

If the aim of introducing LCLH drip irrigation is to help the poor farmers, then credit facility should be considered for the very poor, where the technology is appropriate. Few African countries have agricultural financial institutions and there is no such effective institution in Kenya. Instead, sources of credit assistance for small-scale farmers are mainly NGOs. Although, evidence from this study indicate that most them fear irrigation farming because they consider it a high-risk activity.

8.2.5 Implementation stage

At the implementation stage farmers acquire, install and start to use the LCLH drip kit on their farm. The LCLH drip irrigation technology was not adopted in a vacuum but in an environment characterised by uncertainty and risks. While farmers seemed to have limited obstacles along the innovation-decision process up to this stage, the implementation stage seemed to present major obstacles as illustrated in Fig 8.3. Most of these do not appear to be problems in the Indian low-cost drip irrigation but appeared to limit further movement in the innovation-decision process of low-cost drip irrigation in Kenya. These barriers, which are also likely to have an important influence on the adoption process at other stages of innovation -decision process under a different context, are discussed first before explaining the positive factors promoting the process during this stage. Figure 8.3 shows some of the negative implementation conditions identified in this study.

8.2.5.1 Negative factors impairing LCLH drip adoption at the implementation stage

- ***Technical support service for maintenance***

The study showed that deficiencies in the technical support service were inhibiting the implementation of LCLH drip irrigation. This was in terms of availability of kits, operation and maintenance of LCLH drip irrigation kit.

The drip kit seemed to have more technical problems than other irrigation methods and this was likely to discourage successful implementation. The results showed that farmers were not satisfied with the technical support service mainly because they were unavailable, since the staff did not visit them, were far away or the farmers did not know where to trace them in case of a problem. Others stated they were dissatisfied because the technical staff were unable to fix repairs, mainly due to lack of spares. Moreover, the kits were not available for those who wanted additional ones. These may partly explain why the LCLH drip irrigation appeared to have more problems than other methods. The importance of technical support for irrigation is confirmed by Moris (1984), in a case study in Mali, who found that persistent inadequate support services and fuel shortages were just as important constraints on smallholder irrigation in remote areas as shortages of water.

Farmers complained that the change agents and other technical staff were inaccessible in terms of location and distances. For example, a lady farmer whose filter had broken wondered how she could travel a distance of over 400 Km to Nairobi to buy spares whose value was about 10% of the cost of travel. Even if she managed to go, she wondered where to locate the sources/ agents for the drip kit. This example is typical of many others. As a consequent, many of the drip kits were found to be out of operation due to maintenance problems such as clogging, breakage, leaks and missing parts.

In contrast, the joint efforts of the private sector and the government ensured that this was not a problem in India for LCMH drip irrigation. This implies apparently that efforts should be made to improve effective supply and maintenance of LCLH drip irrigation equipment. Some of these problems may suggest lack of an effective service industry in Kenya to provide back up for technical service.

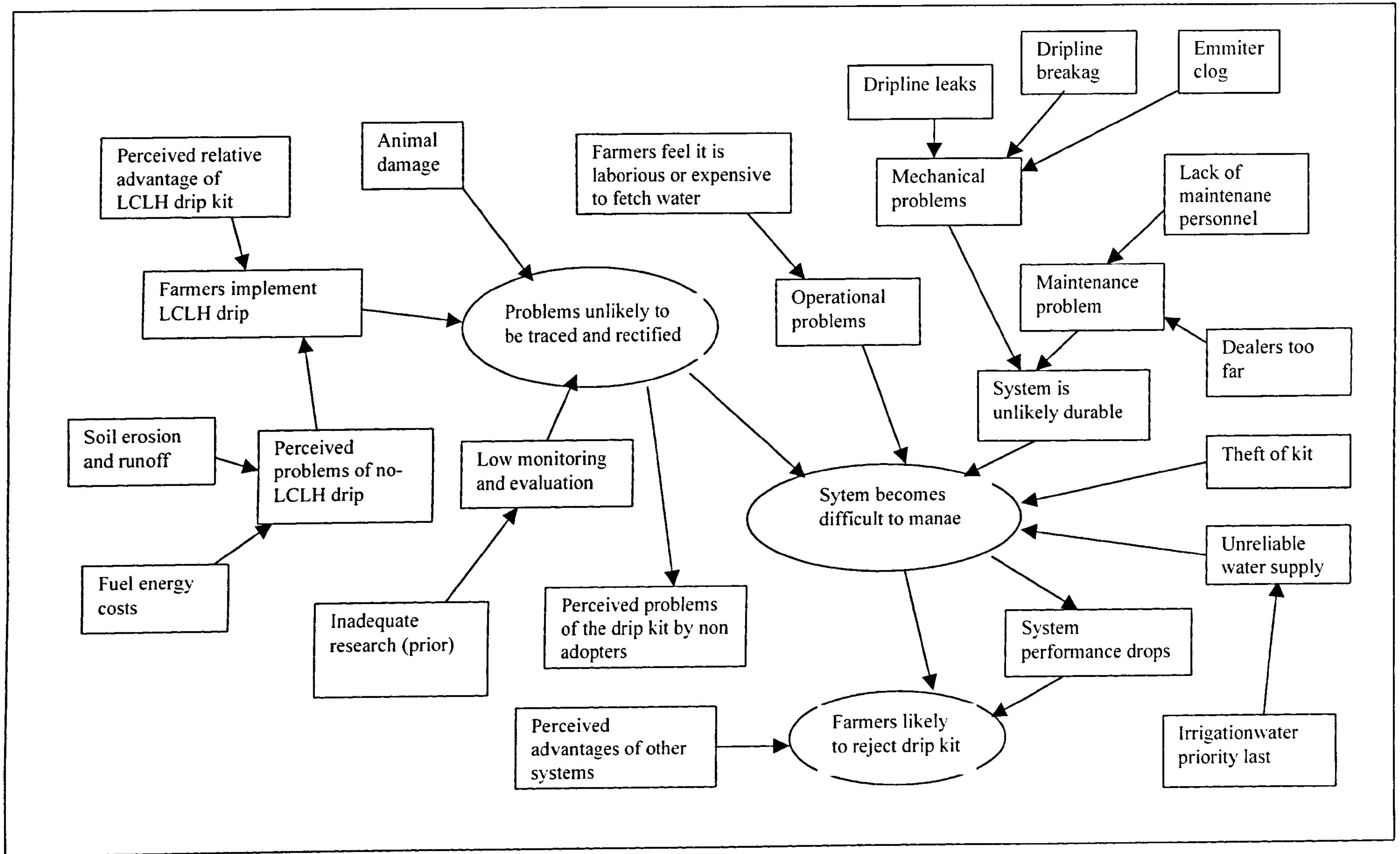


Fig. 8.3 Conceptual model of experience of LCLH drip irrigation during implementation in Kenya

However, Kenya has effective formal and informal sectors with a capacity to handle such problems. The market approach of IDE of establishing supply chains by allowing a profit for these sectors could be examined (Chapter 3) to reduce some of these problems. On the other hand, these are typical problems of the introductory stage of the technology that may disappear with the growth and maturity stages of the drip kit adoption cycle (Appendix 2.1). Kenya has favourable plastic industry. Already there are informally produced plastic sprinkler heads in the field.

- ***Water development and supply***

The irrigation water development in many African countries is low and Kenya is no exceptional. Therefore, it is not surprising to find that over 70% of irrigation water sources were natural streams and rivers. Few smallholder farmers have water storage facilities. This means most farmers obtain their irrigation water by direct abstraction from the sources making irrigation farming more dependent on natural conditions than with storage facilities. Making farming less dependant is a major relative advantage of irrigation hence this problem has implication to irrigation. It was found in this study that most Kenyan farmers obtained their irrigation water from undeveloped sources - streams and rivers. The water scarcity was caused mainly by the seasonal variation of the climate rather than over-abstraction which perhaps explains why direct irrigation water charging and regulation was not common. Few farmers may be encouraged in irrigation water saving from sources that do not conserve water.

Furthermore, more smallholder farmers were likely to turn to poor quality harvested irrigation water where there was low access to reliable water sources. This was likely to be a factor hindering the introduction of the low-cost LCLH drip kit which requires clean irrigation water to avoid clogging (Fig 8.3). For instance, in areas where surface water is harvested as in Matuu there was the problem of poor quality of irrigation water. The only LCLH drip irrigation kit using surface harvested irrigation water in this area was not functioning due to clogging. This problem was also mentioned in Ngon'g, where saline irrigation water was predominant. It was a minor problem in other areas.

Few African countries have any form of water levy that may create the need for water saving irrigation technologies (Cornish 1998). As far back as 1989, Carter (1989) observed that few countries in Africa had well-established legislation on water control.

Hence, irrigation water saving is often not the priority of smallholder African farmer (De Lange 1997). This is likely to be a major disincentive for adoption of low-cost drip irrigation. However, the need to save labour, time and energy to fetch the irrigation water does exist.

For example, Jurdell & Svensson (1998) found that some farmers were unable to continue with the drip kit irrigation in Kithimani and Kajiado in Kenya because of the amount of labour required for fetching the irrigation water manually.

Therefore water availability in terms of volume, distance and over time was found in this study to be important to the implementation of irrigation project and should be carefully evaluated during the planning stage of the LCLII drip irrigation project. This finding suggests farmers should be adopting LCLII drip irrigation only where irrigation water is reliable in volume, distance and over time.

- ***Organisation for reliable water supply***

In places where there has been established a way of sharing water sources or where individual water sources exist the introduction of LCLII drip irrigation, as any other irrigation method, is more likely to succeed. The current policy in Kenya is to hand over all the irrigation water administration to local farmers "at the end of a project". Water Users Associations (WUAs) are important in organising and running of community water resources. The local farmers' water management bodies as in Uasin Gishu and Kajiado Central seemed to have been formed around the irrigation project, but in Chapter 3 it was stated WUAs formed around an existing group are more likely to succeed than those formed solely for the irrigation. For this reason, it was not surprising there were problems arising from WUAs. For instance, some farmers would not pay for the cost of operation and management of the water supply, making it difficult for those who wished to continue with the LCLII drip irrigation. The WUAs appeared powerless in enforcing payment towards running costs. In central Kajiado, there was conflict of interest; while the men preferred to give water to their animals, they did not understand why the women insisted on "pouring water on the ground". This reflects the cultural background differences and possible gender conflict between women and men. While men attached importance to livestock hence preferred the limited available water to be given to cattle, the women attached more importance to vegetables. Such conflict can only be solved by a well organised and an effective WUAs with both sexes represented equally. In practise men dominated water management committees. Therefore, in some cases women were forced to dig their own wells often far from their irrigated plots. Most were discouraged by the increased labour of fetching water due to the longer distances.

Seasonal water unreliability was another problem. This calls for provision of water development in terms of water harvesting, storage, and boreholes. Water development is an expensive service, which should not be left to farmers alone. Therefore, the government or NGOs should be willing to assist farmers in this exercise so that, drip kit irrigation farmers have reliable irrigation water.

- ***Effective irrigation equipment industry***

One reason why SSI farmers in India were able to use low-cost irrigation was because they were able to obtain irrigation equipment relatively easily and cheaply from a well-established local irrigation equipment manufacture and supply industry. In chapter 3, it was found that the only notable irrigation equipment manufactured in sub-Saharan Africa for smallholder farmers, were manual pumps. Kandiah (1997) cites high import duty, inadequate electrical power, insufficient credit system and high cost of (expert) labour as the main constraints of irrigation equipment manufacture. However, there was little evidence from this study that many of these factors applied to the Kenyan industry, except the cost of high borrowing reported in one case. The main problem was the apparent small market for LCLH drip irrigation. Consequently, although Kenya has an established irrigation farming industry, micro-irrigation manufacture was not significant. The study found the irrigation industry is too small for profitable business. Only one company manufactured conventional drip irrigation equipment for the East African region, but this did not include the drip kit. The company reported there would be no major problems in manufacturing of drip equipment in Kenya. It was therefore not surprising that even though the drip kit was affordable, lack of spares was a major problem in Kenya. This may indicate the importance of availability of a well-established irrigation industry in appropriate low-cost drip irrigation manufacture, promotion and supply.

- ***Problems with research work***

Inadequate research on drip kit irrigation meant that farmers' plots were being used as trials for the new system. Therefore, some of the negative effects that should have been screened out before its introduction were likely to be evident on farmers plots, discouraging other potential SSI farmers from using the LCLH drip irrigation kit. Inadequate research findings also meant that there was limited monitoring and evaluation of the LCLH drip irrigation kit introduced, which meant that problems in the field were unlikely to be traced and rectified (Fig 8.3). Eventually this could lead to the LCLH drip irrigation kit becoming difficult to utilise.

When asked about the performance of the LCLH drip irrigation kit; the NARL statement supported the view that the levels of research and monitoring of the technology were low:

> *"The main problem is lack of funds. Even if we get money for research, there would be a problem of information dissemination through reports unless the funding includes this.... We still do not know many things about the system, for example economic viability for different crops/ soils in different ecological zones, its life span, problems unique to Kenya, its water usage, its effects on social set up and agricultural activity etc."*

This statement illustrates generic issues of institutional weakness that also supports the earlier comments from the extension staff on the need for the government to take LCLH drip irrigation more seriously. However, many African governments are hampered by inadequate funds.

8.2.5.2 Positive factors promoting LCLH drip at the implementation stage

Most positive factors found during the study promoting the LCLH drip kit in the implementation stage of the innovation-decision process were mainly perceived problems of non LCLH drip systems. These mainly reflected the advantages in farm management of the LCLH drip system over the others, including:

- ***Dry working conditions***

One of the commonly cited advantage of LCLH drip irrigation by farmers during the interviews was that it created dry working conditions free of mud, unlike other non drip irrigation methods. This is because the drip applies water directly to the root zone of the crop, leaving other parts of the plot basically dry. This provides comparatively comfortable and efficient dry working conditions, unlike other methods. This is a great advantage particularly when irrigating in clay soils.

- ***Relatively less shifts and supervision***

The operation of LCLH drip irrigation is relatively easy and the study revealed farmers valued less the low manual labour required for shifting of the system. In contrast, sprinkler irrigation takes a relatively shorter time for irrigation before it is shifted and hence needs more frequent shifts than LCLH drip irrigation. Because of this, farmers reported that sprinkler irrigation required them to stay around the homestead. This interfered with the farmers' other schedules that required them to be away from the homestead.

- ***Safety of the system***

Farmers who had shifted from traditional or sprinkler irrigation methods reported that they had noticed fewer incidences of crop diseases and pests. Those farmers who previously had used furrow irrigation stated that they had noticed less soil erosion. Therefore, it appeared that the LCLH drip irrigation was safer against spreading diseases and soil erosion.

This can be explained by the fact the application of irrigation water by LCLH drip irrigation allows very little contact of irrigation water over the leaves of the irrigated crop. This reduces diseases and pests that prefer moist and damp conditions to thrive. In addition, since there no splashing or movement of water on the ground by LCLH drip irrigation, soil bone diseases cannot be spread among the crop and soil erosion is minimised.

- ***Long soil moisture available***

Farmers reported that LCLH drip irrigation maintained soil moisture in the root zone of the crop for a longer period than other irrigation methods. Without the use of mechanism of checking how much water has been applied, some farmers appeared to stop sprinkler irrigation with the superficial saturation of the topsoil. Therefore, they were able to notice the soil drying out within short periods after irrigation when compared to LCLH drip irrigated plots. The maintenance of the soil moisture around the root zone of crops at high level caused better performance of crops.

8.2.6 Confirmation stage

The confirmation stage is the penultimate stage in the process and is when small-scale farmers assess if their decision to employ LCLH drip irrigation was correct. During this stage, constant follow up by change agents- technical support, extension, NARL or NGOs is important to assist in solving any emerging problems. This gives the small-scale farmers the morale and continued commitment to the use of the drip kit irrigation. However, small-scale farmers reported lack of follow up by change agents during the implementation and confirmation stages. Consequently, technical problems of the LCLH drip kit, that could have been solved by change agents, built up. This was likely to make some farmers feel that they had not made the right decision in adopting the drip kit. This was potentially damaging to the promotion of the LCLH drip in the study areas, as it was likely to create a negative perception to other potential adopters.

The limited visits by change agents to farmers with subsequent problems during the confirmation stage could be partly the reason for some farmers discontinuing the LCLH drip irrigation due to lack of spares and repairs. The problem of maintenance, and unreliable water supply have been described in detail earlier in this chapter. Other reasons why some farmers discontinued the drip kit irrigation are discussed below:

- Lack of reliable market;
- Size of the kit; and
- Security problems.

8.2.6.1 Lack of reliable market

Marketing of agricultural produce is a world-wide problem. It was not surprising that this was an important issue forcing farmers to discontinue LCLH drip irrigation projects in the study areas. Farmers reported this problem where LCLH drip irrigation was relatively successful. This was likely to be during the confirmation stage. In areas where it was less successful, there appeared to be less market problems perhaps because they were not yet producing significant quantities. The agricultural market was poor apparently due to lack of information, the poor distribution and the small size of the market. From the informal discussions, the farmers did not appear to have information about where markets were, their size, the produce required or the prices. Often the local markets were too small, quickly flooded when production improved. In other areas, the organisation was weak so that some members were not playing their part effectively. The findings illustrate the need to evaluate marketing opportunities before introducing appropriate low-cost drip irrigation in Kenya.

Although there was an established Department of Marketing in the Ministry to promote marketing of agricultural produce, its function were hindered due to reported financial constraints, as in many other African countries. Consequently, farmers were unable to get the relevant information to make right decisions. It was reported that the staff employed to provide the information (and middlemen in some instances) used the information to exploit the farmers. Even where farmers were informed of a potential market, they sometimes were unable to organise themselves to market. A case in point was reported in Ngon'g where there was potential to export vegetables to the Far East but farmers disagreed on what, when and how much to produce. Eventually they lost the market because individual farmers could sometimes not meet the minimum capacity required for export. Another example was in Uasin Gishu in which the LCLII drip irrigation farmers had a reliable local market for their produce but they became short sighted, choosing to sell to middlemen offering higher prices from a neighbouring country without taking into account the consequence to their long term established market. When these middlemen stopped buying from them, they had lost the original market contract.

Kenya's urban market is small compared to its population and this is true of many African countries, whereas the capacity of the India market is relatively huge. This implies that the capacity of the market to absorb agricultural produce from LCLII drip irrigation was likely to be limited. That is why it was found that the problem of marketing became important where there was relatively successful LCLII drip irrigation. However, the potential for horticultural export from countries like Kenya exists and is growing fast, and could be organised and promoted to increase the size of the market. The Fresh Produce Exporters Association of Kenya (FPEAK) appeared to focus its assistance for export of horticultural produce to a class of farmers who excluded smallholders.

A reliable market for irrigated produce provided by the high population was a major promotion factor for LCMH drip irrigation in India. However, market outlets or pricing for many African crops are not guaranteed (Makadho 1984). In her study on smallholder irrigation schemes in South Africa, Chancellor (2003) found that in almost all the schemes marketing was a major concern. This supports the view that both domestic and external agricultural markets were not guaranteed similar findings in this research.

8.2.6.2 Size of the drip kit and rural power supply

The LCLH drip irrigation kit was designed with the aim of feeding it with water manually. So LCLH drip kits do not generally require a pump or power supply. While this was feasible where water was reliable and within reasonable distance, it was found in this study that this was not possible in places where water was not developed or reliable throughout (consistent with Winrock 2000). The possibility of fetching water over distances for the larger kits requiring more than 200 litre of water daily was likely to be a problem even with the use of animal power. However, findings in this study and elsewhere (DFID 2003) suggest that the larger low-cost medium heads drip irrigation appear to have more potential than the small LCLH drip kits. These larger units generally require the use of power or fuel for small pumps. Therefore, the use of power supply in the rural area may be an important factor during the implementation for such units.

It was found that most smallholder commercial irrigation farmers who were not using the drip kit were irrigating larger areas averaging 1.6 acres (0.6 ha) and used small petrol 5 hp Honda pumps. They were in suburban areas hence have access to markets. These farmers may be potentially suitable for low-cost medium drip irrigation where conditions are favourable. Hence, rural power could have a potential role in the promotion of LCMH drip irrigation in areas where fuel is expensive or difficult to get.

It appeared that the use of manual pumps for small-scale irrigation in Kenya was still limited. This is despite the ApproTEC claim that they are widely used (Winrock 2000). In fact, of all the farmers interviewed none had used a manual pump for irrigation. It is possible this was a coincidence but it does demonstrate how rare these pumps were in the study areas. The earlier version of the famous treadle pump was unpopular with irrigation farmers because it had limited capacity to lift water. The majority smallholder farmers who went in for LCLH drip irrigation were upland farmers hence required a pump to pump irrigation water up to the point of use. Secondly, the treadle pump required at least two people to operate, while most farmers preferred to work alone. For these reasons those who could afford it, employed 5 Hp Honda pump sets for hose-pipe spray irrigation or LCMH drip irrigation. The use of electrical power was limited because of poor rural power supply.

In India, 97% of the irrigation pumps sold were electrical (Sundaram 1997), and about 70% of smallholder irrigation farmers use pumps (FAO 1999). This illustrates the likely role of availability of rural power supply in the promotion and success of LCMH drip irrigation in India. The development of electrical power in the rural areas in many sub-Saharan countries is low. Moreover, where power is available, as in some parts of Kenya, it is often erratic, especially during the dry season when irrigation is required most. If the Indian experience were to go by, then Kenya may need to develop reliable rural power supply to promote meaningful low-cost drip irrigation.

This section indicates that water development with subsequent ability to convey water conveniently is important to the adoption of the low-cost drip irrigation in Kenya. This research shows that trying to avoid this problem by using kits based on human water conveyance may not get rid of the problem because the particular drip kits are too small. However, it was found that most non LCLH drip irrigation farmers solved this problem by using petrol pump-sets. More generally, although the lack of rural power supply may not inhibit the implementation of LCLH drip irrigation, which appear to have a low potential, it may inhibit the implementation during the innovation-decision process of the potentially viable low-cost medium head drip irrigation

8.2.6.3 Security problems

It was found that security was an important problem affecting the innovation decision process during the implementation and later stages. The security problems of theft, domestic or wild animals could be minimised by fencing or keeping the kit close to the homestead. Hence, it was not a critical factor to some farmers.

Despite these problems, some farmers continued adopting drip irrigation because of some of the benefits mention earlier in the innovation-decision process.

Table 8.1 Innovation-decision process for low-cost irrigation in India and Kenya

Stage	India (LCMH) Factors		Kenya (LCLH) Factors	
Prior conditions	Experienced farmers in irrigation.	+ve	Savings on labour and energy on irrigation water,	+ve
	Irrigation of high value crops.	+ve	Perceive water scarcity,	+ve
	Problems of non-drip irrigation.	+ve	Rainfed agriculture or livestock husbandry,	+ve
			Management problems of large scale irrigation schemes encourage smallholder irrigation,	+ve
			Inexperienced (cultural) poor farmers,	-ve
			Lack of effective policy,	-ve
			Lack of infrastructure.	-ve
Knowledge	Farmers progressive and aware of drip irrigation,	+ve	Economically and socially well of farmers,	+ve
	Effective promotion methods used.	+ve	Limited and infective promotion methods.	-ve
Persuasion	Positive perception factors of LCMH drip,	+ve	Positive relative advantages as defined by farmers,	+ve
	Effective promotion al methods.	+ve	Personal communication employed.	+ve
Decision	Limited barriers	+ve	Limited barriers.	+ve
	Effective promotional agents,	+ve		
	Personal information available.	+ve		
Implementation	Favourable policies by government, private sector in promoting LCMH drip irrigation,	+ve	Identified positive advantages of LCLH drip kit present*	+ve
	Available infrastructure,	+ve	Irrigation of high value crops.	+ve
	Effective promotional agents and available personal information available,	+ve	Lack of enabling institutional and political factors.	-ve
	Compelling factors from prolonged use of no drip irrigation methods.	+ve	Limited promotion services available.	-ve
Confirmation	Personal information available,	+ve	Perceived problems of non drip irrigation,	+ve
	Efficient water users associations.	+ve	Weak water users associations.	-ve
			Maintenance, and lack of infrastructure, Limited promotional services.	-ve

Notes: +ve denotes promotes adoption; -ve denotes inhibit adoption.

* in cases where technology was appropriate

8.2.7 Section summary

The findings at the various stages of the innovation-decision process are summarised in table 8.1. This table relates the various factors influencing the innovation-decision process for low-cost drip irrigation for India and Kenya at the various stages of the process.

8.3 Modifying the Rogers Innovation-Decision model with respect to low-cost drip irrigation adoption in less developed countries

The results of this study have been used to propose a modified Rogers model for less developed countries constructed from this study (Fig 8.4). Although the adopters' characteristic were similar to the Rogers model (Fig 2.0), the perception factors of the LCLH drip technology in the modified model appeared to be defined by the adopters themselves in contrast to the Rogers model. For instance, the farmers perceived factors of relative advantage such as profitability, affordability, convenience, and safety, as the important factors influencing them to adopt LCLH drip irrigation. These factors did not appear to be perceived strictly according to the Rogers (1995) description. Rather, the farmers appeared to define them according to their own needs and requirements. Hence, the definitions appeared to be related more to the farmers knowledge and not necessarily as described by Rogers (1995).

It was also found that the important influencing factors of adoption appeared to be context specific. For instance political and institutional factors appear important in LDC like Kenya but are less important in developed countries where development has minimised problems related to political and institutional framework. In this study, the political and institutional factors were found to be important during the implementation stage of I-D process with respect to Kenya. Nevertheless, in India they appeared to influence the process during many of its stages. This implies that they are important influencing factors during any of the stages of I-D process. Hence, the influences of the political and institutional framework are presented as acting on many of the stages in the modified Rogers model (Figure 8.4). It is proposed that the factors discussed in this section should be included in the Rogers model for it to be more suitable in Kenya.

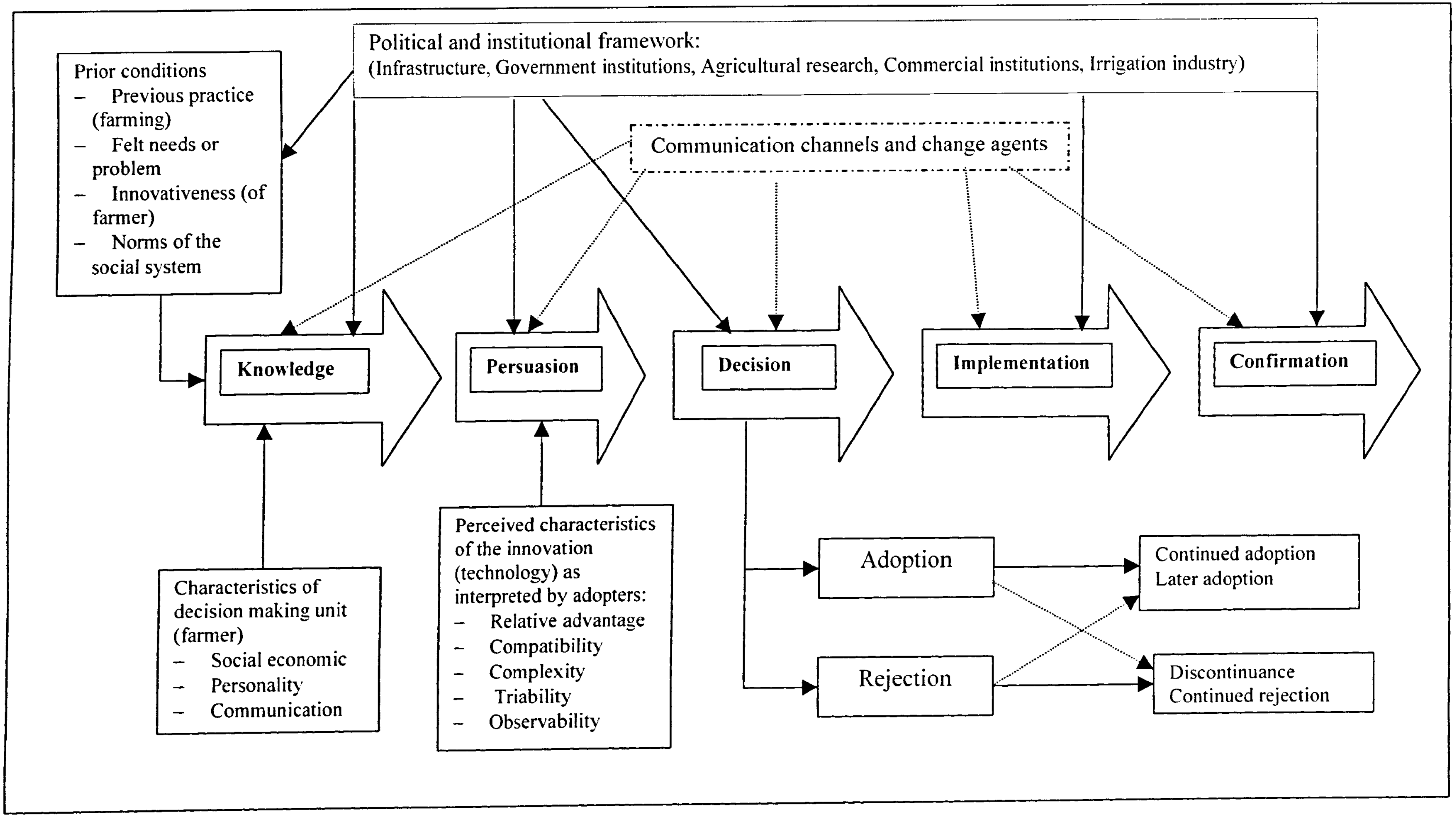


Fig 8.4 Modified Rogers model for low-cost drip irrigation adoption in LDC
(Modification shown by shading)

8.4 Discussion of research questions

The research questions of this study were: -

(i) What are the existing methods by which low-cost drip irrigation is made available to farmers in India, Africa and Kenya?

(ii) What irrigation systems are being adopted by small-scale farmers and why?

(iii) For which small-scale farmers in Kenya is continued adoption of LCLH applicable and why?

(iv) Is the LCLH drip irrigation available to the Kenyan small-scale farmer appropriate to his/her needs?

These questions are discussed in turn: -

8.4.1 Existing methods by which LCLH drip irrigation is made available to farmers

8.4.1.1 Government approach

The promotion of small-scale irrigation only became important in many African countries from the late eighties because of management problems with large-scale irrigation projects. Therefore, policies of smallholder irrigation are not as well developed as for large-scale irrigation. For example, most government extension staff stated that the policy on smallholder irrigation was not clear and they were not fully involved in its promotion. This was the main problem for them affecting the adoption of the LCLH drip irrigation kit. Many extension staff stated that they rarely carried out fieldwork due to lack of transport while others had no exposure to the drip kit technology. The non LCLH drip irrigation farmers' awareness of the drip kit and technical support service was found to be low. It was evident that Government demonstration sites were rare in the rural areas, despite the technology having been in the ministry for over six years. In many African countries, there is poor extension work due lack of interaction between farmers and extension staff, who lack skill, commitment and adequate exposure to technologies (De Lange 1997). The introduction of a technology may benefit from an effective extension service; hence, the lack of such a service in Kenya suggests inhibiting conditions for LCLH drip irrigation adoption.

For LCLH drip irrigation to be successful, it may be helpful if governments prioritise it by funding, formulating clear policies and institutionalising its extension service, and applying effective communication methods, where it is appropriate. Although there were smallholder irrigation guidelines (MOARD 1993), they seemed more designed for the outsiders such as NGOs than for the technical staff.

The need for credit was not found to be a major problem in this study but the analysis of adopters characteristics indicated that the adopters were farmers who were likely to afford it. Some farmers complained that the bucket kit was too small for their needs, instead of buying more kits to extend it. Later this was found to be associated with farmers who dropped out of irrigation. Although this could be due to the reported cases of lack of kits from the promoters, the lack of funds to buy extra kits could be a real factor. In such cases, Government could look into solution of financial problems, including subsidies where such problems were likely to occur.

The inadequate government approach to introduction of LCLH drip irrigation can be seen in two other areas; extension and research. The literature reports that irrigation research in India acted in support of LCMH drip irrigation technology development in developing, modifying and adapting LCMH drip irrigation to solve the real problems of the country. However, it was difficult to get any research reports on work on LCLH drip irrigation from the Smallholder Irrigation Project Research unit. This apparent lack of research on LCLH drip irrigation was not unique to the Kenyan case. In chapter 3, it was found that in many African countries, agricultural research was biased towards general agronomy and economics of agricultural development.

8.4.1.2 Irrigation industry

It was found that the irrigation industry took an active role in the promotion LCMH drip irrigation in India. However, there was no evidence that similar measures were taken by the industry in Kenya. This may be credible from the commercial point of view but this approach was not likely to increase the market of SSI drip kit irrigation in Kenya.

8.4.1.3 *Individuals*

Private individuals played a important role in the introduction of LCLH drip irrigation in Kenya for instance, by initiating such a project in western Kenya. Although that project had problems with of availability of a market, it had put the LCLH drip irrigation in agricultural development in Kenya

8.4.1.4 *Non-Governmental Organisations (NGOs)*

The role of IDE through local NGOs was evident in the introduction of the LCLH drip kit irrigation in India. In chapter 3 it was pointed out that NGOs played an important role in African rural development. But it was found that the number of NGOs directly involved in smallholder irrigation in Kenya was small because they considered it a high-risk activity.

Nevertheless, a few NGOs were found to be indirectly involved in the promotion of the drip kit especially in central Kajiado and Kitui district. Their services in promoting the drip kit irrigation were relatively well funded hence better organised than the government extension staff. For instance, it was apparent that the staff knew where the farmers were, and appeared to have the skills and commitment. They made sure adopters received the necessary induction courses. The farmers too knew where to find the NGOs staff in case of a problem. The main problem noticeable in their area of operation was the lack of kits/spares, resulting from unavailability in the country. Although this approach appeared promising, it was not clear whether the question of marketing had been looked into in detail.

8.4.1.5 *Role of change agents*

It has been noted that LCLH drip irrigation was being adopted by people in upland areas with little or no previous irrigation experience. Such radical innovation requires an effective extension and support service for it to be successful. In countries where low-cost drip irrigation was successful such as India, the extension staff actively promoted the new technology (Fig 3.3). Almost the opposite was true for Kenya: the extension was not actively involved in the promotion of the technology. Some government extension staff reported only seeing the drip kit during agricultural shows or during some seminar. In fact the main issue of the extension staff in the study areas was that the National Agricultural Laboratory (NARL) was by-passing them in many cases, going straight to farmers, and making them sometimes less knowledgeable about the kit than some of the farmers who had adopted it. Most extension staff had problems knowing and locating the LCLH drip irrigation farmers were under their areas of jurisdiction. This was despite the fact they were officially employed to promote such services and were required to solve problems farmers experienced with the LCLH drip irrigation kit. NARL is mainly a research institution but explained that that the funds given for the LCLH drip irrigation project were insufficient to involve fully the extension department.

However, experience shows that sometimes organisations are not keen in involving many other disciplines in their projects because some staff are more interested in looking for what they can get from the project than anything else. This view was supported by an NGO who stated, for this reason, that they themselves preferred keeping the project work within their organisation as far as possible.

The main limitation of the approach adopted by NARL for promotion of the LCLH drip irrigation in Kenya was the limited staff available. As a research office, it did not have sufficient staff to cover the whole country. This perhaps explains partly why there was low knowledge of the drip kit in the study areas, and even where the awareness knowledge was high, the operational knowledge was low.

Some NGOs promoted the LCLH drip kit at the national level. These included those creating awareness by organising workshops seminars such as Winrock International, those involved in the promotion of marketing such as FPEAK, and those institutions involved in the supply of parts (Chapin Living Water Foundation) and accessories (ApproTEC). This strategy appears to be concentrate efforts from different organisations at the national level but with less at the grass root level. This was likely to have little effect on the promotion at the ground level.

This section has shown that three bodies were involved in the introduction of the LCLH drip irrigation Kenya. These were NARL at the forefront, followed by NGOs and the government extension staff to a very limited degree. Individual farmer innovators played a key role in initial introduction on significant scale. The role of the local irrigation industry was insignificant.

8.4.2 Irrigation systems adopted

The LCLH drip irrigation kits and sprinkler irrigation were the main methods under adoption in the study areas. The majority of non LCLH drip irrigation farmers thought that their irrigation methods were profitable and less laborious. It was found that persuasion from the change agents, water saving and peer pressure were the main reasons why smallholder farmers adopted LCLH drip irrigation. However, during the discussions it was evident that the real reason why farmers adopted sprinkler irrigation was because it was easily available and had been used for a long time. For this reason, farmers were more familiar with sprinkler than drip irrigation.

It was found in this section that SSI farmers were adopting LCLH drip, sprinkler, and motorised hose irrigation in that order. This was partly because of past experience (tradition), availability of irrigation equipment and the low promotion efforts for the LCLH drip irrigation methods.

8.4.3 Small-scale farmers in Kenya for whom continued adoption of LCLH drip irrigation is applicable

Linked to the appropriateness (Section 8.4.4), the following main factors, which have been discussed previously, were found to influence the adoption of LCLH drip irrigation: -

8.4.3.1 Need for water saving

Farmers who had the need to save water in order to conserve it, save on energy or on labour were likely to continue with LCLH drip irrigation.

8.4.3.2 Availability of irrigation water

It was found that the distance to source of irrigation, the volume at given time or over seasons, methods of conveyance were important factors in determining the reliability of water. Where water is shared, the effectiveness of WUO in maintaining and distributing water efficiently is also an important factor affecting water reliability.

8.4.3.3 Availability of technical support services

Technical support services are important for the success of the implementation stage in the innovation-decision process. It was stated (Chapter 2) that their services at this stage are important in providing information on the availability, sources of the technology and checking possible problems in order to provide possible solutions. However, it appeared that few farmers received visits from the change agents during and after the implementation stage. Consequently, there were maintenance problems that caused some farmers to discontinue.

8.4.3.4 Size of the drip kit

It was found that farmers who adopt larger units are likely to continue with the adoption.

8.4.3.5 The need for security of the kit

Some farmers discontinued LCLH drip irrigation due to security problems to their LCLH drip kits. Where security may be a problem, farmers should take care to protect themselves from theft or damage by animals.

8.4.3.6 Availability of reliable market

It was found that a reliable market was crucial for the success of LCLH drip irrigation. This could be assisted by providing information and where there is significant number of farmers in areas, group organisation for market could play a important role in creating market for irrigated produce

8.4.3.7 Cultural background-food source

Farmers who depended on donations used the LCLH drip irrigation as an invaluable primary source of food production and that is why they were less likely to stop using the kit. They are likely to be farmers mainly from the poor parts semi-arid areas, who do not depend on livestock as part of their culture. Farmers who depend on livestock and do not practice arable farming are unlikely to adopt the "arduous" LCLH drip irrigation.

This section indicated that an appropriate LCLH drip irrigation for SSI should only be applied by policy makers and implementers where most or all of the following factors apply: -

- Where water resources are developed or available naturally that are reliable in terms of distances to fetch, volume at given time and reliability over time;

- Where farmers have relevant agricultural experience in terms of culture-tradition and farming practise - for good crop husbandry and endurance of the work involved;
- Where there is an effective government policy and extension services;
- Where there is effective technical support service;
- Where farmers have genuine long term needs to save irrigation water for conservation to last longer or irrigate larger areas, to save labour for fetching water, or to save energy used for pumping.;
- Where there is already a reliable market for the produce ; and
- Where farmers have strong disadvantages of using other irrigation methods.

These factors are not in any order of importance because lack of any one of them could cripple the innovation-decision process.

8.4.4 Appropriateness of the LCLH drip irrigation

The appropriateness of LCLH drip irrigation is assessed from the criteria developed in chapter 3 and farmers responses mostly in terms of "Rural People's Knowledge" i.e. farmers knowledge. The various factors examined are presented in Table 8.2, which include:

8.4.4.1 Profitability of the LCLH drip kit

Variable cost gross margin had been reported in chapter 4 from secondary sources that indicated that the large drip kit were profitable. Actual data collected from this study was used to compute the profitability of passion fruits from a farmer in Uasin Gishu. This suggested that the larger kits are profitable, consistent with DFID (2003) findings. However the small low-cost drip kit was reported as not viable, hence not appropriate.

Farmers reported water saving of up to 50% relative to sprinkler irrigation.

Table 8.2 Characteristics associated with appropriateness of LCLII drip irrigation

Characteristic	Association*	Remarks
Affordability	± Ve	Reported but expensive per unit area
Easy of operation and maintenance	- Ve	Reported by farmers, biggest disadvantage
Reliability	- Ve	Reported, appeared high risk technology
Performance/efficiency	+ Ve	Reported, good results in water application
Durability	- Ve	Reported, driplines deteriorate fast under U/V radiation
Local manufacture and use of local material	- Ve	Kits imported from USA
Low energy use requirement	±Ve	Farmers reported energy saving on water savings, drip kit designed to use manual labour, however larger units may require high energy
Compatibility with		
– Farming practises and food consumption	±	Reported, depended on different cultures, not suitable for tenancy farmers and those invested heavily in other methods
– Preferences	±	Reported, depended on different cultures
– Physical attributes	± Ve	Observed, portable, expandable, suited to farmers irregularly shaped small plots, portability posed risk of theft, not compatible with some existing plot sizes, bucket kit unsuitable for non drip irrigated plots.
Image of modernity with		
– Bucket kit	- Ve	Observed
– Drum kit	+ Ve	Observed
– Larger units	+ Ve	Observed
System independence	- Ve	Observed, although depend less on fuel or electrical energy, it needs allot of infrastructure

* +Ve denotes positive association; -ve denotes negative association; and ± denotes both negative and positive association depending on locality

8.4.4.2 *Operation and maintenance*

The problems of operation and maintenance of the LCLH drip kit have been described in detail in the past chapters. As this was the main problem of LCLH drip irrigation, it presented serious implications for the appropriateness and hence the innovation-decision process of the drip kit. It is proposed that change agents should concentrate their work in solving these problems instead of continuing to promote it. They could for example train local technicians, increase the number of distribution centres and try the IDE market approach as described in chapter 3 to create a reliable supply chain.

8.4.4.3 *Reliability of the system*

Because of the maintenance problems associated with LCLH drip irrigation, its reputation for reliability was low among the farmers. During the informal conversations of the survey, some farmers who had discontinued thought it was too risky to go back to it. This suggests the technology had not lived up to their expectations.

8.4.4.4 *Efficiency performance*

There were no problems reported related to efficiency of water application of the LCLH drip kit. Tests confirmed that LCLH drip irrigation met the required standards for the water distribution (Ngigi et al 2000).

8.4.4.5 *Durability*

The LCLH drip appeared not durable, and hence inappropriate. Most systems seemed to last up to about three years instead of seven years as stated by promoters. Apart from the maintenance problems discussed earlier, the plastic drip lines became brittle under the intense U/V radiation of tropical weather. It was reported that during prolonged droughts rodents gnawed the driplines looking for water.

Change agents may try to solve these problems by perhaps trying the IDE kits that are said to last longer than the Chapin ones distributed in Kenya. Local research could do more to investigate materials that are suitable the local conditions.

8.4.4.6 Lack of local manufacture

The lack of use of local manufacture and raw material makes the LCLH drip kit inappropriate. It may perhaps partly explain why there is shortage of kits and the cost is relatively higher than that promoted by IDE. Kenya has a good plastic industry, which is a prerequisite for the manufacture of low-cost drip equipment. Beside, the manufacturers of high head conventional drip irrigation did not report any major problems related to manufacturing in Kenya.

8.4.4.7 Low energy use

The use of low energy by LCLH drip irrigation kit is a major positive role in its appropriateness hence its promotion for adoption. Although farmers reported this benefit, the relatively larger units kits appearing to have more potential than the small ones may require the use of pumps and fuel more than manual labour. Therefore, this advantage is likely to disappear when large units are employed.

8.4.4.8 Compatibility

In general, the LCLH drip kit was compatible with farming practises. However, this depends on the culture of the people using it. For instance, for the semi-nomadic people, who are not used to arable farming, the technology appeared less appropriate because it was not compatible with their culture of keeping livestock. They did not depend very much on food from crops but on livestock, hence their preferences for arable farming was likely to be low.

The design of LCLH drip incorporated physical compatibility of the system with farming practises of many of the small-scale farmers. It was portable, expandable, and suited to some small plots. However, the small bucket drip kit appeared unsuitable for some size of irrigated plots of non drip irrigation farmers. Its portability was both its strength for appropriateness and weakness. This is because it was easy to steal. The size of the small drip kit did not relate to existing irrigated sizes by other irrigation methods.

8.4.4.9 Image of modernity

During informal discussions, a few farmers who had not adopted the LCLH drip expressed the view that the bucket kit was too informal (Jua Kali) compared to the irrigation they practised by pumps. The small bucket kit did not seem to have an image of modernity. The large LCMH drip irrigation units displayed a different picture especially when one looks at an acre or so of irrigated green horticultural crops while the surrounding is dry.

8.4.4.10 System independence

In general, irrigation practice depends largely on other external, facilities to operate, and LCLH drip is not an exceptional. For example, it requires a water supply, reliable markets, roads and other infrastructure. Its appropriateness on this factor may be low.

The evidence from this section indicates that LCLH drip irrigation kit is apparently less appropriate in its characteristics to many farmers and may be misplaced under some operational conditions. This may influence the innovation-decision process.

8.4.5 Sustainability of the LCLH drip irrigation

Before leaving the subject of appropriateness and which farmers are likely to continue with LCLH drip irrigation (Section 8.4.3), it is necessary to consider whether this technology is sustainable from the results of this study. Table 8.3 suggests that the small LCLH drip kits may not be sustainable.

The small unit drip kit did not appear to be a sustainable technology because its potential benefits for farmers appeared to be low. The technology did not demonstrate that it could meet farmers needs. However, in some cases the smaller LCLH **bucket kits** were used under conditions not meant for their use, misplacing the technology. The LCLH bucket kit was designed generally for subsistence farming. Nevertheless, introducing it to farmers who are likely to be commercially oriented, most of who were in humid and sub-humid area (Table 4.2) was likely to make it misplaced technology.

The larger units appeared potentially socially supportive to smallholder farmers because they appeared to be commercially viable. In addition, they could provide food and cash for domestic expenditure providing opportunities to improve social welfare.

It was found that the LCLH drip irrigation enhanced environmental conservation since it conserved energy, soil and irrigation water. Besides, it was safer in control of some diseases. Therefore it conserves the integrity of the natural ecosystem; hence, it is potentially a sustainable agricultural technology.

Table 8. 3 Sustainability of LCLH drip irrigation

Attribute	Relationship*	Remarks
Economical viability	±	Small LCLH drip kits appear to have low potential to satisfy farmers needs. Larger units appear to be economically viable
Social responsibility	+	Farmers reported that it provided food security and domestic expenditure
Environmental conservation	+	Farmers reported that it conserved water and energy, as well as soil erosion. It was also safer in the control of crop pest and diseases.

* +Ve denotes positive association; -ve denotes negative association; and ± denotes both negative and positive association depending on locality

8.5 Review of the Rogers (1995) model with respect to the study

A review of the Rogers innovation decision model with respect to this study (Fig 8.1) was presented at the beginning of this Chapter. The modified Rogers model (Fig 8.4) was presented on page 194.

It was found that external factors, mainly political and institutional, acting during the implementation stage (Fig 8.1), were influencing the innovation-decision process of LCLH drip kit irrigation in Kenya. In fact, these factors are likely to influence many of the stages as in the case of India. Such factors included water development, manufacturing and supply, government policies and research, security and crop husbandry. This may be true of many African countries because of low development. These factors are not emphasised in the Rogers model. Those he emphasised such as characteristics of technology and adopters were found to have a limited role. This indicates that the responsibility for the success of adoption of LCLH drip irrigation was not mostly driven by the individual characteristics as proposed by the Rogers model but by the adoption environment. For example focusing on individual characteristics did not explain why some farmers discontinued the use of the small kits in the Kenyan context. Moreover, the role of institutional factors such as the irrigation industry, research, and financial institutions appeared more important in promoting the successful adoption of LCMH drip in Indian context than the Rogers model indicates.

It is therefore suggested that the Rogers model can be modified to capture the local context of technology adoption. Hence, the modified Rogers model (Fig 8.4) may be more useful in understanding smallholder farmers' participation in the adoption of LCLH drip irrigation in LDC such as Kenya.

Despite this, the Rogers model can provide useful information in explaining how and why farmers may adopt a new agricultural development technology. The model can also provide information on communication channels and the role of change agents, as illustrated in this study. However, the importance of the various factors in the model appear to be defined by the adoption environment. For instance, the availability of developed infrastructure as discussed early in this section were found to be critical in the adoption of LCLH drip irrigation by smallholder African farmers. In contrast, such factors are unlikely to be noted as important in the context of developed countries because they are likely to be already in place. Indeed these was the main cause of contrast between the relatively more developed India and the less developed Kenya.

There was limited evidence found of the orderly and linear progression of the process suggested by the Rogers model. Rather, all of the different stages of the process were present. This is likely to complicate the communication channels and messages to be used since the Roger model proposes that different channels and messages are used at each stage.

It was found that many of the factors influencing adoption of a new technology are related to those affecting appropriateness and to a lesser extent to sustainability of an agricultural technology. However, the true meaning of such factors depend on and can only be interpreted by the people who are affected (the adopters) under the individual context.

8.6 Chapter 8 Summary

This chapter illustrated the use of the innovation-decision process to understand farmer adoption of LCLH drip irrigation in Kenya.

The Rogers (1995) model that employs mainly characteristics of the adopters and technology proved inadequate. It was found that external factors during the implementation and confirmation stages were major determinant factors. These were incorporated into a modified Rogers innovation-decision process model (Fig 8.4).

Although the drip kit appeared to have theoretically good design factors for appropriate technology, in practice some of them were unlikely to improve its adoption rate. The problems reported by farmers (linked to size, maintenance, lack of technical support and other factors identified in this section) indicates that the LCLII drip irrigation kit was not appropriate in its characteristics for some farmers. Furthermore, it appeared misplaced under some conditions, which was likely to hamper the innovation-decision process. The promotion of these kits should be discouraged where it is inappropriate. The use of the larger systems which appear potentially more appropriate may be promoted where conditions allow - water supply, markets, technical support services, and security.

CHAPTER 9
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

9.1 Chapter introduction

This chapter summarises the research work and gives the conclusions and recommendations arising from its findings. Brief outlines of the background, aims, methodology and results have been included in order to link the conclusion to the approach of the study.

9.2 Review of background and methodology

Future water demand is likely to increase with development, creating stress on water resource in many Sub-Sahara African countries. It is therefore necessary to plan and use water resources efficiently especially in agriculture, which utilises relatively huge volumes of water in production. This could be achieved by potentially water efficient irrigation methods such as LCLH drip irrigation.

This research examined the prospects of smallholder drip irrigation in Kenya. It aimed to identify the factors affecting the rate of adoption of LCLH drip irrigation in the context of Rogers (1995) innovation-decision process.

Following a literature review on the approaches of low-cost drip irrigation in India and Africa, the primary information was obtained by informal interviews. The key informants in the first phase were irrigation farmers, government officials, irrigation industry and Non-governmental organisations. The aim of phase 1 was to identify factors affecting adoption. Phase 2 investigated which of these factors were associated with the continued use of the LCLH drip kit. The key informants in phase 2 were LCLH drip irrigation farmers who were still using it (continued adopters) and those who had discontinued.

The survey method adopted in this study appeared more suitable in getting the large variations of responses which were received from the informants, than if a few case studies had been used.

9.3 Some limitations of the survey

One of the limitations of this research was the selection process of research areas and participants. The fact that the areas and participants were non-randomly selected was likely to have created bias rendering the application of statistical analytical methods to improve on generalisation of the findings less applicable (Gregory 1978). Nevertheless, efforts were made to ensure validity and reliability (Chapter 5 and appendix 5.1) of the findings so that the results obtained reflects the general picture of the conditions on the ground.

9.4 Summary of main findings

The literature review showed that LCMH was successful in India promoted by government and industry efforts as well as availability of infrastructure. Compelling factors promoting adoption included problems caused by prolonged use of non drip irrigation methods, such as salinity, flooding, and ground water depletion. This was reinforced by government irrigation water regulation and charging. The farmers were well experienced and had reliable markets for their produce. However, LCLH drip irrigation appeared less successful in India due to lack of sustainable commercial markets.

This study found that LCLH in Kenya was the dominant low-cost irrigation method used by farmers. The different types of low cost drip irrigation used in India and Kenya suggested that lessons from India cannot be simply transferred to the Kenyan conditions.

The level of awareness of LCLH drip amongst small irrigation Kenyan farmers was low except for those using it. This caused wrong perception of LCLH drip kits.

Most farmers adopted LCLH drip irrigation because they believed it saved water, and hence saved on costs of labour or pumping water. The adopters were generally the economically better off in the society. For this reason, credit facilities may be required for the very poor where it is appropriate, if the objective is to assist them.

The non LCLH drip irrigation farmers, most of who were commercial, thought it was not a suitable technology for them because it was incompatible with their irrigated areas or had security problems. Others thought they had already invested too much in their irrigation methods to change.

The survey showed that the quantity of change agents as well as communication channels was limited. The innovation-decision process could be enhanced by increasing the number of change agents and use of mass media, and demonstrations at the farm level. During the knowledge stage, mass media and publications are important in creating awareness, but face-to-face methods and demonstrations are important for persuasion and the later stages. Frequent farmer visits by change agents are important during the implementation and confirmation stages to boost technical support. However, LCLH drip irrigation farmers expressed surprise that there had not been effective follow-up visits since they decided to use the LCLH drip irrigation.

There were a quite a number of farmers whose implementation of LCLH in the innovation-decision process was hampered by external factors such as unreliable water supply, unreliable markets, technical support problems, irrelevant previous experience and security problems. These factors reflecting the low state of development of the sub-Saharan African region, were some of the reasons inhibiting the adoption of LCLH drip irrigation and may explain why the LCLH drip irrigation is not significant in Kenya. Furthermore, effective institutional support from government, NGOs, and irrigation industry appeared to be lacking. These results are consistent with DFID (2003) findings but contrasts with the general claim by IDE, which suggest that LCLH drip irrigation is suitable for all small-scale farmers.

9.5 Application of Rogers (1995) model

The Rogers (1995) model did not provide a complete understanding of the adoption process of LCLH drip in Kenya unless modified to capture the local conditions. This emphasises that the factors influencing the model of innovation-decision process of low-cost drip irrigation were specific to the context of the environment of adoption. The important factors were found to be the provision of infrastructure, policy, extension services, and spares and maintenance. The modified innovation-decision process was formulated to emphasise these factors. The influence of these factors on the innovation-decision process does not appear to be emphasised by the Rogers (1995) model. This suggests that the model is inadequate to understanding the farmers' adoption of LCLH drip irrigation in areas that are less developed such as Kenya. This contrasts with the relatively more developed Indian case, which may explain why LCMH drip irrigation was relatively adopted fast in India. The deficiency in the Rogers (1995) model may be explained partly from the fact that the Rogers model originated from the developed world where such problems are less significant.

However, the Rogers model did provide a useful framework for understanding the smallholder farmer behaviour in adopting the low-cost drip irrigation. Some of the aspects that worked included adopter and technology characteristics in influencing the adoption process. Many of these characteristics are defined differently by adopters according to their needs and requirement and not necessarily according to the Rogers model. They are also categorised differently to the adoption of technology depending on the context of the adoption. For example, many of the appropriate criteria for a technology are also the technology perception factors of the Rogers innovation decision process during the persuasion stage.

Researchers using the innovation-decision process in Kenya should be aware of the political and institutional factors that appear specific to the adoption environment as indicated in fig 8.1. These factors are incorporated in the modified Rogers model for less development countries in Fig 8.4.

9.6 Findings on specific research questions

- ***Question**: What are the existing methods by which LCLH drip irrigation is made available to farmers?*

  The study revealed that three bodies were involved in the introduction of the LCLH drip irrigation Kenya, similar to other African countries. These were NARL at the forefront, followed by NGOs and the government extension staff to a very limited degree. Individual farmer innovators played a key role in initial introduction on significant scale. The role of the local irrigation industry was insignificant. In India, local NGOs were the principle agents of LCLH drip irrigation. However, the irrigation industry was active in the promotion of LCMH drip irrigation.

- ***Question**: What irrigation systems are being adopted by farmers and why?*

  It was found that SSI farmers were adopting LCLH drip, sprinkler, and motorised hose irrigation in that order. However, LCLH drip irrigation was not necessarily the most popular because the study purposively targeted areas with high concentration of the LCLH drip irrigation system. The reasons why farmers chose different irrigation methods were; past experience (tradition), availability of irrigation equipment and the low promotion efforts for the LCLH drip irrigation methods.

- ***Question***: *For which small-scale farmer in Kenya is continued adoption of LCLH drip irrigation applicable and why?*

The survey results suggest that an appropriate LCLH drip irrigation for SSI should only be applied by policy makers and implementers where most or all of the following factors apply: -

- Where water resources are developed or available naturally that are reliable in terms of distances to fetch, volume at given time and over seasons;
- Where farmers have relevant agricultural experience in terms of culture-tradition and farming practise - for good crop husbandry and endurance of the work involved;
- Where there is an effective government policy and extension services;
- Where there is effective technical support service;
- Where farmers have genuine long term needs to save irrigation water for conservation to last longer or irrigate larger areas, to save labour for fetching water, or to save energy used for pumping;
- Where there is already a reliable market for the produce ; and
- Where farmers have strong disadvantages of using other irrigation methods.

These factors are not in any order of importance because lack of any one of them could cripple the innovation-decision process.

- ***Question***: *Is the LCLH drip irrigation available to the Kenyan small-scale farmer appropriate to his needs?*

The LCLH drip irrigation in Kenya appeared inappropriate in many of its characteristics e.g. the size of small LCLH bucket kits. This suggests that it is unsuitable for many conditions under which it was introduced and may be a misplaced technology for some situations.

9.7 Conclusions

The following conclusions may be made from the results of this study suggesting possible explanation why the rate of adoption of low-cost drip irrigation is relatively low in Kenya compared to India:

Different types of low-cost drip irrigation are used in India and Kenya. Whereas the LCMH was predominantly used in India, the LCLH drip irrigation was introduced in Kenya. The LCLH drip irrigation seemed inappropriate and misplaced in some cases. The smaller unit did not appear to meet the needs of some farmers.

Political and institutional factors were found to be critical in impairing the innovation-decision process of LCLH drip irrigation in Kenya. Such factors included poor supply of spares and maintenance of the drip kit. Infrastructure such as markets and rural water supply were often not reliable. In some cases, the distance to irrigation water sources discouraged LCLH drip irrigation. The governments' role in extension and research appeared limited. However, these factors seemed to promote the adoption of LCMH drip irrigation in India.

Compelling factors due to problems caused by prolonged use of non drip irrigation, such as salinity, flooding, and ground water depletion were not found in Kenya. Furthermore, the charging or regulation of irrigation water was limited.

The promotion of LCLH was limited in numbers of change agents and communication methods used. There were security problems but these were less important.

From these conclusions, some recommendations have been made for improving the adoption of low-cost drip irrigation where appropriate below.

9.8 Recommendations for promotion of LCLH drip irrigation where appropriate in Kenya

This section gives recommendations for promotion LCLH drip irrigation where appropriate with respect to the innovation-decision process to policy makers, planners and promoters of the irrigation. It was found that for many farmers LCLH drip irrigation might not be appropriate, hence its promotion may be discouraged. However, having identified the conditions for which continued adoption of LCLH drip irrigation is applicable (Section 9.6) and its appropriateness (Table 8.2), recommendations on the prospects of LCLH drip irrigation for some farmers under such conditions may be made: -

- **Regarding role of change agents**

  The study showed that NARL was the main change agent but apparently, NARL did not have enough resources in terms of personnel to cover the country adequately. The promotion process of LCLH drip irrigation could be improved by involving more change agents. This should make change agents accessible and available overcoming on the major problem reported. The government extension staff could be fully utilised and given incentives. The government staff appeared to be very effective in their work when dealing with NGOs programmes. This was possibly because of the incentives they received from the NGOs. More local NGOs should be encouraged to be involved. NARL however, should concentrate more on its research work on LCLH drip irrigation

- **Regarding awareness of LCLH drip irrigation**

  With respect to making small-scale farmers aware of the drip kit, it was found that there was limited mass media communication and demonstrations at the farmer level. The results suggest that improvement in information dissemination for higher adoption and better management of LCLH drip irrigation could be made by using mass media in the form of radio, television, village workshops (Barazas), as well as posters at the village level in a designated promotion zone.

- **Regarding adopters of LCLH drip irrigation**

  With respect to type of adopters' characteristic, the survey results show that it was mostly the economically better of farmers in the society who were likely to acquire the drip kit. The drip irrigation does not appear to appropriate to the very poor because they cannot afford it. However, if the objective is just to assist the very poor (e.g. for NGOs), then mechanisms should be put in place to assist the very poor if this makes it appropriate. This could be in the form of credit but to ease possible hardship on repayments, the possibility of phasing out repayments should be considered. This may reduce problems associated with high default rates on credit reported during the study (Gakundi 1997).

- **Regarding experience of farmers**

  With respect to the low experience and education of the smallholder farmers, the survey results suggest that a training component should be built into the promotion programme at a local level. The induction courses should cover agronomy, communal water management, and marketing. These were found to be major constraints in the innovation-decision process.

- **Regarding the size of LCLII drip irrigation kit**

  The study suggests that the small kits may not be viable for the farmer, since the do not seem to meet his needs. Therefore, it may be helpful to encourage farmers to consider adopting or adapting the existing ones to larger units capable of irrigating at least an acre, which seem to have to be viable. At the same time, the promotion of the smaller units should be discouraged.

- **Regarding technical support LCLII drip irrigation**

  With respect to technical support services, the survey revealed that there was need to make available both the spares and technicians at the farmer level. This could be done by increasing the number of promotion agents at local level as well as increasing the number of distribution centres at district level in designated promotion areas, by decentralising the national distribution centre at Nairobi. Local technicians could be trained to maintain the LCLII drip kits and local manufacture encouraged to increase the availability of spares. In addition, the IDE market approach as described in chapter 3, in which local suppliers are encouraged to support the system by being allowed to supply services and spares at a reasonable profit, could be tried.

- **Regarding marketing of farm produce of LCLII drip irrigation**

  The survey found that successful LCLII drip irrigation farmers were likely to face market problems. A potential market is essential before introducing LCLII drip irrigation. Even farmers who started with subsistence LCLII drip irrigation expressed the hope to eventually change to go into commercial irrigation in the long term. It is recommended that marketing should form part of the overall promotion services and should be carefully evaluated during planning of LCLII drip irrigation future projects. Farmers should be encouraged to form co-operative or marketing groups for planning, negotiations and contracting for the produce. They should ensure that their officials or other parties do not exploit their group as happens sometimes in Kenya. Similar organisations can be formed using existing groups where possible for shared infrastructure such as Water Users Associations (WUA).

- **Regarding water reliability for LCLH drip irrigation**

  With respect to water reliability, unreliable water was one of the main problems for farmers who discontinued LCLH drip irrigation. It is recommended that during the introduction of LCLH drip kits, water reliability should be considered not just at a given time but over the different seasons including prolonged droughts. This consideration should also include the distances to fetch water over seasons, as water sources become fewer and farther, as well as the means used to fetch the irrigation water. Where distances become excessive it may be too laborious or expensive to fetch water and farmers may neglect the drip irrigation regardless of other relative advantages they may get.

- **Regarding local manufacture of LCLH drip irrigation**

  With respect to manufacturing of drip kits, the study revealed that part of the reason why kits were not available was because they had to be imported. Therefore, broken parts could not found locally. It is recommended that local manufacture may not only avail the kits and components but also reduce the cost, which was higher than that the IDE drip kits. This is possible because Kenya has a good plastic industry required for the manufacture of the drip kit.

- **Regarding security of LCLH drip irrigation**

  With respect to the need for security of the drip kit, farmers may be advised to keep their kits near their homesteads and /or fence off the irrigated plots. However, poorer farmers who have no access to local fencing material may need assistance for fencing.

- **Regarding Government policy and strategy of LCLH drip irrigation**

  This study found that the large kits meet farmers needs and had advantages over other irrigation methods such as water saving, cost and energy. Farmers also reported other advantages of LCLH over other irrigation methods. For example, the drip kit was also safer in terms of disease, pests control and soil erosion. This suggests that the LCLII drip kit has potential in agricultural development in Kenya. However, the study found that there were some constraints to its adoption in the innovation-decision process. Therefore, LCLII drip kit is likely to succeed where these constraints are minimal. Consequently, appropriate LCLII drip irrigation is more likely to be successful if introduced under the following enabling conditions in Kenya:

- There should be need for water saving- whether for labour, energy or conservation
- There should be reliable water. Consideration should be given to water reliability over the seasons, the distances to water sources, and the effectiveness of water use organisation for community water supply
- There should be a potential reliable market. Consideration should be given to local consumption, markets, and urban markets as well as foreign markets. Market organisation was an important factor especially where a conglomerate of small holder farmers practises irrigation.
- There should be reliable or potential technical service. Consideration should be made how the supply and maintenance network can be established and whether this is viable.
- There should be reliable extension service and policy for LCLII drip irrigation. Consideration should be made of availability of sufficient change agents, the information flow to the change agents and subsequently to the farmers. The extension staff should be adequate and offer relevant information for the farmers. Incentives may have to be introduced for extension staff to be more effective
- In some areas security may be required against theft or from animals
- The very poorer farmers may need support in terms of credit if this makes it more appropriate
- The promotion of the small LCLII drip kits should be discouraged

- **Regarding the use of the Rogers model**

  It was found that the Rogers model provided useful information on some aspects of the adoption process. However, the importance of the factors influencing the innovation- decision process of low-cost drip irrigation appeared specific to the local context (of the environment of adoption). For less developed countries like Kenya the institutional and political factors were found to be the important factors. Therefore, the users of the Rogers model should consider this; a modified model was proposed.

9.9 Closing Remarks

This research has achieved what it set out to do. It has used the Rogers (1995) model and identified the important factors explaining why the rate of adoption of LCLH drip irrigation and low-cost drip irrigation in general is low in Kenya. In doing so, it has identified the weakness of the Rogers model, and modified it accordingly to suit the local conditions by proposing a modified model to suit less developed countries.

The introduction of low-cost drip irrigation has many problems to overcome, some of which will present a huge challenge in many of the ailing African economies such as Kenya, for the foreseeable future. The degree of importance of these factors will vary with individual areas.

In some situations, the technology does not appear to be appropriate, and should not be promoted at all. For other situations, recommendations have been made for helping to overcome the problems identified in this study.

It appears that in the short term efforts are likely to continue to be made to introduce low-cost drip-irrigation to small-scale farms in sub-Saharan African countries such as Kenya. These efforts may succeed where the conditions identified as important in this study are favourable, but in the majority of cases where this does not apply, they are likely to be unsuccessful.

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APPENDICES

Appendix 1.0 Review of features of African small-scale farms

(i) African small-scale farms

The definition for small-scale farms is not precise but may vary according to individuals, region, or country. Carter (1989) defines small-scale irrigation as irrigation on plots up to 1 ha, where farmers have the main controlling influence and are using a level of technology, which they can operate and maintain. The farmers are in charge and responsible for all the farming activity on the farm. The smallholder farm may be of a commercial and/or a subsistence nature. The family provides the majority of labour and obtains their principle source of livelihood from the farm. However, Rukuni (1997) states that the general irrigated plot sizes may be less than 1 ha but often ranges to 3 ha.

Small-scale farming is important in most African countries. In Tanzania, Malawi, Zambia, for example small farmers account for 85% of the farming activity (Kandiah 1997). The type of irrigation practised will depend on water availability and the market. The types of small-scale farms below are first classified according to economic interests and then by the organisational make up of farmers similar to Murata et al (1995).

(ii) Types of small-scale farms

(a) ***Types of SSI according to commercial interest***

- ***Subsistence irrigation farming***

  These small-scale farmers practise irrigation with the main objective being survival. This is often found in semi arid areas where survival may be more important than economics. Nevertheless, it may also be found in sub-humid areas on a seasonal basis especially where the dry season is prolonged. These farmers differ from private commercial farmers because not only do they produce for home consumption but they also have irrigation technology that may range from rudimentary to a more advanced form. The water source for the subsistence irrigation farmer is often not very reliable and they do not have adequate water storage capacity. Hence, crop failure is common especially during a prolonged dry season. Any assistance to this group them must be cautious because they often have immediate real life threatening problems that can easily distract them from the main objective of the aid.

- *Private commercial*

The private commercial farmer practises irrigation primarily for commercial gain. Some may set a small portion of their land aside for this purpose but others may hire a plot near source of irrigation water, where insufficient or unsuitable land for irrigation exists. The main advantage they usually have is full water right in the form of their own well, a river or occasionally from a public water point. They often possess an irrigation technology, which is relatively advanced. Those with contracted sales or under a bookers company have an added advantage.

(b) ***Types of SSI according to organisation***

Having examined small-scale farmers in terms of their economic objective attention is now turned to the classification of these farmers in terms of the way they are organised. The two systems are not exclusive but have some common ground.

- ***Community farm plots.***

In many rural areas, vegetables and other crops are grown on small plots using aspersion (traditional bucket sprinkling) irrigation. Farmers from a given area may have individual plots sharing water from one source. Each one of them may not necessarily own the land and each farmer is responsible for his plot and its production. There is usually no corporate responsibility. Containers are used to collect water from the nearest stream or well. In a well off community, irrigation is practised using manual pumps. The size of the plot, what can be grown and how long it can be grown is limited mainly by available land, water and family labour. The irrigation is mainly seasonal only practised during the dry season. This type of irrigation is suitable near water sources such as valley bottoms and swamps. Valley bottom irrigation is widespread in southern Africa and sometimes referred to as "Dambo" (Raussen et al 1998). The farmers produce mainly for their own subsistence and the local market when the demand is high. Sometimes sub-surface irrigation is practised by simply controlling the water table by controlling the drainage. Although this method is less laborious and larger areas can be cultivated, the total farming area is limited by the water table. Often there is the problem of overdrawing the water, which is not very reliable. Occasionally a crop failure is experienced especially when the dry season is very long.

In Zimbabwe it is estimated that "dambos" comprise 1.3 million ha of land in the country of which 0.26 million ha are in communal areas (Palanisami 1997). They are cultivated with maize, vegetables, cotton, wheat and beans. A few of these farms may have the advantage of farming on contract with companies most of which export their product (Dr. Senzanje University of Zimbabwe personal communication). Each farmer has 1.5 ha of land distributed in three blocks.

– ***Out-growers and contract farmers***

Although having similar characteristics to community farm plots this group is much more commercially oriented existing as long as their commercial interests are met. They manage their farms individually. They are not confined to valley bottoms and often employ more developed irrigation technology. This group includes the agri-industrial booker groups. Individual farmers are contracted by an agri-industry individually to supply farm produce at a specified time e.g. sugar cane, sunflowers, fruit. Alternatively, they can be contracted not by industry but a commercial company mainly for export. Therefore the market is assured and often they get credit for the farm inputs. Examples include horticultural production in central and eastern Kenya as well as some "dambo" valley farms.

– ***Co-operatives small-scale irrigation farming***

In this system, farmers are formally organised with management committees from a much large area. The common purpose is to succeed in their farm produce from the irrigated areas by co-operating mainly in water management, marketing and sometimes for procurement of farm inputs and credit. Each one may use his individual farm or a suitable area for irrigation in the district/regions may be used by all individually. The main objective of farming is commercial usually for external market and local market. The co-operative is perennial and the irrigation methods applied may range from traditional to modern technologies.

- *Collective small farms*

This system is very similar to community farm plots because its operation is much more limited locally. However, a community operates as a group on a farm plot and the produce is shared. There is co-operative responsibility for all the activities on the farm. The group manages the water, allocates land, may obtain credit and purchase inputs. It may also organise the marketing. This may or may not be seasonal. This type of farming is preferred where the capital cost of water supply development is beyond the means of one or a few farmers. Often modern irrigation technologies may be employed. Similar to subsistence farmers discussed above, the water source for community farm plots is occasionally not reliable because they usually do not have adequate water storage capacity. As a consequence, they have occasional crop failure when the dry season is longer than average.

Appendix 1.1 Brief review of aspects of irrigation

(i) Introduction on irrigation

Irrigation may be defined as the application of water to the root zone of a plant to improve its performance. This water can be applied on the ground surface in which the irrigation method is called surface irrigation methods (Fig 1.i). Such method includes furrow, basin, and border irrigation. Traditional methods on small plots using these methods or small-containers to convey and apply water to crops are also included in this category. The water can as well be applied through the air, similar to rainfall. This application is overhead method that is dominated by sprinkler irrigation. Smallholder farmers may use pressurised irrigation water in hose-pipes to apply irrigation water by spraying to the crop. This method may be referred to as hose-pipe spray irrigation. The irrigation water can also be applied to the plant root-zone through the ground through what is known as sub-surface irrigation method. The last method is the application of water in continuos trickle form. This is often referred to as trickle or micro irrigation, which is the subject of this study.

The term micro irrigation may imply either irrigation of little magnitude or the use of irrigation technologies that are tiny in size. It includes various crop water application methods that apply frequent water to localised crop root zone through small drops, tiny streams, sprays or jets. The methods use various devices to achieve this, which are used to classify the types of micro irrigation. They include drip irrigation, bubblers, micro-jets, and micro-sprinklers. Each one is now examined individually based on Hillel (1997).

(ii) Drip irrigation

A drip irrigation system is a method of crop water application where water droplets are supplied frequently and gradually to the root zone through emitters installed at intervals on the drip line tube laid stationary on the farm plot. Alternatively, the water may be applied through a series of holes drilled on a drip line (JIID 1990).

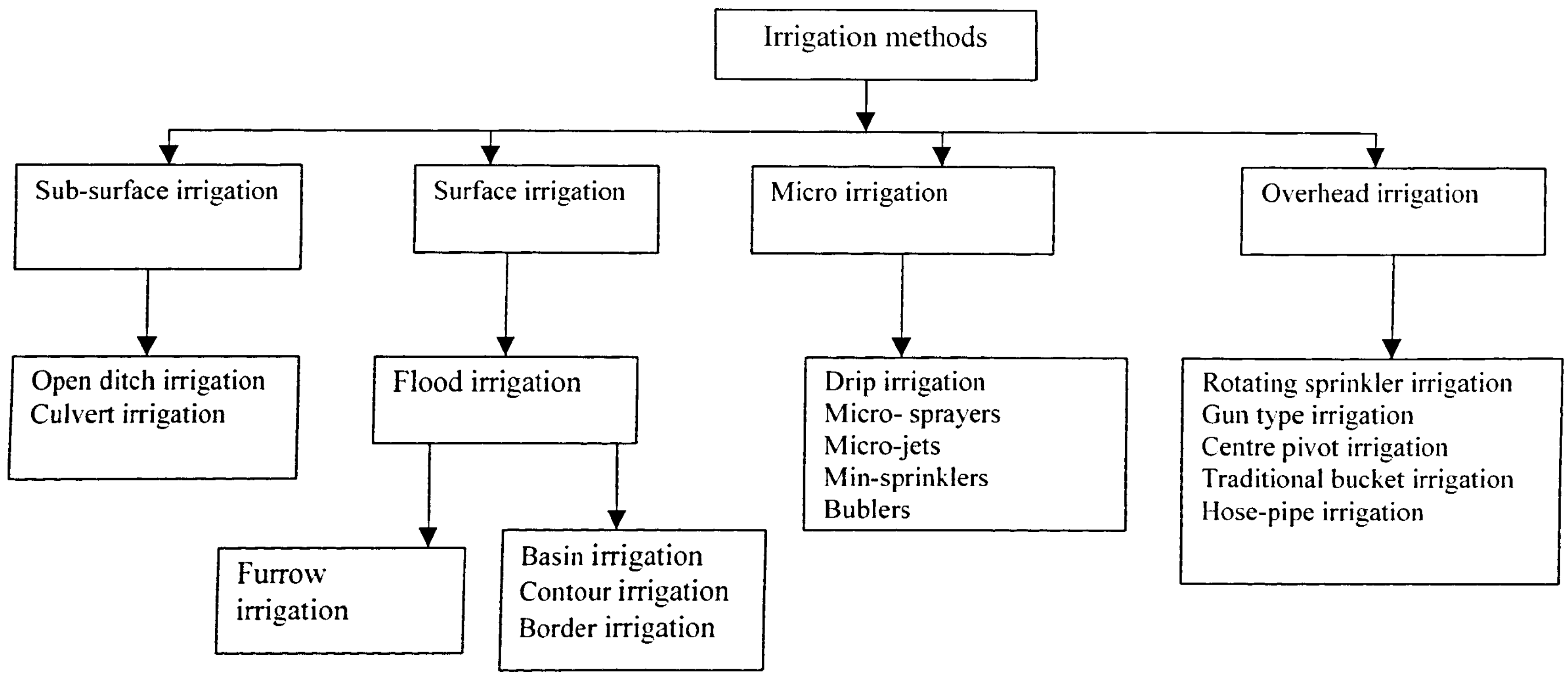


Fig 1.i Typology of irrigation

Hillel (1997) describes a convention (typical) drip irrigation system as having a pump, pressure regulators, a chemical mixer, filters, a meter, a mainline, lateral lines and emitters. The lateral lines are between 10 to 25 mm in diameter. The discharge varies from 1 to 10 litres per hour per emitter, operating on a head of 0.5 bar (4m) to 2.5 bars (18m). The emitters can be spliced into the lateral in which case they are referred to as in-line or they can be plugged on to the lateral tubes as on-line emitters. Commercial emitters are designed to give 2, 4, or 8 litres per hour depending on pressure, irrigating 50% of normal rooting zone.

The system is preferred in sandy soils with low water storage capacity. It is not distorted by wind and not affected by soil texture, topography or surface roughness. Unlike other systems, saline water can be used for the irrigation of some crops such as cotton, tomatoes or dates. Although it needs constant attention for blockages, cracks and rodent attacks, it requires relatively less labour. Compared with other systems, it is less suitable for crops requiring entire wetting of whole crop area.

Getting rid of pumps and the use of simple portable filters and cheap energy sources can simplify the system. Simple non-precision drippers and basic discharge measurement can be employed to reduce the capital costs.

Drip irrigation can apply water either on the ground surface or underground (subsurface) methods.

(iii) Drip surface methods

This method employs water application to the root zone through closed conduits (drip lines) with tiny outlets for water laid on the surface of the irrigation farm. There are two methods of water application depending on the arrangement of the water outlets. These are by point source application using emitters or by line source tubing.

– ***Point source application***

In point source application the emitters are equally spaced a long the laterals. They only irrigate a point area. The emitters of various types may be within the hose (in-line) or attached on the outside (on-line). These are sometimes replaced by holes. Cornish (1998) quotes the common inside diameters of laterals as 12, 32, and 16 mm, with the later being the most frequent. Most emitters work at a head of 10m. These are widely used in vegetables, orchards, flowers, vineyards, landscaping, and nurseries.

– ***Line source tubing***

Unlike point source emitters, line source tubing irrigates a continuos strip of soil. Because they produce a continuos wetted strip they are widely used for row crops such as sugar cane, tomatoes, strawberry and cotton. They normally operate at 3-7m head. There are different types on the market. They are often referred to as drip tubing or drip tape; which is an inexpensive plastic hose with built in orifices spaced along its length.

(iv) Subsurface drip irrigation

In this method the irrigation water is applied underground to the root zone of the crops. For this reason, it is more sophisticated, expensive and limited. It may comprise any of the following: very porous ceramic jars or tubes, emitters, perforations including perforated plastic sleeves, buried at a safe distant from surface operations. Clogging is the main problem although this can be reduced by filtration, addition of acid or herbicides to irrigation water. It is mainly applicable to tree and row crops. This method is relatively undeveloped (Murata et al 1995.)

(v) Bubbler System

There are two types of bubbler micro irrigation systems. The first one is the low head-bubblers. This is essentially a modified drip irrigation system with the water bubbling out of 1cm to 3cm high risers connected to a 10-cm diameter lateral (Hillel 1997). It has the advantages of low capital investment and energy requirements, has limited clogging problems hence no need for filtration. It can easily be constructed from local material. Its discharge is relatively infrequent and high (150-250l/hr) controlled by the height of the risers. The applied water ponds around the crop in small basins. Although it applies best to widely spaced crops, it has had very little promotion efforts from commercial companies because of low commercial prospects.

However, the second type, pressurised bubblers, is more commercialised. This works at relatively high head of 10-12m and needs more energy than the low head bubblers.

(vi) Micro-jets

Jets operate at low pressures and energy. They apply irrigation water in a jet form at relatively higher rates than emitters. They also wet a wider area than tubing or emitters as the water is sprayed through the air either in a fan shaped spray or a number of discreet jets. However, because jets include no moving parts there is a limit to the distance they can throw. They are suitable for under tree irrigation and flowerbeds (Suryawanshi 1995).

(vii) Micro-sprinklers

Micro-sprinklers form the last type of micro-irrigation. Often, they are referred to as micro-sprayers. They have frequent, low discharge (20-250l/hr), to a localised area. They operate at low pressure relative to impact type sprinklers. Unlike most micro irrigation systems, micro-sprinklers require a relatively high head (commonly 10m-30m) to eject water from the 0.25 to 0.35m high revolving nozzles (Cornish 1998). A moving rotor enables them to have a greater radius of throw. The irrigation area can be enlarged from 2 to 10m in diameter. This type of micro-irrigation may not be as efficient as drip irrigation because it is affected by evaporation and wind drift. It has very few blockage problems. The system can be used for vegetable crops, nurseries, flower beds etc (Saksena 1995).

Appendix 2.0 Adopter categories

If the technology is introduced and all the necessary factors are present, not all the individuals will take on the technology at the same time. They may all start at different times and adopt or reject the technology at different times. Others may never start at all. The difference among individuals in their take-up response to a new product is called their innovativeness. This represents the degree to which an individual is relatively early or late in adopting a new product or idea. In social science, potential adopters are generally classified into 5 groups from innovators to laggards based on their innovativeness (Figure 2.3). Although there is some uncertainty (Wind 1982) as to whether there are differences in the traits of individuals used for grouping, the following factors are generally employed:

- Social economic factors - education, income, social status, and age.
- Personality traits – adoption is more likely when the individual is flexible, understanding, deals well with ideas, more intelligent, and a non-risk evader.
- Communication behaviour - if the individual has a wide range of communication from social exposure, mass media, or with promoters.

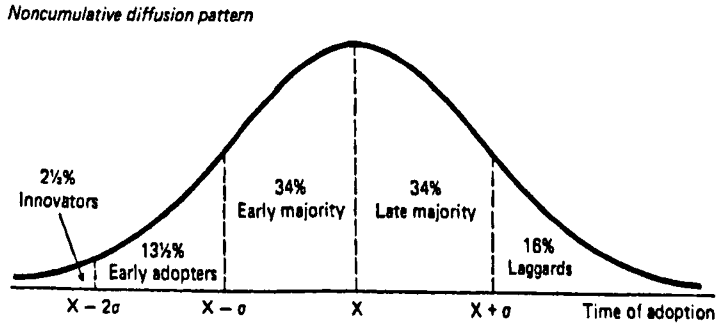


Figure 2.i Adopter categories

Source: Barker (1996)

If the number of adopters is plotted against time the result is a curve which is often close to a normal distribution curve (Fig 2.i) with a mean x. The five groups are defined statistically on the basis of one and two standard deviations from the mean as follows: -

- Innovators the first 2.5 %;

- Early adopters the next 13.5% ;
- Early and Late majority 34 % each ; and
- Laggards, 16%.

Rogers (1995) summarises their main traits as: -

- Innovators – venturesome
- Early adopters - respected

Innovators

The innovators are the first group to adopt a new technology. About 84% of the population will not buy the product until they see innovators and early adopters with it first. Innovators are a very important category in the adoption process because if not identified and targeted by change agents then the whole process may fail. They are essential therefore, in deciding who and where to target a technology as they influence later adopters. Most opinion leaders fall within this group (Smith 1993). A new product that fails to attract them will mostly likely fail in the adoption process because they put the technology on a public show (Doyle 1993). This social display can provide the initial momentum to communicate by rumour mongering. The display could also contribute to emulation by others (Oliver 1990).

Generally, innovators are described as better off, better educated, and tend to be younger with higher social status. This is what was found in this study about the Kenyan case. They usually have money to experiment with (Oliver 1990). They tend to be heavy users of the replacement of the original product and are socially integrated with society. They seek social relationships outside their local peer group (cosmopolitan) and have a broad range of interests.

They are intelligent and eager to try a new idea hence they are risk taking and do not need much persuasion. They have an apparent need for newness, wanting to be the first because they need to be noticed. They have more information sources because they tend to keep close contact with scientific and specialist sources of information. Consequently, they can comprehend the abstract implications of adopting a major technology. The importance of these characteristics in the adoption process may vary according to the technology, cultures and the individual. Because they have some familiarity with the new technology from the experience of what they were using before, their decision process tends to be shorter.

Early adopters

Early adopters tend to be opinion leaders who carefully adopt new ideas (Smith 1993). They are people who choose new technology carefully and are consulted by people from the remaining adopter categories. They may have insisted on trying the product before buying if possible and will want to ascertain its compatibility with lifestyles and practices; its advantage compared to what they already use. They are likely to minimise the risks and the complexity. Foxall (1994) states they tend to keep in contact with promoters, local people and are often leaders. They show high opinion leadership and have high status.

The early adopters are similar to innovators almost in every respect. What differentiates them according to Rogers (1995) and Foxall (1994) is the innovators possession of and showing-off characters that lead to venturesome behaviour. Therefore, it appears that adopters found during the studies were innovators and early adopters because of their traits. The process to move forward to early majority and late adopter may have been hindered by the problems identified in this study during the implementation stage.

Early majority

These may have long decision periods, even though they may have contact with mass media or promoters and early adopters. They are more careful than early adopters, being deliberate in their buying (Smith 1993). They may have dismissed the new idea at first as not for them (Foxall 1999). They adopt the technology just before the average person when the technology will have become common. Being deliberate over adoption decisions, they do not exhibit so much opinion leadership.

Late majority

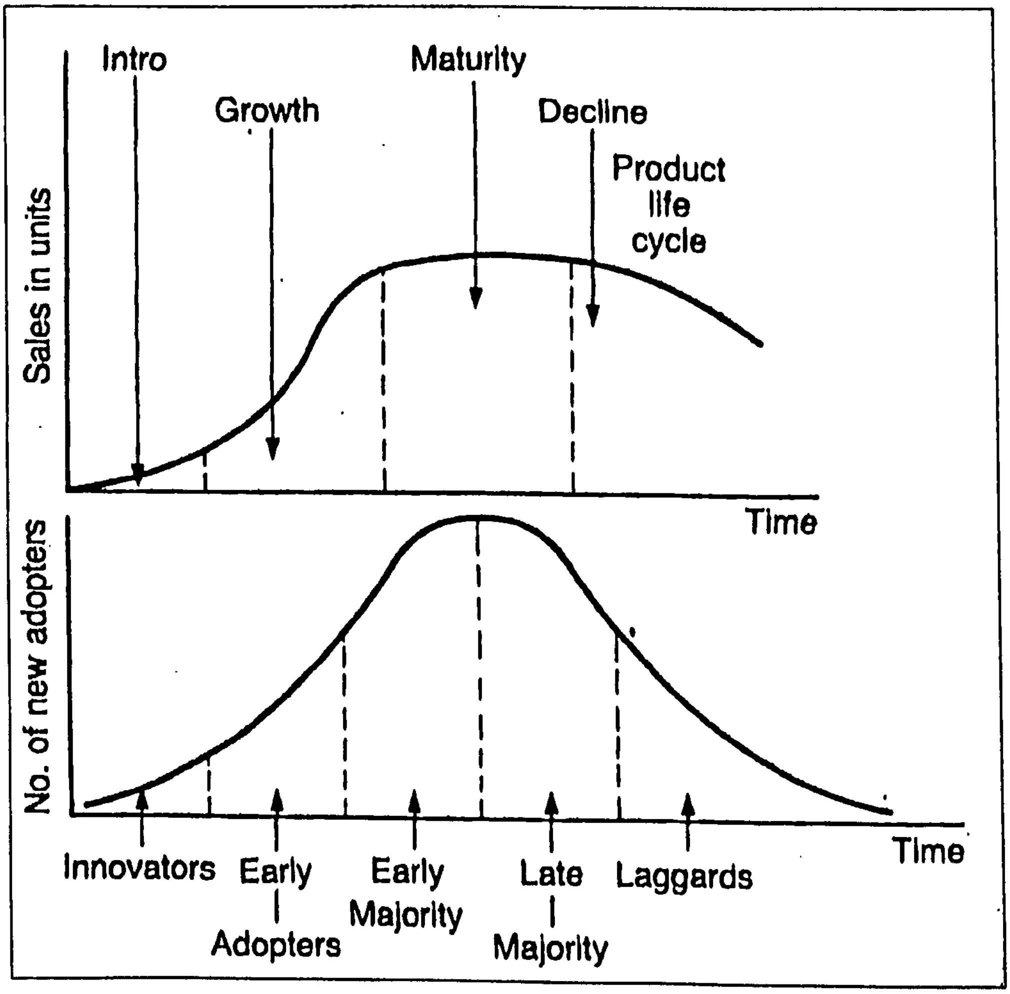
The late majority group tends to be sceptical about a new product and hard to persuade. Nevertheless, they eventually adopt it because of economic necessity or social pressure. In general, they are below average in terms of income, social status, and education. They will only adopt when they see that the risk is minimal (Foxall 1999).

Laggards

The laggards are the last group, to do any thing about the technology. They are generally bound by tradition. They are suspicious of new products and their orientation is towards the past. Instead of using the media, they tend to use other laggards as a source of information (Foxall 1994). Perhaps this is because they tend to be older and from a lower social group. They are generally poorer and hence less capable. They usually adopt when innovators are adopting the next technology.

Appendix 2.1 Technology life cycle and adoption

In the appendix 2.0 the various adopter categories were discussed according to the time, they take to respond to and go through the adoption process. This section explains how a new technology is eventually adopted by these groups in terms of its life cycle (Figure 2.ii). The technology life cycle has four stages - the introductory, the growth, maturity and the decline stages. In its simplest form, it serves as descriptive model of the stages of acceptance of a technology (Wind 1982). The stages of the technology life cycle can be related to the adopter categories as indicted in figure 2.ii The following is a general description of these stages (Wind 1982, Foxall 1999).



Source: Evans 1994 **Fig 2.ii Technology life cycle**

- ***Introductory Stage***

The introductory stage is relatively slow due to lower awareness and distribution networks. It matches the innovator adoption class. Only a small number of consumers tend to be innovators. The length of the introductory period depends on the technology complexity, its degree of newness, how it fits into consumer needs, the presence of competitors and the nature, magnitude and effectiveness of promotion.

- ***Growth Stage***

The second stage in the technology life cycle is the growth stage. This is the stage when the demand starts increasing rapidly by early adopters. At this point, satisfied opinion leaders and other innovators influence others by word of mouth.

- ***Maturity Stage***

This is the saturation stage when the distribution has reached its peak. It is the response of the majority adoption. The total of the population that is ever going to buy the technology has been reached. The volume is stable. At this point effective distribution is often a problem.

- ***Decline Stage***

Changes in product technology and other factors may lead to the decline. Adopters may change to other types of the technology.

Appendix 3.0 Irrigation methods and crops of India and some African countries

Country	Irrigation (x1000) ha.											Crops (x1000) ha.
	Year	Surface	Sprinkler	Micro	Year	Cereals (tons)	Vegetable (pulses)	Sugar cane	Rice	Fruit	Wheat	Maize	Other
India	1993	-	700.0	71.0	1993	3 555.0	2 441.0	3 614.0	19 633.0	0	20 654.0	-	16 247.0
Benin	1994	4.0	4.5	1.4	1993	-	0.3	-	8.4	0.2	-	7.9	-
B. Fuso	1992	15.4	11.5	3.9	1992	80.0	5.4	-3.9	30.9	-	-	-	1.5
Egypt	1993	2830.0	312.0	104.0	1993	-	-	-	538.0	-	894.0	804.0	1502.0
Gambia	1984	1.6	0.0	0.0	1991	18.2	-	-	11.3	-	-	-	-
Ghana	1994	5.8	0.6	0.0	-	-	-	-	-	-	-	-	-
Kenya	1992	44.6	21.0	1.0	1990	-	26.6		14.1	4.9	-	-	9.9
Malawi	1992	15.7	11.3	1.0	1992	2.0	3.7	1.5	7.5	-	-	-	3.3
Morocco	1989	9886.0	103.2	4.0	1990	410				186.0	140.0	-	337.0
Namibia	1992	3.0	1.8	1.3	1992	50.0	-	-	-	-	1.1	-	0.9
Nigeria	1993	-	-	-	1989	1852.0	137.0	-	714.0	-	50.0	-	23.0
S. Africa	1992	396.0	660.0	144.0	1988	1320.0	-	-	-	-	170.0	106.0	
Tunisia	1991	294.0	55.0	6.0	1992	8.3	108.0	-	-	112.0	33.0	18.0	37.0
Zambia	1922	28.4	17.2.0	0.8	1991	81.5	5.6	12.5		9.5	14.5		4.4
Zimbabwe	1993	21.0	87.4	8.0	1989			31.8			47.5		44.8

Source: adapted from FAO 1999; FAO, Water Report 7 1995

Appendix 3.1 Irrigated small-scale farm plot sizes India

Landholding	Size	Average Size	% of total number of holdings	% of total irrigated area
Marginal	<1ha	0.4	59.0	14.9
Small	1-2 ha.	1.44 Ha.	19.0	17.3
Semi-medium	2-4	2.76	13.2	23.2
Medium	4-10	5.9	7.2	27.2
Large	>10 ha	17.33	1.60	17.4

Source FAO 1999

Appendix 3.2 The cost / benefit of LCMH irrigation of some crops in India

Crop	Cost $/ha.	Yield /ha.	Payback months	BCR-1*	BCR-2**	Spacing (m)	Comments
Coconut	408	-	-	1.4	5.0	7.62x7.62	
Sugar cane	1255	200	18	1.31	2.78	0.83x1.66	Micro 10-yr life
Cotton	1584	1.5	18	1.83		0.9x1.5x1.8	Cotton, tomato,
Bananas	1193	75	14-18	1.52	3.02	1.52x2.44	Sugar cane
Tomato	1255	75	5-6	2.0	-.	0.45x0.45x 1.65	spacing for pair row
Orange	722	-	12. 2	2.6	11.05	4.57x4.57	
Mango	408	-	-	1.35	8.02	3.04x3.04	
Papaya	784	750	12	1.54	4.01	7.62x7.62	
Vegetables	1255	-	-	1.35	3.09	-	
Grape	1467	45	12	3.28	-	3.03x1.8	
Citrus	722		12	1.76	6.01	4.57x4.57	

Source: Sivanappan 1995 & Saksena (1995)

* BCR-1 is benefit cost ratio excluding water saving
** BCR-2 is befit cost ratio including water saving.

Appendix 4.0 Gross margin for passion fruits using low-cost drip irrigation

Farmer: Mr F. Kosyum from Uasin Gishu District

During the survey farmer from Uasin Gishu who irrigated passion fruits on a quarter an acre using low-cost medium head drip irrigation was selected as an example to estimate economic benefits of low-cost drip irrigation.

The main issues were the yield and the production cost in a year. He applies fertiliser, manure and chemicals to his passion fruits crop. The farmer stated that he was able to harvest 8 bags of 60 kg of passion fruits per week. The price at the time was Kenya shillings (Ksh 20) per Kg, but varied between Ksh 10-50. He stated that because he was able to irrigate throughout the year, he was able to harvest about 9 months (38 weeks) in a year. He harvested and sold on average about Ksh 9600 per week. His estimated annual variable Gross margin was worked as follows:

GM = Gross output-Variable costs

Production (gross output)

Enterprise sales for passion fruits

- Harvested once a week for 9 months (38 weeks)
- 8 bags of 60kg per week for sale (480Kg)
- Each Kg valued at Ksh 20
- Total Ksh 9600 per week

Total year Ksh 364800

Input Costs (variable costs)

	Ksh* per year
– Land preparation (assumed hired tractor)	1,200.00
– Watering 2 times daily (Ksh 60 a day for 38 weeks)	15,660.00
– Weeding 4 times	2260.00

– Fertiliser including top dressing	2 bags	2,350.00
– Manure (2 oxcarts)		800.00
– Chemicals		1,890.00
– Seedlings (350 @ Ksh 40)		14,000.00
Total cost		**38,860.00**

GM	**=**	**Gross output -**	**Variable costs**
GM	=	Ksh 364,800 -	Ksh 38,860
	=	325,940	
	=	Ksh 325,940 ($ 4,178) for 0.25 acres	
	=	Ksh 3,262,600/ha	($41,828/ha)

* US$ = Ksh. 78

Appendix 5.0 Phase 1 survey questionnaires

The adoption of LCLH drip irrigation in small-scale farms in Kenya

Appendix 5.0a Questionnaire for non LCLH drip irrigation farmer

Confidential Serial number________

Date ____________

(a) District ----------------------------

Location ----------------------------

Area (village) --------------------------

Name of farmer/ Farm --------------------------

Farm size --------------------------

Ecological zone --------------------------

(b) The Interview

I. Background

1. When did you start irrigation?
2. Is this a rented plot/farm?
3. What is your main objective of:
   (a) farming?
   (b) irrigation?

II. Irrigation practice

1. What size is your irrigated area?
2. What crops do you irrigate on your farm?
3. (a) What has been the effect of irrigation on your farms income?
   (b) Why?
4. What irrigation method do you have?

5. What method of irrigation did you have before adopting the present method?
6. Why did you choose this irrigation method?
7. (a) Do you have difficulties with this irrigation method?
   (b) *If yes,* what are they? (prompt)
   (c) *If no,* Why not?
8. What was the cost of the system?
9. (a) Does it have benefits compared to other irrigation methods?
   (b) *if yes*, what are they?
   (c) *If no,* Why not?
10. (a) Have you heard of LCLH drip irrigation kit?
    (b) What do you know about LCLH drip kit irrigation kit?
11. How did you hear about it?
12. (a) Is LCLH drip kit irrigation appropriate to your farming system?
    (b) Why?
    (c) *If yes*, would you like to adopt it?

III. The water supply

1. What is the source of irrigation water?
2. (a) How would you describe the irrigation water quality?
   (b) *If good quality*, Why?
   (c) *If poor quality,* why?
3. Do you know the effect of using saline irrigation water?
4. (a) Is the irrigation water controlled or charged?
   (b) *If yes,* does this limit the irrigated area?
5. Do you have an irrigation pump?
6. *If used,* What is the make and power of the pump-set?
7. What energy does it use?
8. How much was the cost?

IV. The Respondent

1. What is your level of education?
2. What is your agricultural training?
3. How long is your farm experience?

Remarks --

The adoption of LCLH drip irrigation in small-scale farms in Kenya

Appendix 5.0b Questionnaire for LCLH drip irrigation farmer

Confidential Serial number________

Date __________

(a) District ----------------------------

Location ----------------------------

Area (village) ----------------------------

Name of farmer/ Farm ----------------------------

Farm size ----------------------------

Ecological zone ----------------------------

(b) The Interview

I. Background

1. When did you start irrigation?
2. Is this a rented plot/farm?
3. What is your main objective of
   (a) farming?
   (b) Irrigation?

II. Irrigation Practice

1. What size is your irrigated area?
2. What crops do you irrigate on your farm?
3. (a) What has been the effect of irrigation on your farm income?
   (b) Why?
4. (a) What irrigation methods do you have?
   (b) What method of irrigation did you have before adopting the present method?
5. Why did you choose LCLH drip irrigation?

6. (a) Does it have benefits compared to other irrigation methods?
   (b) *If yes*, what are they?
   (c) *If no,* Why not?
7. How did you hear about it?
8. (a) Did anything prevent you from adopting it faster than you would have wanted?
   (b) If yes, explain?
9. Which company sold it do you?
10. What was the cost of the system?
11. (a) Did you buy it cash or on loan?
    (b) *If loan,* what credit facilities did you use?
    (c) *If loan*, what did you not like about the loan/credit?
12. (a) Are you satisfied with dealers' services?
    (b) If no, Why not?
13. (a) Do you have difficulties with this irrigation method?
    (b) *If yes,* what are they?
    (c) *If no,* Why not?
14. Is LCLH drip irrigation appropriate to your farming system?

III. The water supply

1. What is the source of irrigation water?
2. (a) How would you describe the irrigation water quality?
   (b) *If good quality*, Why?
   (c) *If poor quality,* why?
3. (a) *I*s the irrigation water controlled or charged?
   (b) *If yes,* does this limit the irrigated area?
3. Do you have an irrigation pump?
4. *If used,* What is the make and power of the pump-set?
5. What energy does it use?
6. How much was the cost?

IV. The Respondent

1. What is your level of education?
2. (a) Do you have any agricultural training?

   (b) What is your agricultural training?
3. How long is your farm experience?

Remarks --

Appendix 5.0c Questionnaire for irrigation equipment manufacturers and suppliers

Confidential Serial number________

Date ___________

(a) Company ---------------------------------

Enterprise ---------------------------------

Town ---------------------------------

Respondent title ---------------------------------

(b) Questions

I. Background

1. What is your main enterprise?
2. How long have you been carrying out the business?
3. What irrigation equipment do you deal in?

II. Raw materials for irrigation equipment

1. Where do you get most of your raw material and equipment?
2. (a) Have you tried to import from India?

   (b) *If no*, why not?

III. Manufacturing

1. Where do you get your research information for manufacturing?
2. What standards do you use for micro irrigation equipment?
3. (a) Do you have problems of manufacturing and supply of micro irrigation equipment?

   (b) *If yes*, what are they?

IV. Supply and promotion

1. Do you promote LCLH drip kit irrigation in the country?
2. *If yes,* how do you promote LCLH drip kit irrigation in Kenya?
3. Do you have demonstration sites for LCLH drip (kit) irrigation?

V. Prospects of Smallholder LCLH drip irrigation

1. What do you think are the main problems for LCLH drip irrigation
2. in Kenya?
3. From your experience what is the prospects of LCLH drip irrigation in Kenya?

Remarks

(Request technical pamphlets)

The adoption of LCLH drip irrigation in small-scale farms in Kenya

Appendix 5.0d Questionnaire for Government & Research division

Confidential Serial number________

Date ___________

(a) Ministry ------------------------------------

Department ------------------------------------

Respondent Officer ------------------------------------

(b) **Questions**

I. Extension

1. How long have you been in this office?
2. Is there a current government extension policy on development of irrigation methods for small-scale farmers?
3. (a) Is the government facilitating the introduction of LCLH drip kit irrigation in your department?
   (b) *If yes,* what is the government doing?
   (c) *If no,* are there plans do so in the future?
   (d) *If yes,* what are they?
   (e) If no, why not?
4. How does the ministry/Dept. create awareness of LCLH drip irrigation technology for SSI farmers?
5. Does the ministry/dept. have small demonstration sites for small-scale LCLH drip irrigation technology?
6. (a) Does the ministry assist the small-scale irrigation farmers in marketing including access to foreign markets?
   (b) If yes, how?
   (c) If no, Why not?
7. What is the Governments policy on irrigation water charges?
8. What are the problems for LCLH drip irrigation in the country?

The adoption of LCLH drip irrigation in small-scale farms in Kenya

Appendix 5.0e Questionnaire on small-scale LCLH drip irrigation National Agricultural Research laboratories Project

Confidential Serial number ________

Date ___________

(a) **Ministry** -----------------------------------

Department -----------------------------------

Respondent Officer -----------------------------------

(b) Questions

(i) Research

1. What is the current research policy on small-scale irrigation and irrigation technology?
2. How did the current project on LCLH drip irrigation for SSI farmers start?
3. What are the main objectives of the project?
4. How do you intend to achieve these objectives?
5. Where have you sold most of the irrigation kits?
6. How do farmers finance for the acquisition of the LCLH drip irrigation kit you sell?
7. How does the research department create awareness of the LCLH drip irrigation technology to small-scale farmers?
8. (a) Do you get problems in small-scale irrigation research and development work?
   (b) *If yes*, what are they?
   (c) *If no*, why not?
9. What are the problems for LCLH drip –irrigation in the country?
10. (a) Do you have any current or recent research on LCLH drip irrigation in Kenya?
    (b) *If yes*, what is it?
    (c) If *not*, why not?
11. (a) What do you think are the prospects of LCLH drip irrigation in Kenya?
    (b) Why?

12. Why is it that there is very little information including annual reports on this project even in your Library?

- *Do you have any literature on the project that can be of assistance?*

The adoption of LCLH drip irrigation in small-scale farms in Kenya

Appendix 5.0f Questionnaire for small-scale irrigation NGO

Confidential *Serial number*________
Date ___________

(a) **NGO** -----------------------------------

Department -----------------------------------

Respondent Officer -----------------------------------

(b) **Questions**

I. **Background**

1. What is your main activity as an organisation?
2. How long have you been operating in Kenya?
3. How long have you been with this NGO?
4. How did this project start?

II. **Project Target**

1. (a) Do/would you promote the use of LCLH drip irrigation methods?
   (b) *If yes,* how?
   (c) *If no,* why not?
2. (a) Which geographical areas do you target for operation?
   (b) Why?

III. **Extension**

1. Do you do agricultural extension work?
2. How do you create awareness of the irrigation technology to small-scale farmers?
3. Are you aware of small-scale LCLH drip kits that NARL is trying to promote in Kenya?

IV. Farmer Assistance

1. How do you help small-scale irrigation farmers?
2. What are the qualifications for credit?
3. How do you make sure that the loan is repaid?
4. (a) Do you have a problem with the repayments?
   (b) *If yes*, what is it?
   (c) *If no,* why not?

V. Problems and prospects

1. Discuss the problems of small-scale LCLH drip irrigation farmers?
2. (a) What do you think are the prospects of LCLH drip irrigation in Kenya?
   (b) Why?
3. How would you view the future of this organisation?

- *Do you have any literature on the project that can be of assistance?*

Appendix 5.1 Field data collection

(i) Data collection in Uasin Gishu district

I had been informed by NARL that there were about 80 small-scale farmers in Eldoret. However, it emerged that this was not the case. I was later to learn from fieldwork that I should have visited all the areas to be surveyed first to confirm the availability of SSI before making the final programme, instead of relying on information from NARL. Although this could have been expensive, it probably would have been worth it.

When I first arrived in Eldoret, in fourth week of February 2001, the first officer to meet was a co-operative District Agricultural and Livestock officer who introduced me to the District Irrigation officer. I went with them through the interview during which they explained further the origin, position and future of LCLH drip irrigation in the district. This was also the time when they were preparing for the District Agricultural Show so I was able to visit their stand thus learn how they were promoting LCLH drip irrigation in the district and what problems they faced. I took advantage of the show for discussion with various officers, as it was easier to meet most of them then. During this time I was introduced to the field officer I was going to work with in Tuyo Luk in Moiben Division which was about 50 Km North East of Eldoret.

Four days after I arrived in Eldoret I was able to go the field. This delay was due to the show activity. Unfortunately, my extension officer was new in the area and did not know his farmers well. I had hoped that he is well known in the area to provide a cordial entry into the community. Realising that this is not the case, I decided to look for assistance of the local administrator - the chief. He was co-operative, helpful, and knowledgeable. He knew the history of the LCLH drip irrigation in the area and who has what. I informed him that I wanted at least 20 LCLH drip irrigation farmers from whom I could select (randomly) the ones to interview but he told me that he could remember only a few farmers. He stated that although more than 50 farmers had initially obtained the kits most of them had stopped using it. Therefore he could only remember the few that were still using or those who had recently stopped in the last one or two years. This could have further complicated the idea of farmer selection by simple random sampling. I was later to learn that would the trend throughout the study.

The study area is flat area with a sub-humid climate. The rainfall is about 900-1000 mm a year allowing rainfed farmers to have a one crop in a year. It has a long dry spell of about 4 month. It is not an economically poor area by Kenyan standards as it has a good rainfed agricultural system. In general, agriculture is mixed with livestock and arable farming. Most farms are medium from 3-8 hectares although large farms of over 30 ha on freehold land tenure system exist. Most farmers grow seasonal crops as wheat, maize and barley. But it is difficult to rule out small vegetable growing as in most Kenyan farms. In general, irrigation practice was just in its growths stage. The general observation with irrigation in Tuyo Luk area was that it appeared that the LCLH drip irrigation was introduced to a community that was not practising irrigation before. Therefore, it was difficult to find other small-scale farmers practising other forms of irrigation other than LCLH drip irrigation for the interview. The soils are a mixture of red clay and sand and the area has good seasonal roads. The whole area depends on a single pump-fed (dam) water supply system although natural springs and streams exist. However, in general, the area has very few rivers and streams making water very scarce during the dry season.

After seven days, I had interviewed only about nine adopters, which was the number we could get. The administrator had the advantage of having attended all the awareness meetings of the new LCLH drip kit including those in which they used to sell/give the kits. This enabled him provide valuable additional information. For instance, he explained how LCLH drip this project came into being. A progressive farmer had wanted to start a passion fruit factory. However, the area is sub-humid necessitating the use of supplementary irrigation. So, he planted about 30 acres of passion fruits under irrigation at the same time promoting the use of the LCLH drip kit in the area. Meanwhile he promised to buy all the fruits, which he sold under contract to some factory in Nairobi over 300 Km away before he started his. Before long, some businessmen came from a neighbouring country and offered to buy the same for twice the price he was offering. The results, he had no fruits to sell consequently loosing the contract. After sometime, the people from the neighbouring country had enough passion from their own country and so stopped buying. At that time, this had created a severe market problem. This story demonstrates how farmers sometimes can be short-sighted.

Failing to get the target number of farmers, I had to travel to Nairobi to try getting more in the third week of March 2001. Moreover, since the work in Uasin Gishu involved one project in one area, most of the problems seemed very similar. I thought I needed people with different background, outlook, and perhaps different ecological zone.

(ii) Data collection in Ngon'g division

Having failed to get enough respondents in Uasin Gishu District, I looked for other areas that had high numbers of adopters according to the information from KARI. By this time, I had interviewed some government officers at the ministry headquarters and later at district level in Eldoret. This had given me a fair picture of what the government's view of LCLH drip irrigation is. I thought of Ngon'g in Kajiado district because it was the nearest to the centre of operation. I therefore decided to go to its divisional headquarters straight avoiding the district headquarters to gain on time. The officer in charge of irrigation was on leave but I found a co-operative acting officer. We took about a week interviewing farmers up to fourth week of March 2001.

One of the problems of the interview survey is that the time of contact with the participants was short. Depending on the nature of the participant and or the escort extension staff, it was sometimes difficult to build that relationship of friendship and trust which is vital for open response to the questionnaire, depending on the nature of the participant and or the escort extension staff. This was so important in some cases that some extra time had to be spent trying to build up this trust. This was because it could make the difference between getting valid and unfounded information. The original plan was to interview two people each day but because of this, sometimes only one was achieved. The situation in Ngon'g was almost the reverse of the case in Eldoret.

The majority of small-scale farmers were non-LCLH drip irrigation adopters. Only about four had LCLH drip irrigation equipment. The farmers in Ngon'g practised mostly irrigation using small petrol pumps and hosepipes. They grew mostly vegetables to sell to Nairobians as they were on the outskirts of the town. Although this area was drier (750-900mm) of rainfall, than Tuyo Luk, it had more streams from the surrounding hills. Being on the outskirts of Nairobi the farmers had less problems of marketing. However, the majority practised irrigation on small rented plots of less than half an acre. Unlike Tuyo Luk, the farmers here were mainly commercial oriented arable small-scale irrigation farmers growing vegetables for the city. Very little arable farming was rain-fed. The farmers were less dependent on a single water supply.

By this time, my target of interviewing 20 LCLH drip farmers was far from accomplishment. With such few farmers obtained in Ngon'g this increased my doubts about the reliability of the information I had received from NARL of the whereabouts of the LCLH drip kit they were promoting. However, since Kiambu was much nearer about 40 Km and it had been mentioned as one of the district with a high number of adopters, I planned to go there. Having found a disappointing figure of LCLH drip irrigation small-scale farmer adopters, I decided that I should visit the whole district unlike my previous work in Ngong'. I therefore visited the district headquarters during the last week of March 2001. Fortunately, the District Irrigation officer was someone familiar. He was organising a seminar not related to irrigation and would not be ready until after a week. He agreed to make a programme to tour all the three divisions in the district. However, he cautioned that he was not sure if we could get more than ten LCLH drip irrigation farmers that I wanted. With one full week free, I decided to visit the Manufactures and Suppliers of Micro irrigation.

(iii) Data collection from manufacturers and suppliers

I therefore got down to the telephone and made appointments with three companies viz. Agro irrigation Equipment, Amirani, and Booth. I had learned of their operations from the ministry headquarters and Kari. The first company to visit of manufacturers and suppliers was Amirani. Although the person I spoke was co-operative and responsive, he was busy with telephones, customers, and staff. This is where I spend the longest time on the interview - two and half-hours. However, this seemed a general trend with the other manufacturing and supply companies except ShedNet and Warren companies. During the pilot testing, the manager of Beta Engineering had concentrated on the interview taking less than an hour to complete. Therefore, I never expected that I would spend more than twice this time anywhere else.

The second company was Agro Irrigation Equipment. I had met and briefly interviewed one of their technicians serving micro irrigation on a farm in Uasin Gishu. Later I went to Booth plastic Company. In general the companies responded positively to the questionnaire and provided very useful information. However, they were very cautious with sales information. I also had the impression of one of the companies that the informant was either too cautious or of a level/rank not adequate to answer some of the questions.

Although all these three companies dealt with drip, sprayers, and jets micro irrigation equipment, none of them actually manufactured them. They supplied equipment which had been sourced from outside, mostly Europe, and either assembled or supplied it to farmers. So, I was faced with the task of finding and interviewing a company that actually manufactured and sold micro irrigation in Kenya. The Booth Company staff seemed to indicate that their factory in Thika manufactures micro irrigation equipment. In addition, I had made a farmer in Kajiado who had indicated that he had bought his micro system from some manufacturing company in Thika. With Kiambu programme very near, I decided to visit Thika after this programme.

(iv) Data collection in Kiambu district

During the second week of April 2001, I went to check on the irrigation officer in Kiambu. I found that he had made a two-week programme for the three divisions in the district as promised and had already dispatched these programmes to the respective heads. We were to start from the furthest division Kikuyu, then Lari, and finally Kiambu itself. The programme went on smoothly except for a one-day disruption when our visit coincided with another of senior officers from the head office.

Unlike Kajiado and Uasin Gishu, parts of Kiambu are very humid receiving rainfalls of up to 1300 mm a year, coming twice a year. Agriculture is mainly industrial beverage crops with some zero grazing livestock. Farmers grow tea, coffee as cash crops but also practice a lot of horticulture and floriculture. By Kenyan standards, Kiambu is one of the economically well off districts in the country. Although there are large farms, the land is highly fragmented with average individual holding of less than one acre with land title deeds. The soil is mainly red clay with numerous streams in valleys forming a general undulating landscape. It has relatively a better water supply and communication system. Therefore, unlike previous areas studied farmers can grow two rain-fed crops in a year. In spite of these, it has more irrigation (supplementary) relative to the drier areas surveyed before. Most of this was overhead irrigation on large coffee farms while micro irrigation was dominant in highly commercialised horticultural and floriculture industry. There was also some small-scale irrigation in the drier parts of district bordering Ngong and Thika. In this district the farmers were more advanced in the irrigation equipment. Most of them used sprinkler irrigation to grow vegetables, which they supplied to Nairobi as the district is on the outskirts of Nairobi.

It was very difficult to get small-scale LCLH drip irrigation farmers in the area. After considerable efforts, I learned of a women group in Gatundu that had the LCLH drip kit from KARI. Perhaps this is what KARI was referring to when they talked of many farmers with the kit in Kiambu. At this point, I was so much concerned about the anomaly between the report I had received from KARI and what I was actually finding on the ground. Consequently, I posed this question to the District irrigation Officer. His explanation was that sometimes KARI deals with farmers directly hence his office would not be aware of such farmers. But, his extension staff at the grass roots is supposed to visit these farmers and assist them in agriculture matters. Therefore, they are bound to see and meet these farmers in their course of their duty. How did he explain this? It was said that this is sometimes not possible for lack of transport to tour the division. So, unless the farmer has some type of problem that makes him approach the extension staff he may not be known as keeping a LCLH drip irrigation system. In this case, the only person who would know is NARL. However, it had denied keeping records of the LCLH drip kit sold to which areas.

As mentioned in section earlier, I was aware of the possibility that the research work might raise the expectations for some immediate help to some farmers. It is almost natural because here is a government officer with someone interested in the irrigation problems. It was 'logical' that the participants would expect some kind of help or immediate solutions to their problems. A case in point was when two farmers in Toy Luk and Kiambu asked, "Are you going to ask us questions and disappear without any help as it happened last year?" This question was raised despite my explanation during the introduction that I was not going to give a straight help or solution. This is because some of these farmers had received help at one point, if not had heard that people get help, or they were hearing through the media or otherwise of some other people getting aid. Therefore, it was natural to them to expect and ask such a question. Stating bluntly that the research was purely for academics would have discouraged many to open up and respond positively to the interview. I felt that it was essential to explain the purpose of the research to the participants clearly from the beginning but stating that the findings might be of use to them in future and explained how. It was hoped that this would destroy any false expectations from the participant at the same time creating a positive response. This was very important not just to the participants but also to those who guided me in the field not to raise farmers' expectations. The technique appeared to work.

(v) Data collection from Non-Governmental Organisations (NGOs)

With about a month remaining, I had not interviewed any NGO and the number of LCLII drip irrigation farmers interviewed was not anywhere the planned number. I therefore decided to change my plan after the interviews in Kiambu. Instead of interviewing the NGOs the first week of May, I would do this next. Any time left over would be used to try to get an extra number of small-scale LCLII drip irrigation farmers. So, the fourth week of April 2001 I went to find out from a national NGO registration office about the NGOs that dealt with small-scale irrigation. I found out that out of over 4000 NGOs only one was listed under irrigation services. This was "Small Scale Irrigation Development Organisation" in short SSIDO. It was difficult from the registration office to know if any of the 4000 dealt with irrigation indirectly. I decided to check with SSIDO and ApproTEC since I thought they should know any sister NGO involved in the field of irrigation.

Consequently, I made an appointment with the manager of SSIDO to visit after three days. However when I reported at the office he was away and his assistant was in the field for the next three days. The only alternative was to rebook the appointment. Meanwhile I contacted ApproTEC who agreed to be interviewed the following day. The only connection of their work to LCLII drip irrigation was the construction of a treadle pump that could be used for irrigation in small-scale farms. They supplied this to individual farmers, groups, and NGOs. Plan International is one of the NGOs they mentioned as their main customers. The following day, I decided to contact this NGO. Their headquarters in Nairobi informed me that the best people to respond to the interview were in one of their branches in Embu, 150 km away from Nairobi. The headquarters were kind enough to give the names of right officials to approach. I tried to get the branch on telephone to get a booking; it was impossible so I just decided to go there the following week.

While waiting for the SSIDO appointment to mature, I decided to find out about the micro irrigation manufacturing equipment in Thika. First, I went to the Booth Plastic factory in Thika only to discover that they do not deal with irrigation equipment manufacture as I had been informed by one of their branches in Nairobi. Later I discovered ShedNet on the outskirts of Thika town. I had been looking for this micro irrigation equipment manufacturing company. After confirming that they were the main manufacturers of micro irrigation equipment in Kenya, I booked an appointment for an interview the following day. They were very co-operative and showed me what they did, their supplies to other areas in Eastern Africa, their concern for the LCLH drip kit in research work. I was able to get a technical evaluation report of the KARI LCLH drip kit from ShedNet, which I could not get from NARL itself, who could not even state that such document existed. After interviewing Shed Net and ApproTEC I went back to SSIDO. I finally interviewed them at the end of April 2001.

(vi) Data collection in Matuu division

My plan was now set to interviewing the Embu Plan International branch that I had so unsuccessfully tried to get on telephone. I went there the first week of May 2001. I was lucky to get one of the officers when she was preparing to go out for three days field work. Presently we had the interview, because of this I had reasonable amount of information from all the key informant groups.

In that case, my next task would be to finish off the survey by getting information from more LCLH drip irrigation farmers as planned. So, where would this lead me to next? I felt that since Machakos district is a semi arid area there should be some LCLH drip kits. NARL had even mentioned Kithman area in Machakos as one area where a number of farmers had the LCLH drip kit. In view of the experience with such information, I decided to confirm it. The day after arriving from Embu I telephoned the Machakos District Agricultural Office to check whether they had some LCLH drip irrigation for small-scale farmers. The reply was what was expected; the office was not sure which areas had a significant number to recommend me to go. However, Matuu area would be a good area to try since farmers have a long tradition of irrigation practises. The following day I travelled to Matuu where I spend the next three days.

Matuu is over 120 km from Nairobi (Fig 4.1). It is a semi arid area with rainfall of less than 700 mm per year, and irrigation is done primarily for subsistence and the rural market. Accordingly, they have very low incomes. It was the driest of all areas so far visited. The annual rainfall is unreliable with long dry season. For this reason, the area has better but fewer communication systems of seasonal roads. Mixed farming of livestock and cereals and other vegetables was the dominant agricultural activity. This was grown on flat and undulating landscapes with many seasonal rivers. There is limited water supply system. Although the freehold landholding are relatively large (generally 10 acres); they are not very productive due to unfavourable climate. Crop failures were common. Therefore, irrigation is the dominant arable farming activity in these areas compared to rainfed agriculture. However, most of the irrigation method in the area is furrow and to a limited extent sprinkler. Although some areas have black cotton soils, most areas have sandy soils.

When I arrived at Kithman, the divisional headquarters, I met an officer who took me to Matuu location. Accompanied by the area extension staff I was able to interview about five farmers including a women's group. For the first time I met an NGO extension staff in the field and had a useful discussion with him. He had supplied one of the women's groups with a LCLH drip kit for small-scale farming. In all I managed to interview two LCLH drip irrigation farmers including the women's group. This was the last survey area before preparing to come to UK the second week of May 2001.

Appendix 6.0 The analysis procedure

(i) The approach to data Analysis

The design of the data collecting method of the study determines the required analysis method. The survey design was to describe and explain based on the research objectives. Therefore, the aim of the analysis of the data was to build up a picture of the factors affecting the adoption of SSI LCLH drip irrigation in Kenya. It was thought that descriptive quantitative statistics, briefly explained below, was sufficient to describe and explain the research data hence it was adopted.

(ii) Nature of the data and transcribing

The nature of the data collected was nominal and in the form of field narration of 51 interviews in tapes with farmers, government officials, industry, and NGOs on various subjects as seen on questionnaire (Phase 1).

Later, the data was compiled by transcribing it from the original tape onto 270 pages. In doing so, it was important to keep close to the original data to keep the relationship between the original questions and the responses. The compiling was followed by sorting out the material that was relevant to the study and organising them in the order of the questionnaire. This was necessary because during informal discussions the respondents did not necessarily bring out issues as outlined on the questionnaire.

(iii) Categorisation and coding

Then, the data was categorised and coded to reduce the numerous different responses into manageable information taking into account the research objectives. To get optimum criteria, Swift (1996) states that it is necessary to continually checking back to see in what ways we are constrained by the design while looking ahead to the data analysis to achieve the research objectives.

In a lot of research-work field data is often categorised to make it feasible to examine and explore. Dey (1993) lists some of the motives for categorising data for qualitative analysis as follows:

- To create the conceptual tools necessary for analysis;

- It extracts from the mass of data those observations which can be related to specific a criteria; and
- The extracted data can be inspected in detail for distinction, comparisons analysis etc.

The inspection may produce connections between categories. He then describes the sources of generating categories as:

- Inference from the data;
- The research questions;
- Substantive, theoretical issues; and
- Imagination, intuition, literature, and previous knowledge.

During the data processing, it was essential to avoid any prior conceptions as could likely affect the validity of the data collected. Moreover, the fact that the questionnaire was based on overall direction and purpose of the research assisted indirectly in the advance establishment of categories and analysis.

(iv) Approach to coding

The process of coding involves the construction of variables and categories from the raw data. In doing so, it was important to consider how the research may best be presented in terms of the variables and their codes. Swift (1996) states that the drawing up of a coding is governed by the approach the researcher takes in respect of what the data signify and useful ways of understanding. He categorises the approaches as follows:

(v) The representational approach

A research may view the raw data i.e. the words spoken, as expressing in their surface content what is "out there". Therefore, the research will produce codes reflecting the surface meaning of the raw data as closely as possible. He does not consider any views he may have about the underlying variables and meaning.

(vi) Implicit (anchored) approach

In this case the researcher may view the data as having additional and inherent meaning and are depended on the data-gathering context. According to this perspective, the pre-codes and the categories derived from open ended data should reflect the research context as well as in words said in this approach the coding frame takes into account facts of the situation rather than treating the data individually as though they are context free.

(vii) Hypothesis-guided approach

In the preceding two approaches the researcher has taken the research theory in account. In the hypothesis guided approach the researcher may view the raw data as having a variety of meanings according to the theoretical perspective from which they are approached. In contrast to the representational approach, this approach might use the raw data and other disparate material to create or investigate variables that were defined in terms of his theoretical perspective and the research purpose. Therefore the coding frame would be one based on the researcher's views and hypothesis, and research questions rather than on the surface meanings of the set of written answers or responses.

A mixture of these was used in this research. However, the representational and the implicit approach have some advantages. First, the questionnaire for the interview was set based on the research objectives and questions. It was therefore expected that most of the responses would be closely related to the research set incorporating the hypothesis method. Secondly, using the raw data in the coding had the advantage of minimal loss of data compared to processing it into a form suitable to other coding methods. Consequently, rechecking, alternative interpretation, and looking at the raw data from different perspective at later stages was possible. Finally, it was hopped that the implicit and the hypothesis-guided approaches will automatically be part of the discussion of the results. Therefore, it was necessary to avoid a process that would likely be similar later. The implicit approach was relevant in cases where the words or meaning do not fit into the context in which they were said.

In practice, once all the responses had been compiled the next step was to categorise and code them. The coding process is not categorisation since it does not produce members of a class of objects (Dey 1993). This is because it is the name for the data bit but does not identify the index/label as member of a class of objects. The codes were created based on the review of the summary responses.

(viii) Scoring of the codes

There are two alternatives for selecting scoring data - to go in for individual bits/points or episodes. The former will lead to a more detailed analysis. In the other method several data-bits are collected (single or episodes) and the assigned to categories. These are then coded by indexing for easy abbreviations, identification and location. I used the second option in order to get the true meaning of the context of word. The data was coded in its context by examining comparisons between the data bits. At this stage, the data was ready for scoring to produce a tally table, which were used in the descriptive statistical analysis and homogeneity analysis.

Appendix 6.1 Problems of small-scale irrigation farmers (phase 1)

Problem	Participants #	# responses	Percentage participants	Percentage response	Cumulative % response
Unreliable water supply/shortage during drought	50	34	68	18.7	19
Lack of market	50	32	64	17.6	36
Maintenance Mechanical ***clogging, leaks, breakage, personnel, source, distance)***	**50**	**24**	**48**	**13.2**	**50**
Operational *(unable to install, laborious)*	50	13	26	7.1	57
Crop husbandry	50	11	22	6.0	63
Animal damage-wild/livestock	50	9	18	5.0	68
Lack of finance	50	7	14	3.9	71
Soil erosion	**50**	**7**	**14**	**3.9**	**75**
Compatibility *(cannot extent, used on seed bed)*	50	7	14	3.9	79
More consideration from government	50	5	10	2.7	82
NARL direct dealing/lack of kits & information	50	5	10	2.7	85
Few farmers using it	50	5	10	2.7	87
Expensive/laborious to fetch water	50	4	8	2.2	89
Irregular /power rationing	50	4	8	2.2	92
Cost of water development	50	4	8	2.2	94
Fuel cost	50	4	8	2.2	96
High interest	50	3	6	1.6	98
Government/aid dependence	50	2	4	1.1	99
Roads	50	2	2	1.1	100.0
Total		**182**		**100.0**	

Appendix 6.2 Summary findings of study on LCLH drip kit adoption in Kenya (Phase 1)

Aspect	Main study findings	Verified by	Category
Pre-conditions of the adoption process			
Irrigated crops	High value horticultural crops grown followed by cereals	Accounted for 80% responses	Economic
Irrigation water sources	Natural fresh water streams or rivers	44% of farmers sources for irrigation water	Infrastructure
Aim of irrigation	Was commercial	62% of all farmers engaged in commercial irrigation	Economic
Irrigated area	Less than 0.1-0.25acres	Average 0.15 acres, non-LCLH drip farmer 1.6 acres	Economic
The adoption process			
Main methods adopted	To LCLH drip irrigation and to sprinkler	Was 51% and 29% of responses respectively	Technological
Financial requirements	No major problem preventing farmers adopting fast	Over 63% of all farmers bought cash LCLH drip irrigation kit immediately after deciding	Economical
Knowledge of the LCLH drip irrigation kit	Awareness of the LCLH drip irrigation kit low	80% of non LCLH drip irrigation kit farmers had no information and understanding knowledge particularly i.e. low	Social
Persuasion	Communication channel were mainly change agents and friends	44% stated this as source of information on LCLH drip irrigation. Shows and print employed by NARL	Social
Promotional strategies for kit	Generally lacking.	Government extension, NGOs and manufacturers had no promotion programmes. Only NARL had	Social
Relative advantages	High. The kit was affordable, portable, expandable, water saving with reported good economic food security benefits. Not appropriate in some cases	Most farmers (88%) thought main benefits were economical in energy, water, and cost. Others (43%) were happy with food production and domestic expenditure	Technological
	Farmers expressed its safety in terms of soil erosion, disease control and weed control	19 % of the farmers considered this an advantage	Technological
Compatibility	Farmers considered the kit convenient in terms of type of crops, shifting, no supervision, no mud, and apparently relatively longer wetted soil times.	Of those interviewed 50% of farmers stated this reason	Technological
	Farmers who had shifted from bucket	Accounting for 56% of responses.	Technological

	irrigation thought the kit was less laborious		
Divisibility	Some farmers were uncertain of financial return on the smallest kit of two 15m LCLH drip irrigation lines.	A small fraction about 13% thought the effort was not worth and preferred paid casual work	Technological
Compelling factors of adoption process			
Water regulation	In general water was not regulated	73% of all the farmers stated that water sources were free	Institutional
Water charging	Irrigation water was not directly charged	90% of all farmers stated irrigation water not directly or indirectly charged	Institutional
Water quality	Not considered in irrigation practice	79% did not know effects of poor irrigation water quality on crop production. 32% positive responds to salinity mostly in dry areas	Institutional
Why LCLH drip irrigation kit considered inappropriate	Perception (wrong) that it was expensive, only for large farms difficult to manage. Already heavily invested in other methods	60% of non LCLH drip irrigation farmers thought LCLH drip irrigation inappropriate on misconception and 20% on investment respectively	Social-economic
Implementation Stage of the adoption process			
Field follow up and review	Infrequent monitoring and evaluation with subsequent lack of action	Farmers in U/G reported kit evaluation data collected twice since 1996 but no action to their problems. Elsewhere no action.	Technical
Dealer satisfaction	Most farmers (63%) dissatisfied with dealers services of the LCLH drip irrigation kit	56% said never saw them and or did not know their location	Technical
Main problems of LCLH drip irrigation kit irrigation	Were poor maintenance, inadequate water supply, and marketing	LCLH drip irrigation kit had more maintenance problems than other methods (24%), unreliable water supply or poor organisation for water utilisation (22%) and farmers faced lack of market and or information, organisation for marketing (15%)	Technological , institutional
Crop husbandry	Problem was farmers knowledge of crop protection practise as when and what chemical to apply and importance of getting disease free seedlings	Many passion fruits farm plots had been affected by in Uasin Gishu. The extension officer in Ngong' reported over dosing of fertiliser as a major problem	Technical
NGOs involvement	Most assisted in marketing of farm produce for small-scale farmers but few	50% assisted in marketing. Only SSIDO registered as dealing with small-scale irrigation.	Institutional

	were in LCLH drip irrigation kit irrigation		
Government policy on water saving irrigation methods	Lacking or not clear	All the extension officers stated they are not aware of any such guidelines.	Institutional
Role of assistance in marketing	Lacking due to funding	Statement from government extension staff (67%)	
Research on small-scale irrigation technologies	Government research limited due to funding. Industrial research foreign	Statement from NARL	Institutional
Prospects of LCLH drip irrigation kit	Most respondents generally optimistic in view of current problems.	About 60% expressed the view that it had high prospects and only 18% suggested that the prospects were low.	Technological
Irrigation industry			
Scale of manufacturing	Low	Only one factory manufacture parts. Rest (86%) imported from Europe and Israel	
Problem of manufacturing	No major problem found	ShedNet manufacturing company did not have any	

Appendix 7.0 Questionnaire for phase two of the survey

The adoption of LCLH drip irrigation in small-scale farms in Kenya

Questionnaire for drip kit adopters and discontinued adopters

Confidential serial number________

Interview *Date*_______________

(a) **District** ______________________________

Location ______________________________

Area (village) ______________________________

Name of farmer/ Farm ______________________________

Ecological Zone ______________________________

Adoption Success ______________

Unsuccessful ______________

1. (a) How long have you used/been with drip irrigation kit?
   (b) Did you buy it?
2. What is/was the type of your drip kit?
3. Is the aim of irrigation for subsistence, commercial or both farming?
4. (a) *Do* you have other arable means of obtaining food?
   (b) *Discuss.*
5. *(a)* Do you have a problem with marketing for your irrigated crops?
   (b) Explain?
   (c) If yes, how serious is the problem?
6. (a) *Do* you have group or private individual type of market?
   (b) *If group*, are you satisfied with the marketing association?
   (c) *Please* discuss

7. *(a) If group,* are you satisfied with the marketing association?
   (b) *Please* discuss

8. (a) Is there a water supply reliability problem during the irrigation period?
   (b) *Please, explain*?
   (c) *If yes*, how serious is it?

9. (a) What are the ownership rights of the water supply?
   (b) Are you satisfied with the water supply management?
   (c) *Please* discuss

11. (a) Is the irrigation water regulated?
    (b) *If yes,* explain?

12. (a) Does the quality of water affect your drip kit irrigation?
    (b) *If yes*, how serious is this problem?
    (c) *Please,* discus

13. (a) Are you satisfied with the support service for drip Kit?
    (b) *If not*, how serious is the problem with support services?
    (c) Please explain

14. (a) Did you have previous experience or training in irrigation/arable farming before drip kit irrigation?
    (b) *Please,* explain you previous experience?
    (c) *If no,* do you have problems with how and when to use crop chemicals?

15. (a) Do you have a problem with your drip kit security?
    (b) If yes, how serious is it?
    (c) Please, discuss

16. (a) Is your drip kit working?
    (b) If you stopped drip kit irrigation, when did you stop?
    (c) If you stopped drip kit irrigation, why did you stop?

Appendix 7.1 Homogeneity analysis input data file

QN1B	QN2	QN3	QN4A	QN4B	QN5A	QN7A	QN8A	QN10A	QN11A	QN11C	QN12	QN13A	QN14A	QN14B
D	B	C	N	R	Y	Y	2	N	N	1	P	N	Y	N
D	B	S	Y	B	Y	N	2	Y	N	1	B	N	N	N
D	O	S	Y	R	N	N	1	N	N	1	D	Y	Y	D
D	B	S	N	B	N	N	1	Y	Y	4	B	N	Y	D
D	B	S	Y	R	Y	N	1	Y	N	5	D	Y	N	N
D	B	C	Y	R	Y	Y	1	N	Y	3	P	Y	N	Y
D	B	S	Y	R	N	N	2	D	Y	4	P	N	N	Y
D	O	S	N	D	N	N	2	N	Y	4	P	Y	N	N
D	O	S	N	A	N	N	2	N	Y	4	P	Y	N	N
D	D	S	N	A	N	N	2	N	Y	4	B	Y	N	N
D	D	S	N	A	N	N	2	N	Y	4	B	Y	N	N
D	D	M	N	D	Y	Y	2	D	N	3	P	N	Y	N
D	D	M	N	A	N	N	2	N	Y	4	B	Y	N	Y
D	O	S	N	D	N	N	2	N	Y	3	B	Y	N	N
D	B	S	N	A	N	N	2	Y	N	2	P	Y	Y	Y
C	O	C	Y	A	Y	N	1	N	Y	1	P	N	N	N
D	D	S	N	A	N	N	2	N	Y	4	B	Y	Y	D
D	D	S	N	A	N	N	2	N	Y	4	B	Y	Y	D
D	D	S	N	A	N	N	2	N	Y	4	B	Y	Y	D
D	O	S	N	D	N	Y	2	N	Y	4	P	Y	Y	N
C	O	M	Y	R	N	N	1	N	N	1	P	Y	Y	N

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C	B	M	Y	B	N	N	1	N	N	2	P	N	N	N
C	O	C	Y	R	Y	N	1	N	Y	3	B	N	N	N
D	B	M	Y	R	N	Y	1	N	N	3	P	N	Y	N
D	B	S	Y	R	N	N	2	N	Y	4	B	N	Y	N
C	B	M	Y	R	N	N	2	N	Y	4	P	Y	Y	N
D	B	S	Y	R	Y	N	2	N	N	2	B	N	Y	Y
C	B	C	N	D	N	N	2	Y	N	1	P	Y	Y	N
S	B	S	Y	R	N	Y	2	N	Y	2	D	Y	Y	N
S	B	S	Y	R	N	Y	2	N	Y	4	P	Y	Y	N
S	B	S	Y	R	N	Y	2	N	N	2	B	Y	Y	N
S	B	M	Y	R	N	N	1	N	N	1	P	Y	Y	D
S	B	M	Y	B	N	Y	1	N	Y	4	P	Y	Y	N
S	B	S	Y	R	Y	N	1	N	N	1	B	N	Y	D
C	D	M	Y	A	N	N	1	N	N	1	P	N	Y	N
D	O	C	Y	R	Y	N	2	N	Y	4	P	Y	Y	N
C	O	C	Y	R	Y	N	1	N	N	1	P	N	Y	N

QN15A	OBJECT	ACQUISTN	SIZEN	AIMN	OMFDN	FDMIN	MKTPROB	WTRELIAN	WATRAITN	WTAQUALN	SAPOTIN
Y	N	1	1	1	1	1	1	1	2	2	2
N	N	1	1	2	2	2	1	2	2	1	2
N	N	1	2	2	2	1	2	2	1	2	2
N	A	1	1	2	1	2	2	2	1	1	1
N	N	1	1	2	2	1	1	2	1	1	2
N	A	1	1	1	2	1	1	1	1	2	1
Y	A	1	1	2	2	1	2	2	2	3	1
Y	A	1	2	2	1	3	2	2	2	2	1
Y	A	1	2	2	1	4	2	2	2	2	1
N	A	1	3	2	1	4	2	2	2	2	1
N	N	1	3	2	1	4	2	2	2	2	1
Y	N	1	3	3	1	3	1	1	2	3	2
N	N	1	3	3	1	4	2	2	2	2	1
N	A	1	2	2	1	3	2	2	2	2	1
Y	N	1	1	2	1	4	2	2	2	1	2
N	A	2	2	1	2	4	1	2	1	2	1
Y	N	1	3	2	1	4	2	2	2	2	1
Y	N	1	3	2	1	4	2	2	2	2	1
Y	N	1	3	2	1	4	2	2	2	2	1
Y	A	1	2	2	1	3	1	1	2	2	1
N	A	2	2	3	2	1	2	2	1	2	2
N	N	2	1	3	2	2	2	2	1	2	2

Y	A	2	2	1	2	1	1	2	1	2	1
Y	N	1	1	3	2	1	2	1	1	2	2
N	A	1	1	2	2	1	2	2	2	2	1
N	N	2	1	3	2	1	1	2	2	2	1
N	N	1	1	2	2	1	1	2	2	2	2
Y	A	2	1	1	1	3	2	2	2	1	2
N	A	3	1	2	2	1	2	1	2	2	1
N	A	3	1	2	2	1	2	1	2	2	1
Y	N	3	1	2	2	1	2	1	2	2	2
N	N	3	1	3	2	1	2	2	1	2	2
N	A	3	1	3	2	2	2	1	1	2	1
N	N	3	1	2	2	1	1	2	1	2	2
N	N	2	3	3	2	4	2	2	1	2	2
N	N	1	2	1	2	1	1	2	2	2	1
N	N	2	2	1	2	1	1	2	1	2	2