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Agricultural technologies for marginal farming systems in Asia: Adoption and diffusion of SALT in the Philippines and SRI in India

Roshani Malla
Iowa State University

Agricultural technologies for marginal farming systems in Asia: Adoption and diffusion of SALT in the Philippines and SRI in India

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Roshani Malla

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Program of Study Committee:
Francis Owusu, Major Professor
John Miranowski
Robert Mazur

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ABSTRACT

Information on technology adoption and diffusion in a given society is important for research, extension, and development efforts that benefit the marginal farmers. This research reviews literature focused on the adoption of two agricultural technologies/practices; SALT in the Philippines and SRI in India to examine the roles of various stakeholders in the process. The identification of the roles of the major stakeholders in technology adoption and diffusion is important for identifying and alleviating the constraints affecting diffusion of innovation. The study uses the innovation system approach to analyse the role of stakeholders in the process. It especially focuses on how institutional influences change the innovation and adoption process, and on the role of various stakeholders in changing the conditions for the adopters. The case studies show that successful technology adoption is dependent on a wide range of factors, the most important being the network of research, training and development stakeholder groups that come from public, private and NGO sectors. Farmers' characteristics like farm size, land ownership, access to information, environmental awareness, membership in local groups, and utilization of social networks emerge as some of the variables that are more often positively associated with adoption of technologies. Likewise complexities of technologies, labor constraints, and weak policies have negative and significant influences on the adoption of technology. The study concludes that farmer adoption rates can be improved by strengthening influential stakeholders' networks and promoting technology into communities with genuine support and supervision from the government.

CHAPTER 1: INTRODUCTION

Background to the Study

Agriculture is a key factor of economic growth, especially in the early stages of economic development. It accounts for large shares of national income, employment, and exports and can generate patterns of development that are favorable for the poor (Diao et al. 2007). However, the current economic and pricing system continues to push farmers towards concentration of production forcing small farmers to abandon their farms (Norman et al. 1997, Horrigan et al. 2002). There are currently nearly 500 million farmers who farm less than 2 hectares of land. These small farm holders are predominantly concentrated in Asia and Africa (Hazell 2011).

Devendra et al. (2002) characterize the traditional small farm scenario as characterized by low capital input; limited access to resources; low levels of economic efficiency; diversified agriculture and resource use; and conservative farmers who are illiterate, living on the threshold between subsistence and poverty, and suffer from an inability to use new technology. Asia alone accounts for 87 percent (roughly 435 million) of small farmers who constantly face the challenges of environmental degradation and economically inefficient production systems (Thapa 2009). To intensify the problem, much of these lands are classified as degraded lands or lands that have already undergone moderate to severe erosion (ARLDF 2004). Given these challenges, there is an economic, environmental, and social imperative to develop more sustainable and diverse agricultural systems in the region and help small farms to continue operating and to do it profitably.

The characterization of the major farming systems provides a useful framework for the development and implementation of appropriate agricultural development strategies. Based on factors like available natural resources, farm size, and dominant cropping pattern Dixon et al. (2001) have identified sixteen major farming systems in Asia. For the purposes of this study, two of the major farming systems have been selected; upland and rain-fed farming system based on the percent of land area covered by these systems, agricultural population depending on them, and prevalence of poverty in the regions with these farming systems. The upland farming systems are predominant in East Asia and Pacific where it occupies 19 percent of the total land area of the region and is practiced by 27 percent of the total agricultural population. Similarly rainfed farming systems are predominant in South Asia. It occupies 29 percent of the total land area with 30 percent of the total agricultural population depending on it (Dixon et al. 2001). Even though these farming systems are dominant in Asia, they are practiced at the margins of agricultural productivity. Sustainable farming system in the upland and rainfed agricultural lands is one of the greatest challenges many regions in Asia face. These farming systems are under threat and show unmistakable symptoms of the emerging unsustainability of resource use and production practices (Jodha et al. 1992). Therefore there is a need for practices and technologies that are sustainable and provide resources for the sustenance of the large agricultural population.

Problem Statement

Despite the alternative that sustainable agriculture represents for many farmers, widespread adoption of sustainable agriculture practices have not occurred (Pretty and Hine 2000). This might imply that strategies to speed adoption of sustainable agricultural practices have not been effective. Modern agriculture begins on research stations where researchers have access to all the necessary inputs but when the package reaches the farmers, even the best performing farms cannot match the yields the researchers get (Pretty 1995). Therefore, technology packages must relate to the socio-economic environment and bio-physical environment of farmers. Socioeconomic environment includes, among others, land, labor, and capital and it must also consider farmers' ability to absorb or digest complex and new information about state-of-the-art conservation measures because of their general low level of literacy (Mercado et al. 2001). Technology that is affordable, encourages local participation, utilizes local materials and resources, sustainable, gender considerate, meets the basic needs of the local and, is culturally/socially appropriate is likely to be successfully adopted (Murphy, 2009). One way to draw insights about technology adoption and diffusion is the use of retrospective analysis to understand how previous technological innovations have been targeted to address issues in specific locations and conditions.

Hypothesis and Research Objectives

Information on agricultural innovations diffuses through networks of stakeholders rather than being freely available. This research is based on the idea that effectiveness of technologies is not the only factor to influence adoption at farm level. Rather diverse stakeholders play crucial mediating roles in the process of technology adoption in farm communities. When an effective collaboration between stakeholders is fostered throughout the adoption and diffusion process, the effort is more likely to be successful and sustained. To demonstrate, this research reviews the adoption and diffusion of SALT in the Philippines and SRI in India.

The purpose of the study is to review the available evidence on the adoption of suitable agricultural practices and technologies in the Philippines and India. It focuses on the development of Sloping Agricultural Land Technology (SALT) and System of Rice/Crop Intensification (SRI/SCI) and the strategies used by the Philippines and India to promote the diffusion and adoption in the respective countries. This study was designed to gain a better understanding of agricultural technology adoption and the barriers involved in the process. The specific objectives of this research are:

1. Document the current state of upland and rainfed farming systems in Asia
2. Identify the major technologies/practices for overcoming challenges of these farming systems in the region
3. Examine the roles of various stakeholders in the diffusion and adoption of SALT in the Philippines and SRI/SCI in India and assess the outcomes of the process

Research Methodology

The research is based on secondary data and employed two-phases of data gathering. The first phase involves identifying various farming systems in Asia based on data obtained from the Food and Agriculture Organization (FAO). This was complemented by searching articles and books that discuss the status of various farming systems in Asia. A case selection of countries and farming system specific technology/practice was done. The second phase involved a review of the literature and developing the criteria for a successful adoption and diffusion of agricultural technologies.

Case Selection

The initial phase of research for this project involved searching out various farming systems in Asia and their relation to poverty. From the list of 16 different farming systems of Asia classified by Dixon et al. (2001), two farming systems were selected; upland and rainfed farming systems. The selection was based on three criteria: land area, agricultural population, and prevalence of poverty. The next step was to identify countries where these two farming systems were predominant. The upland farming systems was prevalent in East Asian countries like Indonesia, the Philippines, Thailand, etc. whereas the rainfed farming systems was mostly found in South Asia, especially in India. For the case of upland farming system, the Philippines was chosen and for the case of rainfed farming system, India was chosen based on the percentage of respective farm area and indicators of the agricultural sector, e.g. agricultural GDP, crop production index, and crop yield. In both the countries, rapidly increasing population was also considered important in the selection criteria, because it implies an increasing rate of land consumption.

Considering their specific nature, two technologies were selected: Sloping Agricultural Land Technology (SALT) and System of Rice/Crop Intensification (SRI/SCI). SALT is specific to upland farming systems where the land is sloping, whereas SRI/SCI is widely used in drought prone lands that are dependent on rain. In each case, the development of SALT or SRI in the Philippines and India respectively, the main actors and organizations, the tactics and strategies, and the outcomes achieved in the countries were studied.

Data Sources and Analysis

The sources for the literature review consisted of journals and articles and websites about the status of farming systems in Asia and the sustainable technologies/practices used in those farming systems. Other sources were journals, articles, and books on theories of diffusion and adoption. Whether it concerned journals, news articles or websites, attention was paid to the perceived reliability of the source and academic contents. The information was used only if it was consistent with other sources. The websites have only been used if the source of the information was clear and was deemed reliable for the kind of information sought. Many websites were official websites of the governments, International Non-governmental Organizations (INGOs), research organizations, and academic institutions.

One of the first steps in the technology intervention is the identification of individuals and groups who hold some kind of "stake" or interest in the technology. This allows researchers to carry out a more detailed analysis of each group involved in the process of adoption and diffusion. The identification of stakeholders can frequently provide important insights into their influence over the adoption and diffusion process. During the literature review, the major stakeholders were grouped into the following categories: national government institutions, non-governmental organizations (NGOs), international donors/development agencies, civil society, and users/farmers. Subcategories of characteristics of the technology/practice in question such as demand for labor, costs of establishment, costs of operation, perceived risk were also included to determine the rate of adoption. Furthermore, socio-economic factor such as land ownership was included for the analysis.

Limitations

One of the major limitations of the research has been the availability of data. Although many useful sources were used, it was impossible to locate others sources that were considered very valuable to the research, especially information on the dissemination of SALT in the Philippines. Lack of resources prevented visiting the countries selected for the case study therefore the research had to rely only on publicly available data. Since not all sources can be retrieved, it can cause a limitation to the research and a loss of potentially valuable information. This research relies on secondary data and the absence of statistical tools and analysis was a constraint for careful selection and triangulation of data and key sources.

Asia is a diverse region in terms of geography, agro-ecology, culture, social capital, political systems and, resource endowment and ethnic groups. Hence, this study cannot generalize for the entire region in general, or the case studies countries in particular. However, recommendations and policy implications of this study could be used in other locations having comparable or similar context.

Organization of the Thesis

The thesis is organized in five chapters. Chapter two reviews the pertinent literature on farming systems and sustainable agriculture, adoption and diffusion of agricultural technologies and different approaches of diffusion of innovation. Chapter three provides a discussion on the upland farming systems and the adoption and diffusion of SALT in the Philippines. Similarly the fourth chapter presents discussions on rainfed farming system and SRI in India. Both the chapters depict the use of SALT and SRI in respective farming systems, their approach to sustainability, and the associated limitations; and describe their adoption and diffusion highlighting the roles of various stakeholders in the Philippines and India respectively. Chapter five depicts a summary with a comparison between the adoption and diffusion of SALT and SRI in two countries. Finally the main conclusions from the research and recommendations for further research are given.

CHAPTER 2: LITERATURE REVIEW

This chapter starts with a brief description of sustainable agriculture and farming systems followed by literature review on adoption and diffusion of technology, role of stakeholders, and different approaches for technology diffusion. At the end of the chapter a conceptual framework is presented that showing how these concepts are interrelated.

Farming Systems and Sustainable Agriculture

FAO describes a farming system as "a population of individual farm systems that have broadly similar resource bases, enterprise patterns, household activities and constraints, and for which similar development strategies and interventions would be appropriate. Dixon et al. (2001) mapped eight broad types of farming systems and 72 detailed farming systems in the developing countries. The classification of the farming systems has been based on the following criteria: available natural resource base (including climate, landscape, and farm size) and dominant pattern of farm activities and household livelihoods (including crops, livestock; technologies used; and off farm activities). The classification of farming systems is essential so that the unique features of each farming systems can be studied and the associated problems can be addressed effectively.

To characterize farming systems as sustainable, the concept of sustainability has to be broadened in terms of the nature of the farming activities. In the past three decades the concept of sustainable agriculture is being considered as an alternative to the negative impacts of conventional farming, however, there remains disagreement among farmers, the general public, and even agricultural professionals about what the concept means (Ikerd et al. 1997). Nevertheless, most proponents of the concept will agree that sustainable agriculture is not a defined set of agricultural practices but a long term goal that challenges farmers to think about the consequences of agricultural practices, as well as the functioning and interactions of agricultural systems. Sustainable agriculture is more frequently defined utilizing its three main aims: environmental health, economic profitability, and social and economic equity. Despite these different goals, each must be pursued at the same time in order to advance sustainability (Ikerd et al. 1997, Horrigan et al. 2002, Norman et al. 1997).

The diversity of the definition of sustainability is largely explained by the position and the opinion of the user. Pretty (1995) argues that the definitions of sustainability are also time specific. Although sustainable agriculture does not refer to a standard set of agricultural practices, there are certain methods or practices that enhance sustainability. Such methods are known as sustainable agricultural practices. Farmers are known to use a wide range of sustainable agricultural practices such as crop rotation, cover crops, no-till and low-till farming, soil conservation, diversity, nutrient management, integrated pest management, rotational grazing, water quality/wetlands, agro-forestry, and alternative marketing. Norman et al. (1997) however point out that sustainable agriculture is time and place specific, and thus represents a dynamic concept. Since farming systems vary greatly across geographical areas and time, sustainable agriculture will continuously adapt to the context in which occurs.

Developing one for all strategy for agricultural development in Asia is difficult because of their diversity in terms of agro-ecological characteristics, infrastructural development, and socioeconomic variables. The different farming systems identified in Asia face their own sets of challenges and thus need specific agricultural practices to overcome them. To address the concerns about the sustainability of upland and rainfed farming systems, technological innovations that deliver solutions to environmental problems and yield growth are required. The adoption and diffusion of sustainable agricultural practices and technologies to address issues like land degradation, low agricultural productivity, and water scarcity has become an important issue in the development agenda of Asian agricultural systems. Ideal technologies are characterized by increased long term sustainable productivity, labor intensity, suitability for women, adaptability to seasonality, stability and resilience, compatibility with integrated and diversified systems, low external input requirements, and ease of adoptability. Apart from higher productivity, the characteristics of the practices and technologies should also include the basic tenets of diversification, intensification without resource degradation. Sustainable agriculture requires that farmers to find balance and harmony among the economic, social, and ecological dimensions of their farming operations (Ikerd 2005). Therefore, practices that minimize the rate of soil degradation, increase crop yields and raise farm income are the key to sustaining agricultural productivity.

Adoption and Diffusion of Technology

Diffusion of this innovation refers to the spread of abstract ideas and concepts, technical information, and actual practices within a social system, where the spread denotes flow or movement from a source to an adopter (Rogers 2003). It is the process by which an innovation is communicated through certain channels over time among the users. An innovation diffuses within a community through its adoption by individuals and groups. Rogers differentiates the adoption process from the diffusion process in that the diffusion process occurs within society, as a group process; whereas, the adoption process is pertains to an individual. Thus, diffusion and adoption are closely interrelated even though they are conceptually distinct. The unit of analysis in adoption study is an individual decision maker (farmer) whereas diffusion is the cumulative adoption path or distribution of adoption (percentage of farmers, percentage of area) over time or space with the community, region, nation or another geographical scale as the unit of analysis.

In the conventional or ‘central source’ view of agricultural research and development, innovation or a technology is developed from ‘upstream’ activities in the formal research system and is adapted by ‘downstream’ research until it is ready for diffusion to farmers (Biggs and Clay 1981, Biggs 1990 as cited in Cramb 2000). But in practice agricultural innovations are also seen to derive from multiple sources that include but are not limited to research-minded farmers, administrators, Non-Governmental Organizations (NGOs), private corporations, and extension agencies (Biggs 1990 as cited in Cramb 2000). The result of which as Cramb (2000) explains is the incorporation of components from both old and new systems where the farmers can always reinvent the technology based on the situation and need. Parayil (1999) also refers technology as a body of knowledge with its own internal dynamics of change and progress, the building blocks of technology being ideas, information, and other manifestations of knowledge rather than mere material artifacts. One implication of this perspective is that the process of technology development is ever evolving and being modified.

In adoption and diffusion studies, the adoption of technology is usually related to an individual. In other words, there is greater emphasis on the individual farmer. Conventional adoption and diffusion research, however, does not pay much attention to co-ordination between interdependent actors. The rate at which a new technology is adopted depends not only on the technology traits, but on various factors such as socio-economic and cultural factors, participation of stakeholders and the environment that enables an effective interaction between the stakeholders. The Asian Development Bank (ADB)[1] defines stakeholders as "people, groups or institutions that may be affected by, can significantly influence or are important to the achievement of the stated purpose of a project. The identification of stakeholders can frequently provide important insights into: (i) the nature of their interest (whether positive or negative); (ii) the extent to which stakeholder's interests overlap; and (iii) their influence over the adoption and diffusion process. The stakeholder groups include government, civil society, and the private sector at national, intermediate and local levels. They are:

- General public: those who are directly or indirectly affected by the project (women's groups, farmers' groups, individuals and families)
- National and local government: civil servants in ministries, cabinets, elected community leaders
- Civil society organizations: networks, national and international NGOs, grassroots organizations, trade unions, policy development and research institutes, media, community based organizations.
- Private sector: umbrella groups representing groups within the private sector
- Donor and international financial institutions: resource providers and development partners

Characteristics that Influence Adoption at Farm Level

The revolution in agricultural technology, which has occurred in the last few decades, has opened ways for livelihood improvement for some farmers, but has by-passed many others. Some new technologies are scale neutral, but others, such as many types of farm machinery, are

[1] ADB. 2003. Poverty and Social Development Papers No.6. Manila

irrelevant to small farmers in developing countries. Whether in a developed or developing country, government, private, and local groups aim to provide their citizens with efficient and cost effective technologies (Wicklein 1998 cited in Luca 2012). However, in resources limited region, it becomes essential that the most appropriate technologies be utilized for any given project.

It can be argued that potential adopters' perceptions of the characteristics of a new technology affect the speed of its adoption. Rogers (1983) identified five characteristics of innovations that have impact on the adoption; relative advantage, compatibility, complexity, divisibility, and observability. Technologies that fulfill the user's needs, are reliable, easy to maintain, and are affordable often are more successful in any farming system. On the other hand relative advantage is associated with economic category like profitability and non-economic category like saving of time and lesser demand of labor. A reliable technology meets certain local/cultural/economic requirements. Similarly technology that is affordable to farmers and is within the means of their financial resources is highly desirable. The technology does not necessarily need to be inexpensive if the benefits are sufficient to outweigh the burden of the initial cost, nevertheless is some cases the operational cost of the technology can be a limiting factor for adoption. Flexibility of the technology means that it should be able to adapt to different farming conditions (Murphy et al. 2009, Luca 2012).

Barriers to Adoption

In recent times, several development organizations and government agencies in developing countries have prioritized development programs and policies to enhance agriculture recognizing the need of increased crop productivity over the long term. Some of these programs and policies have been short term in their focus especially those that were resource extractive in nature, sectorial in orientation and usually replicated development designs and experiences that were often unsuited to the farm situation (Jodha 1992). Many barriers to adoption of sustainable agriculture practices have already been identified. Barriers related to the farmers' knowledge and information needs, and the availability of information to farmers seems to be important in the literature. However, beliefs and values of farmers also seem to be a reason for the lack of receptivity to new information. On the other hand economic factors seem to be equally important in the literature (Rodriguez 2005, Murphy 2009, Norman et al. 1997). Some studies explain how policies are shaping the economic environment that constrains adoption of these technologies (Norman et al. 1997, Parayil 1999, Horrigan et al. 2002, Teklewold 2012). Additionally, there are incompatibility factors with sustainable agricultural practices. Incompatibility is exacerbated by the fact that sustainable practices are relatively more complex compared to conventional technologies, in that sustainable practices depend more on local conditions.

Apart from the elements mentioned above, factors like land tenure can greatly influence the rejection of new agricultural practices and technologies. Not only in developing countries but also in the developed countries where many farmers often rent land, willingness to adopt a new technology is seen low. In settings where land tenure is weak and property rights insecure, farmers may not have an incentive to invest in beneficial technologies (Rodriguez 2005, Jack 2013).

Participatory Development Approach

One of the biggest problems with many agricultural technologies over the years have been the tendency to generalize and make recommendations for farmers across large and highly heterogeneous areas without the participation of farmers in the decision making process. However in recent times this problem has been tackled by approaches that signify a need to involve the community at the initial planning stages of projects till the implementation stages. There is an agreement in the literature that to achieve agricultural development, an effective farmer-oriented approach has to be adopted. The participation farmers or the technology users enables co-owning the projects and also boosts the determination of the users to improve the accomplishments (World Bank 2001, El Gack 2007).

The World Bank initially defined participation as a process through which stakeholders influence and share control over development initiatives, decisions and resources, which affect them[2]. As the generalization of all the stakeholders was much criticized the World Bank modified the definition and emphasized on poor and marginal as the primary stakeholders. Participatory technology development is an approach that promotes farmer driven technology innovation through participatory processes and skills building involving experimentation to allow small scale farmers to make better choices about available technologies. Participatory methodologies are often characterized as being reflexive, flexible and interactive, in contrast with the rigid linear central source model (Biggs and Clay 1981). One of the characteristics of participatory approaches lies in innovative adaptations of methods drawn from conventional research and their use in new contexts, in new ways, often by as well as with local people. Another key characteristic of this approach is the emphasis on field based innovation rather than classroom based learning and strengthening links with local research organizations and other sources of new technologies. The accountability between stakeholders is another aspect of this

[2] 1994 Report of the Participatory Development Learning Group

approach through which members in a community/farming systems become more aware of each other's roles and responsibilities.

In summary sustainable farming systems require a more equitable access to productive resources and opportunities to progress towards more socially just forms of agriculture. Apart from being profitable and efficient, establishing compatibility with the social and environmental conditions by pursuing a greater productive use of local knowledge and practices, including approaches widely adopted by farmers traditionally ensures long term sustainability of a farming system (Pretty 1995). Whether a technology will facilitate sustainable farming in communities on a wider scale is a matter of successful diffusion and adoption of this technology. A successful adoption of technologies and practices is affected by a number of technical, socioeconomic, policy, and institutional constraints. Only by properly understanding and addressing the constraints can the process of diffusion and adoption of technology can be efficient. Although external assistance may help in building the infrastructure, this will not be sustainable unless the beneficiaries and local institutions participate in planning and construction, as well as contributing to the cost and management of their operation and maintenance.

Conceptual Framework

Following the above discussion, the study analyses the roles of various stakeholders in development, adoption and diffusion of SALT in the Philippines and SRI in India. As opposed to regarding farmers as passive recipients of technology, the participatory development approach recognizes them as actors with assets and capabilities, which enable them to pursue their goals. The conceptual framework shows the linkages between various stakeholders and how they relate to the desired outcome. It indicates that technological innovation could stem from various actors at macro or micro level and is channeled towards adoption through formal or informal networks of stakeholders. Decision making at farm level to adopt and diffuse these innovations depends on not only the preference of technology but also on the research, information and support provided by institutional stakeholders.

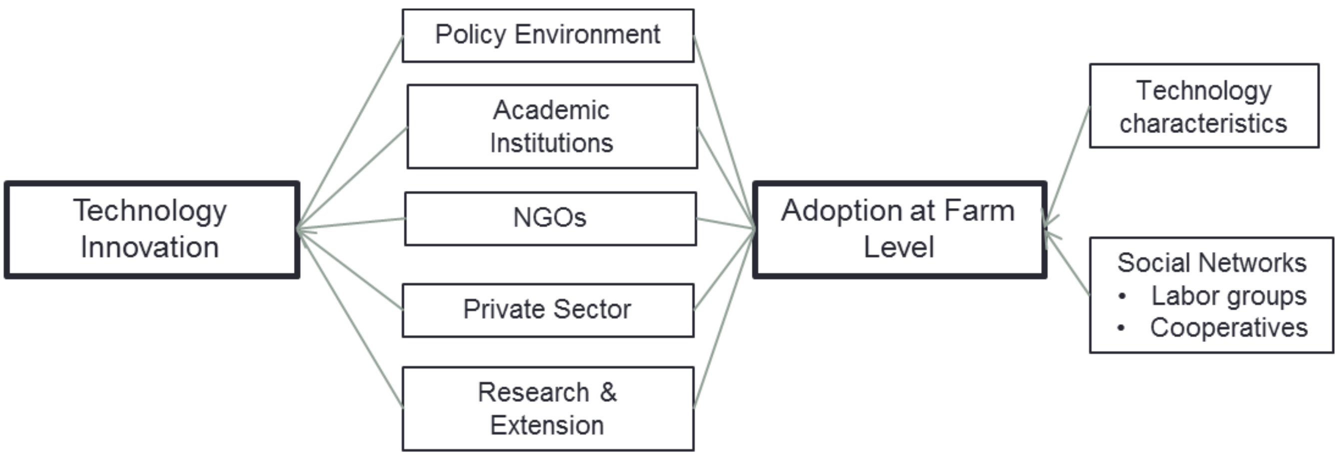

Figure 1 Conceptual framework of the study

CHAPTER 3: UPLAND FARMING SYSTEM AND SALT IN THE PHILIPPINES

This chapter consists of three sections. The first section gives the description of upland farming systems. The second section describes SALT and its development and the last section discusses the adoption and diffusion in the Philippines that includes the description of roles of various stakeholders involved and the barriers faced in the process.

Upland Farming Systems

Upland farming systems, by definition, are found on elevated, usually sloping or steep land. While these systems differ from place to place throughout the Asia-Pacific region, there are some features common to many of them. For example, most are rain-fed and many are based on shifting cultivation. The system is found in humid and sub-humid tropical, subtropical, and temperate environments in upland and hill landscapes of moderate altitude and moderate to steep slope. Soils are generally of low fertility, shallow and susceptible to erosion (Dixon et al 2001). Even today, semi-subsistence tends to predominate, linked with small-scale production by individual households. Much of the cultivated area is terraced which are generally irrigated from local streams and rivers or depend on rain. In some areas, for example in the Philippines and Indonesia, substantial terraces have been constructed for rice cultivation, but in most cases only simple terracing has been developed and soil and water conservation structures are completely absent (Hardaker et al. 1993, Harrington 1993, Pandey 2006).

By their very nature, these systems are environmentally sensitive and vulnerable to over-exploitation. As the intensity of production is increased on lands often with very steep slopes and thin, fragile soils, concern grows about the sustainability of upland agricultural production (Hardaker *et al.* 1993). One of the serious problems facing the uplands is the loss of topsoil from the farmlands and grazing lands. Much of the upland soils easily degrade when subjected to over exposure and over cultivation (Kang 1993). The erosion processes are complex and include natural (geological) and man-induced erosion. The loss of topsoil affects not only the inherent productivity of land but also increases the cost of food production through the loss of nutrients from the soil which require farmers to substitute the loss in the form of fertilizers. In addition to reducing the in-situ productivity and sustainability, it also reduces the sustainability of lowland agriculture through siltation and damage of irrigation infrastructure (Francisco 1994 as cited in Lapar 1999).

Yet upland agriculture is important throughout most of the Asia-Pacific region. The Upland Farming System represents an important part of the agriculture sector in most countries of the region. Table 1 provides basic information on the extent of uplands in selected countries in Asia.

Table 1: Land distribution and population statistics in selected countries in Asia

	Bangladesh	India	Indonesia	Nepal	Pakistan	Philippines	Sri Lanka	Thailand
Land area* (000ha)	13,017	297,319	181,157	13,680	77,088	29,817	6,463	51,089
Upland** (000ha)	5,920	125,900	7,000	1,324	18,300	1,150	225	9,700
Upland*** (000ha)	8,653	208,330	138,233	5,833	27,300	16,180	2,307	27,70
Arable lands (% of total land)	58.6	52.9	13	16.4	26.9	18.1	19.1	30.8
% of population in agriculture	68	51	36	91	45	35	33	39

Source: FAOSTAT, World Bank 2011.
* Excluding area under inland water bodies.
** Excluding area under permanent crop, pasture, forest and woodlands.
*** Including area under permanent crop, pasture, forest and woodlands.

Upland Farming System in the Philippines

In the Philippines, more than 55 percent of the land is upland. These lands are under increasing pressures as the population increases, however; it has received less attention and benefits from government research and extension services than lowland farming systems for reasons like remoteness, complexity of system, lack of water resources, a lack of perception of their importance, etc. (Jodha 1994, Partap 1998, Dixon 2001). Deterioration of natural resources, biodiversity and the overall environment has occurred in many areas. This is a result of high population densities, leading to the extensive cultivation of fragile slopes without the adoption of appropriate soil and water management practices (Dixon et al. 2001).

Of many factors causing land deterioration in the Philippines is the combined effect of population growth and land hunger, and inequitable social conditions of a skewed land ownership. The economic development in postwar Philippines did not provide adequate jobs, resulting in the further marginalization of the impoverished in the uplands (Walpole 1994). The uplands forests are generally subject to mass deforestation for economic reasons. In addition, shifting cultivators due to population pressure move to newly opened areas and begin to practice swidden (slash and burn) agriculture. The intensive agricultural practices applied to the land rapidly degrade the land. At the same time, the marginal or fragile lands have increased from 2 million hectares to 12 million hectares (Walpole 1994, Garrity and Augustin 1995). Despite the fact that irrigated land increased in recent decades, farmers still face problems of water requirements in terms of timing and quantity as water resources have become more scare and valuable.

Environmental issues and legal processes of land title aggravate the problem of availability of suitable land for upland agriculture, especially for small and poor farmers. A critical development issue in the upland areas is lack of security of land tenure. The Philippines consists of 7,107 islands covering 298,170 square kilometers of land and 1,830 square kilometers of water. After independence in 1946, the problems in land distribution kept on emerging (Vargas 2003). Land distribution is highly skewed and despite various land reforms, the majority of rural people remain landless. While considerable swaths of lands have been redistributed, the most productive and fertile private agricultural lands remain with wealthy private landowners (USAID 2011). Information about ownership, boundaries, location, land uses and land values is not provided in a systematic way in many local governments. Thus fraud occurs in land titling and conflicts over land ownership can take years to be solved (Vargas 2003). Because of lack of legal ownership of the lands, farmers are generally unwilling to invest resources in development without secure land tenure or ownership. Land tenure, land leasing and land markets are policy issues that have to be reviewed in order to promote development in upland and mountain areas.

A key concern facing the future development of the upland farming system is the increasing population in hill and mountain areas that is exerting growing pressure on natural resources (soil, water, flora and fauna). Widespread, severe natural resource degradation in many areas has given rise to substantial local costs in the form of lowered yields, mudslides and scarcity of water in the dry season. Low farm income and the general problems of population puts pressure on agriculture which has led to the use of more productive, intensive farming methods in place of traditional subsistence farming. However, intensive farming methods that are suitable for low lands can be disastrous when used in uplands contributing to soil erosion, deforestation, overgrazing, and haphazard natural resource extraction further reducing land productivity.

Upland farming systems require huge labor inputs and need to be properly maintained in order to avoid mudslides, soil erosion, and leaching of nutrients from the soil. Besides that, from an economic point of view, in small sized farms exacerbated by land degradation, the amount of harvest is limited and only a few species of crops are grown. This makes the crops susceptible to pests, plants diseases and natural disasters, which in turn affect the farmers' economy as well. Because of these drawbacks in many Asian countries, sloping land farms have not been effective in alleviating food insecurity. The major changes required in the upland farming system should therefore be concerned with: (i) preservation of the natural resource base; (ii) improvement of technologies for both crop and livestock management; (iii) diversification of products; (iv) increasing opportunities for improved marketing of products; and (v) more responsive agricultural support policies (Dixon et al. 2001, Partap 2004). Development of improved technologies for food production specifically targeted to upland systems can hence be a component of a long-term growth strategy. Such technologies, backed up by supporting policies, can overcome the problem of food insecurity which can further encourage households to diversify into income-generating activities that provide an important pathway for escape from poverty (Lapar and Pandey 1999, Pandey 2006).

Sloping Agricultural Land Technology (SALT)

Sloping Agricultural Land Technology (SALT) is a conservation farming scheme developed by Rev. Harold Watson while working in the Mindanao Baptist Rural Life Center (MBRLC), a non-government organization based in the Davao del Sur province in Southern Philippines during the early 1970's. It is a diversified farming system which can be considered agroforestry where rows of permanent crops are grown between contoured rows of nitrogen fixing plants. SALT as an integrated farming system was initiated in the Philippines to help arrest the alarming devastation of the island’s sloping land. As a mixed farming scheme, SALT has four interrelated objectives (Watson and Laquihon 1985): to minimize soil erosion, to restore soil fertility, to produce food sustainably, and to generate regular and adequate income. The SALT's first two objectives on soil protection and stabilization are to be achieved through the “screening and greening” effects of the double hedgerows of multipurpose woody legumes planted very densely on slopeland contours spaced at 3-4 meters apart. The tree-type legumes are fast coppicing and occupy 25% of the farm area. They have an herbage yield of about 25-30 mt/ha per year, which is perfect for mulching and green manuring. The fulfillment of these objectives then contributes to the other two objectives i.e. sustainable production of food which leads to regular and adequate income generation (Laquihon 1998, Suico et al. 1997).

SALT encompasses a range of components of sustainable farming and is often used synonymously with contour hedgerow intercropping (Garrity 1999). Under this system, the slopes are divided into strips of land for cultivation and separated by double hedgerows of nitrogen-fixing trees or bushes planted along contour lines. These hedgerows are the key element of the entire system. They act as erosion barriers and stabilizers for hill slopes. The hedgerows also contribute to soil fertility through nitrogen-fixation as biomass of the hedges can either used as mulch for soil or recycled back in to the soil as compost. They can often be grown on sites unsuited for food production from conventional crops and in doing so they can stabilize eroding soils and reclaim the land for cultivating other crops.

General Steps of SALT

The procedure involved in SALT is simple, easily applicable, and low-cost consisting of following basic steps (Tacio 1993, ARLDF 1997, MBRLC 2012).

i. *Making the A-frame for laying out contour lines across the slope:*

The frame can be made of three wooden or bamboo poles (two should be about one meter long each and one about one-half meter long to be used as the crossbar of the frame) nailed or tied together in the shape of a capital letter A with a base of about 90 centimeters. The carpenter's level is tied on the crossbar.

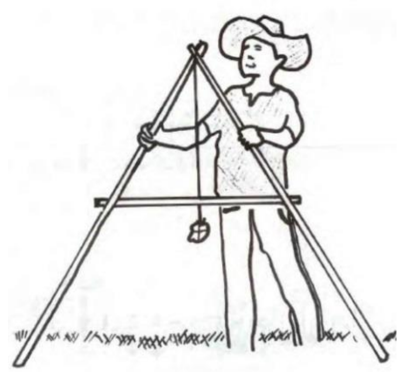

Figure 2: Basic A-frame

ii. *Finding the contour lines:*

One leg of the A-frame is planted on the ground while the other leg is swung until the carpenter's level shows that both legs are touching the ground on the same level. The spot where the rear leg stands is marked with a stake. The same level finding process is repeated with stakes every 2-3 meters distance along the way until one complete contour line is laid out, and until the whole slope is covered. The closer the contour lines to each other, the more potential erosion control occurs. Also, more nutrient-rich biomass is produced and made available to the crops growing in the alley.

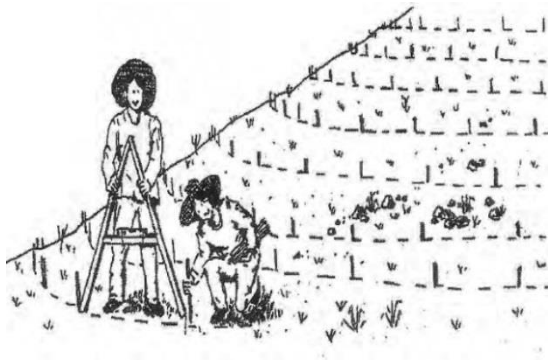

Figure 3: Laying out a contour line

iii. Cultivating the contour lines:

One-meter strips along contour lines are ploughed and harrowed until ready for planting. The stakes serve as guide during ploughing.

Figure 4: Cultivating the contour lines

iv. Plant nitrogen-fixing species:

On each prepared contour line, make two furrows one-half meter apart. Plant the seeds in each furrow so that a thick stand of seedling is grown.

v. Planting the permanent crops:

The space of the land between the thick double rows of nitrogen-fixing trees is called a strip, where the crops are planted. Permanent crops may be planted at the same time the seeds of Nitrogen Fixing Trees and Shrubs (NFTS) are sown. Only the strips for planting are cleared and dug; and later, only ring weeding is employed until the nitrogen fixing trees are large enough to hold the soil for full cultivation to begin. Permanent crops are planted in one strip out of every four. This refers to strips 1, 4, 7, 10 and so on. Coffee, banana, citrus, cacao, and others of the same height are good examples of permanent crops. Tall crops are planted at the bottom of the hill and the shorter ones are planted at the top.

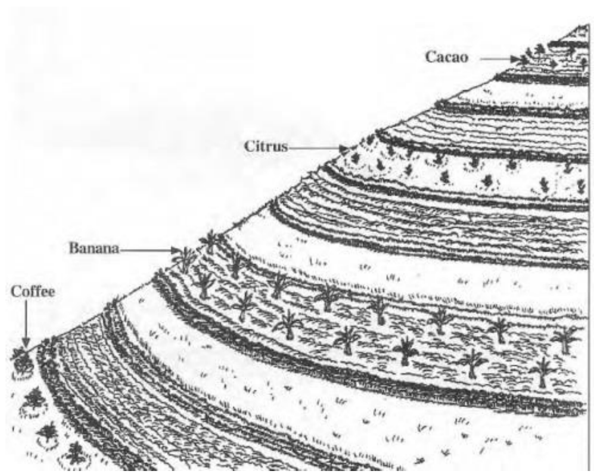

Figure 5: Permanent crops planted in every third strip

vi. *Cultivating alternate strips:*

The soil can be cultivated even before the nitrogen-fixing trees are fully-grown. Cultivation is done on alternate strips, on strips 2, 5, 8 and so on. The uncultivated strips collect the soil that erodes from higher cultivated strips. When the nitrogen-fixing trees are fully grown, every strip can be cultivated.

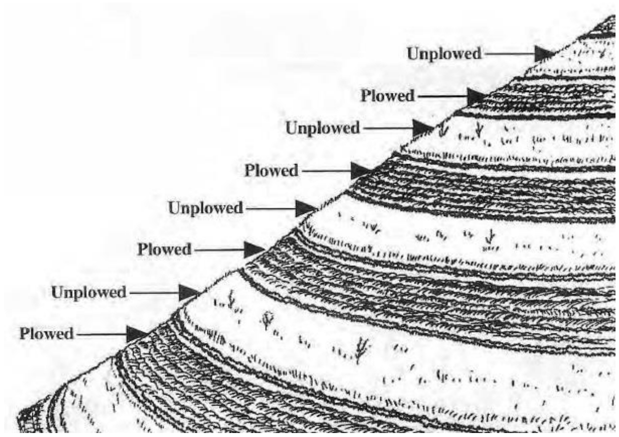

Figure 6: Alternating plowed and unplowed strips

vii. Planting the short-term and medium-term crops:

Short- and medium-term income producing crops are planted between strips of permanent crops as source of food and regular income, while waiting for the permanent crops to bear fruit. Suggested crops are pineapple, ginger, sweet potato, peanuts, sorghum, corn, melons, squash, and up land rice, etc.

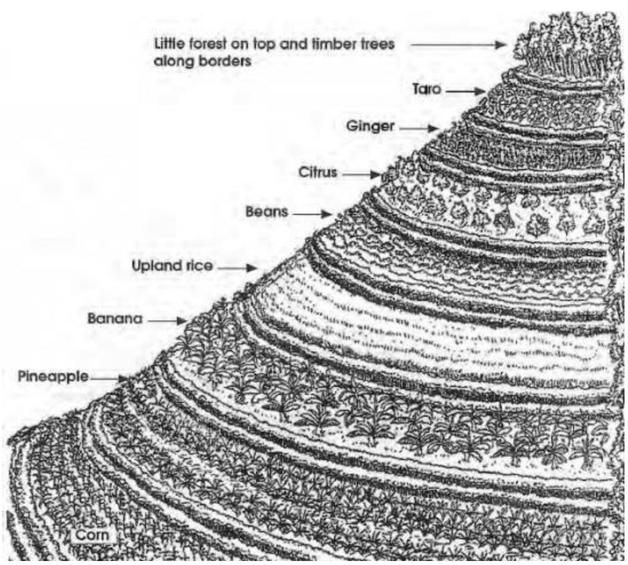

Figure 7: Strips of short term plants in between strips of long term crops

viii. Trimming the nitrogen-fixing trees:

Once a month, the continuously growing nitrogen-fixing trees are cut down at a height of one meter from the ground. Cut nitrogen-fixing leaves and twigs are always piled at the base of the crops. They serve as an excellent organic fertilizer for the plants. In this way, only minimal amounts of commercial fertilizer, if any, are necessary.

ix. Management (crop rotation):

The non-permanent crops are always rotated to maintain productivity, fertility and good soil formation. A good way of doing this is to plant grains (sorghum, corn, upland rice, etc.), tubers (sweet potato, cassava, etc.) and other crops (pineapple, squash, melons, etc.) in strips where legumes (beans, peanuts, pulses, etc.) were planted previously and vice versa. Other crop management practices such as weeding, insect and weed control are also done regularly.

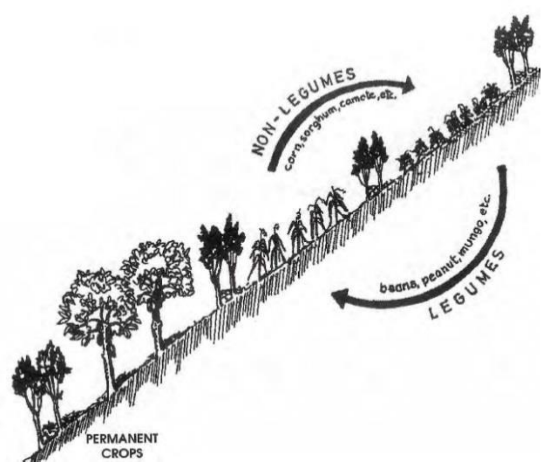

Figure 8: Crop rotation

x. Building green terraces:

To enrich the soil and effectively control erosion straws, stalks, twigs, branches, leaves, rocks and stones are piled at the base of the thick rows of nitrogen-fixing trees. As the years go by, strong, permanent and naturally green terraces will be formed which hold the soil in place.

Figure 9: Buildup of terraces over time

SALT's Approach to Sustainable Farming

The "bio-diversified" scheme of SALT aims at meeting both immediate and long-term needs of the upland household for food, fuel, feed, and cash income. Apart from adequately controlling soil erosion, SALT also helps restore soil structure and fertility, efficient in food crop production, applicable to at least 50 percent of upland farms, easily duplicated by upland farmers, culturally acceptable, have the small farmer as the focus, workable in a relatively short amount of time, require minimum labor, and economically feasible (ARLDF 1997, Laquihon and Pagbilao 1998, Tacio 1993). Because of its focus on small farmers, SALT incorporates major ingredients of sustainable farming such as effective land use by incorporating livestock, resource management, and can be easily replicated on other farms using local resources.

The ability of SALT to reduce land degradation is apparent because of the underlying nutrient recycling practice. The trimmings from hedgerows and crop residues can be used as mulch in addition to contour cultivation, which also is very effective in controlling soil loss. This practice incorporates combinations of contouring, mulching and minimum tillage and could provide a sustainable agricultural practice on hilly topography. An additional attraction is that it is a potential source of a number of farm inputs from within the farm boundaries, protecting the farm's resource base and, ideally, sustaining and increasing yields at the same time (Partap 1994).

Resource Management

There has been widespread awakening to the importance of sustainability in resource management in recent times. Sustainable resource management must be productive, stable, viable, and acceptable to farmers, while protecting soil and water resources. Farms on which contour hedgerow intercropping has been adopted meet these multifaceted requirements of sustainable resource management (Craswell 1998). SALT offers options for alternative hedges or vegetative barriers that can add to the diversity of the agricultural system. Some common alternatives to nitrogen fixing trees and shrubs used as hedgerows are fruit trees, coffee, cacao, legumes, rubber, and pineapple barriers. Pineapples planted on the contour are also effective in reducing erosion. Along with these barriers, locally important plants such as *pitpit*, *valangur* - a stem vegetable, *gaga* - a low lying broadleaved plant used for wrapping betel nut, and banana have been included as possible alternatives. The aim of these treatments is to provide benefits to the farmer from the hedgerow in return for his labor required to establish it. In this case, the conservation value of the hedgerow becomes an added benefit over a longer term.

The effect of SALT practice on annual total runoff and soil loss is made apparent by several studies. Paningbatan (1995) reported a four-year long (1988-1991) field experiment conducted on a 1.2-ha foot slope of Mount Makiling at an experimental farm in Laguna, Philippines. In 1989, soil loss was very large (124 ton/ha) in the farmer's practice (T1). With the use of buffer hedgerows and contour cultivation (T2), soil loss was reduced to 40 ton/ha. When the hedgerow trimmings and crop residues were used as mulch in addition (T3), soil loss was markedly reduced to 3 ton/ha. Similar results were also observed in the data for 1990 and 1991. Table 2 presents the effect of each treatment on annual total runoff and soil loss.

Table 2: Annual runoff (mm) and soil loss (ton/ha)

Treatment	Runoff			Soil loss		
	1989	1990	1991	1989	1990	1991
T1	347	490	30	124	198	99
T2	184	304	115	40	25	4
T3	75	197	72	3	5	0.4

Source: Paningbatan (1995)

The results strongly suggest that this practice, which incorporates combinations of contouring, mulching and minimum tillage, can reduce soil loss in sloping lands and thus aid in sustainable management of upland farms. The pronounced effect of SALT in reducing soil erosion can be attributed to the significant decrease of both runoff and sediment concentration. This indicates that infiltration rates are greatly improved by the presence of hedgerows, contouring and mulching. The undisturbed soil within the hedgerow strip enhances biological activities which favors the formation of stable soil structure with large soil pores. This in turn, favors higher infiltration rates (Paningbatan 1995).

Very little research has been done on water management under contour hedgerow systems. However, one study showed that water is managed more effectively in the lower alleys because the total root density of mono-species hedgerows and food crops increased from upper to lower alleys (Agus 1997). On the other hand Singh et al. (1989) observed in his study that there was severe competition for water between hedgerows of *Leucaena leucocephala* and food crops in water scarce semi-arid regions.

Besides controlling erosion, the buffer hedgerow in an alley cropping system can serve as an effective living structure for nutrient cycling. The ability of nitrogen fixing trees to grow on poor soils and in areas with long dry seasons makes them good plants for restoring forest cover to watersheds, slopes and other lands that have been denuded of trees. Through natural leaf drop they enrich and fertilize the soil. There is also a reduced need for expensive inputs like chemical fertilizers (Partap and Watson 1994) because of the organic matter that is added to the farm. In addition, they compete vigorously with coarse grasses, a common feature of many degraded areas that have been deforested or depleted by excessive agriculture thus reducing the labor to cut the grass. Maniego (1986 in Pannigbatan 1995) reported that 5 tons of dry herbage from Leucaena hedgerow trimmings produced in one year can provide about 145 kg N, 15 kg P and 75 kg K per hectare, which could supply the fertilizer needs of the alley crops. The SALT project on the island of Mindanao reported that hedgerows occupying 20% of the land area produced about 290 kg N and 100 kg K per hectare per year (Watson and Laquihon, 1985). Furthermore, as the age of hedgerows increases, soil-conserving and yield-enhancing properties improve (Shively 1999).

Productivity and Economic Viability

SALT's objectives on managing land productivity can be accomplished by growing farmer preferred high-value crops. These crops, which can occupy up to 75 percent of the farm area, are grown on the strips between the double hedgerows at a proportion of 2/3 annuals and 1/3 perennials (Laquihon, Suico et al. 1997). Partap et al. (1996) argue that cost-benefit analysis (labor and chemicals versus marketable yield) indicates that for the early years after establishment, the benefits of the hedgerow treatments do not outweigh the costs to the farmer, unless the species planted on the contour is a cash crop. Partap and Watson (1994) also assert that for the first two years, the net income from SALT farming is less than the net income from traditionally farmed lands however in the later years income from SALT farming starts increasing and surpasses the net income from traditional farms. A consistent pattern is that the cost of establishing hedgerows exceeds returns initially (due to labor costs and forgone production), however with time, hedgerows appear to provide yield benefits than the conventional practices (Nelson et al. 1998, Shively 1999). Farmers are more interested in species that have multiple benefits and provide direct impact on both short and long run. Therefore SALT systems that utilize legume shrubs, fruit trees, coffee, cacao or rubber provide useful economic returns. Cash derived from hedgerow trees and/or shrubs may provide an incentive for SALT adoption by farmers, as well as funds to purchase other external inputs and tools (Craswell 1998).

SALT enables farmers to stabilize and enrich the soil and to grow food crops economically as very little to no inputs (such as chemical fertilizers) are required. Under low input conditions SALT performs as an optimum production system focusing on long term sustainability. The SALT scheme is tailored for small farms and for raising both annual food crops and permanent crops. Small farmers with few tools, little capital and little knowledge of modern agriculture can use SALT effectively (Partap and Watson 1994).

Adaptability of SALT to Varying Conditions

As an integrated system three other SALT systems have evolved from the original system, SALT 1, which combines agricultural crops and hedgerows in the ration of 75:25. SALT 2 integrates goat husbandry, SALT 3 is a combination of small scale afforestation with food production, and SALT 4 focuses on fruit trees as cash crops (ARLDF 2004, Critchley et al. 2004, Laquihon et al. 1998). The other SALTs are:

• *SALT - 2* (Simple Agro-Livestock Technology)

This scheme is a small-scale livestock based agroforestry system. Land use is divided into forage garden, field crops, and the livestock barn (preferably dairy goats). Forty percent of the land is used for agriculture, another 40 percent for livestock and the rest 20 percent for forestry or contour hedgerows interspersed throughout the farm. As in conventional SALT, hedgerows of different nitrogen fixing trees and shrubs are established on the contour lines. The manure from the animals is utilized as fertilizer both for agricultural and forage crops.

A new variant of SALT -2 called the *SUPER- SALT* integrates the elements of the so-called "modern" farming, such as high yielding varieties (HYVs), commercial fertilizers, pesticides, and appropriate farm equipment into the SALT-2. Only purebred and high milk producing cattle are used as breeding stock. In a sense, Super SALT is a much amplified version of SALT-2, thus the adjective "super" (Laquihon et al. 1998).

• *SALT - 3* (Sustainable Agro-forest Land Technology)

It is a cropping system in which a farmer can incorporate food production, fruit production and forest trees that can be marketed. Also referred to as the "food-wood" integrated system, the upper half of the slopeland is for timber crops of short, medium, and long-term harvest periods. The lower half is planted with food crops and woody legumes, following the SALT-1 pattern. Fruit trees can be planted between the contour lines. The plants in the hedgerows can be cut and piled around the fruit trees for fertilizer and soil conservation purposes. In areas where the soil is too steep for row crops, contour lines may be established 2-3 meters apart and planted with suitable hedgerow species. In between the hedgerows, coffee, cacao or other permanent crops can be planted.

• *SALT - 4* (Small Agro-fruit Livelihood Technology)

This system is based on a half-hectare sloping land with two thirds of the total land developed for fruit trees and the rest intended for food crops. Hedgerows of different NFTS are planted along the contours of the farm.

Limitations

Adaptability of this technology to varying local conditions and to meet different needs of farmers is a huge benefit of SALT. Farmers can choose and adopt the kind that suits his/her need and land situation and can even further integrate or recombine all the four SALT variants into the land. However, there are some inherent features of these farming systems, which can become constraints for the application of SALT farming in small farms where the division of land for variation of SALT does not seem feasible.

Although some farmers viewed contour hedgerows as effective for control of soil erosion, their suitability is not appreciated by most. Major reasons for the dislike of contour hedgerows is: reduction in arable land area, lateral spread of hedgerows over the field and shading vegetable crops, regular maintenance requirements, and not providing immediate financial return (Poudel 1998). Constraints include the tendency for the perennials to compete for growth resources and hence reduce yields of associated annual crops. Moisture competition between hedgerows and associated crops was seen as a problem when alley cropping is used in drier areas, particularly if the hedgerows are spaced closely (Kang 1993). But the major problem is the extra labor needed to prune and maintain the hedgerows. Vegetative techniques like SALT are generally less expensive but labor-demanding compared to engineering practices.

SALT in the Philippines

Sloping Agricultural Land Technology (SALT) is a conservation-farming scheme developed by Rev. Harold Watson while working in the Mindanao Baptist Rural Life Center (MBRLC), a non-government organization based in the Davao del Sur province in Southern Philippines during the early 1970's. SALT as an integrated farming system was initiated in the Philippines to help arrest the alarming devastation of the island's sloping land. This section discusses the innovation history of SALT and the role of various actors in its adoption and diffusion in the Philippines. Furthermore, it discusses governance and land tenure issues in the Philippine upland to help understand the barriers for adoption of new technologies.

Innovation History

In early 1970s the Philippines was deforesting its landscape at the rate of almost 200,000 hectares per year. Monocropped shifting cultivation, often known as *kaingin* was and still is the predominant form of agriculture in the Philippines (Liu et al., 1993; Laquihon et al. 1997). In the uplands the migrants from the low lands plowed deep and downhill the sloping lands, much as they had done in the lowlands. This along with other factors such as heavy use of pesticides, and unmanaged resource use were diminishing plant and animal diversity, a decreasing water and fuel supply, soil erosion, river siltation, and shoreline sedimentation leading to decline in crop yields to unprofitable levels (Fujisaka and Garrity 1988, Garrity 1999). Farmers were concerned about the consequences and it became evident that practical conservation farming options were needed to address the issues that several upland farmers were facing (Tacio 1993).

In 1973, Watson from MBRLC, met Dr. James L. Brewbaker in Hawaii who gave him some seeds of *Leucaena leucocephala*, collected by Dr. Brewbaker and his colleagues in Central America. Watson planted the *Leucaena* seeds at several locations on MBRLC's 19 hectares. Watson and his associates were struggling to hold up their terraces in the sloping lands and it became evident that this could best be done with living trees and that the *Leucaena* as a nitrogen-fixing legume was suited to all soil types except the most acidic soil sites. They kept on experimenting. At first they planted one row of *Leucaena* but if several trees did not grow so well, there would be several gaps on the barrier for soil to wash through. Finally they settled on planting two dense rows with seeds of *Leucaena* just half a meter apart. Two dense rows made a reliable hedge and the soil that washes off the slope could be built up against the hedge to make the terrace. In 1978, Watson and his associates finally verified and completed the scheme and called it Sloping Agricultural Land Technology or SALT (Tacio 1993).

MBRLC as the Forerunner

In 1978, a hectare of land was selected as a test site at the MBRLC. The site was typical of the surrounding farms in that it had a slope steeper than 30%, had been farmed for 5 years or more, and had soils similar to those of most farms in the Philippines upland. Contour lines were carefully established with the aid of an A-frame, and the planting of hedgerows and permanent crops began. This experiment was done so as to demonstrate SALT and this site was used by MBRLC as a training site. In the early 1980s, SALT began spreading to surrounding farms and villages (Watson 1995, MBRLC 2012). The MBRLC conducted various training and extension programs to hasten the adoption of this technology. They established a presence in some of the more remote areas of the country to promote this technology (Cramb *et al*. 2003). The 19-hectare demonstration farm located in the rolling foothills of Mt. Apo in Mindanao is basically a training center for small-scale upland farmers. The usual duration of a SALT training course is 3-5 days with each training group consisting of 20-35 people. Initially MBRLC supported the trainees with seeds and materials to facilitate the adoption. The dissemination throughout Mindanao province, where the center was established, was done mainly through church groups (Watson 1995). Out-of-school Youth Program was a special training program provided to young people who left school early, mainly for financial reasons, which focused on agriculture with an emphasis on SALT.

MBRLC utilized an impact area approach in extension. In an identified area, a team of extension workers - usually composed of agriculturists, health workers, and community development trainers - worked together with the villagers for the development of the area (MBRLC). Between 1980 and 1992, MBRLC developed teaching aids such as leaflets, manuals, bulletins, flip charts, transparencies and slides which were also broadcast over the Center's radio program transmitted by various radio stations. Radio listeners requesting copies were supplied free of charge. Newspapers and magazines with a good circulation also received copies (Watson 1995).

Role of the Government

Even though SALT was developed by MBRLC, an NGO; the Department of Agriculture (DA) in the Philippines contributed its own initiatives for developing upland agriculture systems.

The DA began promoting SALT in the early 1980s. In the following years contour hedgerow farming with leguminous trees became a common feature of extension programs for sustainable agriculture on the sloping uplands (Garrity 1996, Nelson et al. 1998). These projects were carried out in different provinces thus following a province – by – province approach where they were introduced differently by various government entities, international development agencies, and NGOs. Some of the major projects implemented in the Philippines are discussed in the following section.

SALT Related Projects

Between 1982 – 1992, there were several projects there were implemented in various parts of the Philippines that included SALT in the agenda. Most of the projects carried out by the government in collaboration with international funding agencies. Some of the major programs are listed below.

Integrated Social Forestry-DENR and USAID:

The Department of Environment and Natural Resources (DENR) initiated the Integrated Social Forestry (ISF) in Magdungao, Iloilo Province in 1979; however there were few activities until 1986. The project, which was funded by DENR and the United States Agency for International Development (USAID), had livestock dispersal programs for buffaloes, horses, goats and pigs, and also provided participants with ducks and chickens. From 1983 to 1988, USAID and the government of Philippines established agroforestry projects in Philippines and introduced contour hedgerows as the primary focus. The project also provided the farmers with incentives (Pattanayak 1998). USAID supported the system in other parts of the country with initial success of attracting farmers by providing economic incentives such as seeds and technical support. There were high levels of adoption initially, however much of this was attributable to the material and monetary incentives offered by the project. (Ref)

The Upland Stabilization Project- Philippine Government and ADB:

In Palawan Province, the Upland Stabilization Project (USP) was implemented during 1982-1990. Asian Development Bank (ADB) and the Government of the Philippines funded the project with the stated objective to facilitate agroecologically sound utilization of the upland areas and stop further degradation resulting from shifting cultivation (ADB 1991). However, primary emphasis was given to the elimination of shifting cultivation. Many farmers practicing shifting cultivation resisted participation. To overcome this resistance, a mixture of inducement and coercion was used. The project provided planting materials, fertilizer, and money for labor, which overcame the major material constraints to initial adoption. At the same time, the very presence of project staffs, combined with their authority to grant or withdraw cultivation rights based on adherence to project requirements, exerted strong pressure to adopt recommended technologies and land-use practices (ADB 1991, Cramb 2000). Adoption of contour hedgerow intercropping started soon after the project began but also declined rapidly thereafter. About 50 percent of the farmers in the project area had adopted contour hedgerows. Some of the adopters had merely allowed the project to establish hedgerows or terraces on their farms through paid contract workers, without understanding the purpose of the measures or being convinced of their benefits. Hence, they did not know how to establish or maintain the structures. After the project staff left, most of the farmers did not continue the practice. Significantly around 33 percent of "adopters" abandoned or actively destroyed the conservation measures established (Cramb 2000).

Soil Conservation - DENR and World Neighbors:

The World Neighbors, an international development organization, in collaboration with the DENR, promoted a range of soil conservation practices including contour hedgerows in Cebu in the early 80s. The strategy to promote SALT was a participative, community-based approach where farmers were included in planning, decision-making, management and implementation, with the long-term view of transferring responsibilities to the farmers; extension and training; encouraging farmers to adopt conservation farming and practice crop diversification on cultivated land. They provided technical and material assistance; communal reforestation; and the development of infrastructure and facilities. Overall, the contour hedgerow technology spread around the initial target area and the Cebu case is often cited as a successful example of adoption of soil conservation technology (Garrity 1993, Lapar and Pandey 1999, Lapar and Ehui 2004).

Certificate of Stewardship Contracts-Philippine Government:

Some other strategies the government used was to include the households in Domang, northern Luzon under the Certificate of Stewardship Contracts (CSCs), a conditional 25 year lease of public forest land requiring farmers to establish agroforestry measures such as contour hedgerow cropping for soil conservation. Under this program not only the farmers were provided with the security of land with a lease but also economic incentives per meter of hedgerows established. This program also involved higher levels of funding and excellent extension support. One participant’s farm was used as a demonstration farm and training site. Between the start of this program in 1984 and the end in 1993, 90 percent of the residents of the village had adopted contour hedgerows (Cramb 2000). In this case, the successful adoption of the technology occurred due to the land tenure under CSC, energetic extension workers and the payment of subsidy to establish hedgerows.

Integrated Social Forestry Project -DENR and Academic Institutions:

The DENR in the Philippines also used the same strategy of proving land tenure to farmers in Maganok village and Bukidnon Province. An Integrated Social Forestry Project (ISFP) began in collaboration with Central Mindanao University and Xavier University between 1988 and 1992, which was funded by the Ford Foundation. What was different in this project was that lead farmers were chosen from villages included those who had attended seminars, workshops and trainings in various places. They were allowed to choose a package of SALT (SALT 1, SALT 2, SALT 3, or SALT 4) and when they came back they were assisted by the project team members to implement it on their farms. Once their farm was established these farmers were encouraged to act as extension agents and were provided monetary incentive for successful establishment of hedgerows on other farms. This strategy worked initially but the adoption rate dropped after the project ceased, many stating that they did not have enough knowledge about the technology since the lead farmers established the hedgerows.

The projects discussed above can be compared in terms of the organizations involved, the strategy they used for promotion and adoption and the outcome of the project. It is listed in the following table.

Table 3: Comparison of the projects

Organization(s) involved	Project	Location	Strategy	Year	Outcome
DNER, USAID	Integrated Social Forestry	Magdungao, Iloilo Province	Provided economic incentives; seeds, livestock etc.	1983-1988	High number of adoption initially
Philippine Government, ADB	Upland Stabilization Project	Palawan Province	Elimination of shifting cultivation	1982-1990	50% adopters initially, 33% of initial adopters abandoned
DENR, The World Neighbors	Soil conservation	Cebu	Participatory, community based approach, provided technical and material assistance	Early 80s	High levels of adoption
Philippine Government	Certificate of Stewardship Contracts	Domang, northern Luzon	Lease of public forest land requiring farmers to establish agroforestry measures	1984-1993	High level of adoption
DENR, Ford Foundation, Central Mindanao University, Xavier University	Integrated Social Forestry Project	Maganok village and Bukidnon Province	Trained lead farmers, Farmers-to-farmers extension	1988-1992	Initial adoption dropped after program ceased

Research and Extension

A number of agricultural colleges and universities developed research and demonstration SALT farms under the Agricultural Education, Outreach Project (AEOP), which received financial support from the USAID during the 1980s (Tacio 1988). Significant resources have been committed to research and extension of hedgerow intercropping in the Philippine uplands by domestic and international agencies. Institutions spearheading R&D in farming systems in the

Philippines includes the International Rice Research Institute (IRRI), a non-profit research and training organization; the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCAARRD), a sectorial council under the Department of Science and Technology (DOST); and the University of the Philippines at Los Baños (UPLB). The Farming Systems and Soil Research Institute (FSSRI), an institute based in the College of Agriculture in UPLB, replicates SALT and provides leadership in developing strategies for technology dissemination.

In 1985, IRRI initiated a farming systems research program in acid uplands of Claveria, Misamis Oriental province in collaboration with the Department of Agriculture. A contour hedgerow-based farming system was promoted using the farmer-to-farmer extension approach based on the strategy of the World Neighbors project in Cebu (Fujisaka and Garrity 1988, Cramb et al. 2003). Sixty-four out of 182 farmers trained had established contour hedgerows by the end of 1990 (Fujisaka 1993, Cramb et al. 2003) but about one fourth of the initial number of adopters abandoned the technology stating that the choice of species planted as hedgerow was not effective for them (Lapar and Ehui 2004). The International Centre for Research in Agroforestry (ICRAF) took over the IRRI research site in Claveria in 1993 and proceeded to conduct field trials on contour hedgerow systems. While contour hedgerows were considered ineffective and subsequently abandoned by about 25 percent of the initial adopters, others modified and/or maintained their hedgerow structures.

Between 1980 and 1992, there was active involvement of institutions and organizations that adopted SALT in their upland development projects (Table 4). Despite the resources for research and extension, adoption of hedgerow intercropping by upland farmers in the Philippines has been currently sporadic and transient, rarely continuing once external support is withdrawn.

The national government continues to provide bulk of the budget for research and extension support but so far it has failed to develop an effective institutional structure to provide overall leadership and coordination of the various activities conducted by numerous units of the DA (Balisacan and Hill 2003).

Table 4: List of government and non-government institutions adopting SALT (1981-1992)

Organization	Category	Year	Estimated number of farmers involved
Federation of Free Farmers	NGO	1981	15
Forest Management Bureau	GO	1981	15
Southern Philippines Devt. Authority	GO	1982	15
Kilusang Kebuheyen at Kaunlaran	GO	1982	100
Phil.-Australian Devt. Assist. Program	GO	1982	700
Department of Agrarian Reform	GO	1982	10
Agri. Education Outreach Project	GO	1983	150
Farm Systems Dev. Corporation	GO	1983	30
Davao Medical School Foundation	NGO	1983	20
Farmers Training Center for Rural Development	GO	1984	50
Department of Agriculture	GO	1984	500
Overseas Missionary Fellowship	NGO	1984	20
National Electrification Administration	GO	1985	503
Save the Children Foundation	NGO	1985	25
Support Technology Assisting Rural Transformation	NGO	1985	10
Cotabato Rural Upliftment Movement	NGO	1985	15
International Human Assistance Program	NGO	1985	15
Catholic Santa Cruz Mission	NGO	1985	50
Regional Rainfed Development Program	GO	1985	30
Philippines Business for Social Progress	NGO	1986	50
Resource Ecology Foundation for Regeneration of Mindanao, Inc.	NGO	1987	100
DAR-UNDP-Food and Agriculture Organization	GO	1988	150
Central Visayas Regional Project	GO	1988	50
Meralco Foundation. Inc.	NGO	1989	200

Table 4 (continued)

Organization	Category	Year	Estimated number of farmers involved
Regional Rainfed Development Program	GO	1985	30
Philippines Business for Social Progress	NGO	1986	50
Resource Ecology Foundation for Regeneration of Mindanao, Inc.	NGO	1987	100
DAR-UNDP-Food and Agriculture Organization	GO	1988	150
Central Visayas Regional Project	GO	1988	50
Meralco Foundation. Inc.	NGO	1989	200
Kapwa Upliftment Foundation, Inc.	NGO	1989	30
Mag-Uugmad Foundation, Inc.	NGO	1989	50
Muslim-Christian Agency for Rural Development, Inc.	NGO	1989	15
Soil and Water Conservation Foundation	NGO	1990	100

Source: www.agnet.org

Challenges and constraints in adoption and diffusion

Although effective in reducing soil erosion, farmers' adoption of SALT in the upland farming systems of the Philippines has been very low (Partap and Watson 1994, Garrity 1999). This is partly because of SALT's high cost of establishment (Garrity 2002, Fujisaka 1993) but also more significantly because of the institutional factors such as the land ownership and governance factors (Nelson 1998, Garrity 1999, Cramb 2000, USAID 2011). Land tenure is a big problem in the country, which is seen as a huge barrier in adoption of not only SALT but other agricultural technologies as well. The problem is land tenure and governance factors are descried in the following sections.

Issue of Land Tenure

Philippine history shows that traditionally the land-tenure arrangements in pre-Hispanic Philippine society were characterized by communal ownership of land. But over the years under different colonial rules, the land distribution tended to become concentrated in landed elites resulting in displacement of large masses of peasants. The post-independence government also pushed out indigenous peoples from their ancestral lands for infrastructure projects, marginalizing them and making them landless. It has also been asserted that the Philippine government, controlled by landed elite, has been reluctant to provide farmers with full legal titles to the land that they cultivate (Takigawa 2007, Vargas 2003). The state has instituted various land reforms, the latest of which is the 1988 Comprehensive Agrarian Reform Law (CARL). The CARL broadened the scope of rural land reform by including private and public agricultural lands regardless of crops and tenure arrangements, and providing for support services to agrarian reform beneficiaries, including infrastructure, capability-building and credit/marketing assistance. Lands were to be distributed to landless farmers and farm workers within a period of 10 years, but when this was not achieved, the law was extended for another 10 years, and then again extended until 2014.

While considerable swaths of land have been redistributed, the most contentious private agricultural lands, which are also the most productive and fertile, remain with wealthy private landowners (Vargas 2003, USAID 2011). This means that the poor are left with less productive and difficult lands found mostly in the upland areas. Where farmers do not have long-term security of tenure, there is less likelihood that they will invest in the long-term sustainability of their land. The security of land tenure affects farmers' planning horizons, and the confidence with which they can expect to capture the long-term benefits of investments in new technologies and practices (Cenas and Pandey 1996, Nelson 1998).

Uplands and Governance

The Philippine Government defines uplands as lands with at least 18 percent slope, lands that fall within mountain zones including plateaus lying in high elevations, and lands with hilly and mountainous terrains (Bureau of Forest Development). However, the technical definition of what constitutes the uplands has always been a topic for debate. There are attempts to differentiate the uplands from hilly lands and highlands, with uplands being only those with 18 percent in slope, while highlands are those that fall in high elevations, regardless of whether they have slopes 18 percent or higher. While this debate is not the focus of this study, one can however not ignore its bureaucratic implications. In this differentiation made by the government, some types of uplands are limited to lands above 18 percent in slope and under the Forestry Reform Code of 1975 are placed under the administrative jurisdiction of the Forest Management Bureau (FMB) of the DENR. On the other hand, significant portion of hilly lands, particularly those that fall below 18 percent in slope, are placed under the administrative jurisdiction of the DA, the Local Government Units (LGUs) and the Department of Agrarian Reform (DAR). Thus the uplands possess a bureaucratic identity that involves several government agencies (Contreras 2006).

A portion of the uplands under the jurisdiction of DENR are suitable for agriculture but are managed in the context of Forestry Reform Code of 1975 that puts emphasis on conservation rather than agricultural land development. Later policies and programs have gradually accommodated upland cultivation, but are subject to regulation and control. The DENR focuses on conservation, but has yet to implement a comprehensive approach to enhancing upland agricultural productivity through crops cultivation and livestock production. The agency supposed to address the issue of agricultural development is DA (Contreras 2006).

Unfortunately, the DA has yet to fully articulate a well-defined upland agenda. The Agriculture and Fisheries Modernization Act of 1997 (AFMA) doesn’t have a single reference to upland agriculture. This is also evident in the marked absence of data on the actual contribution of upland agriculture to national agricultural productivity, and to GDP and GNP. The multiplicity of institutional actors and of definitions makes the uplands problematic for the state to fully address. This intensifies the problem of fit between the current bureaucratic system and the development aspects of the uplands. The overlapping of the functions of different institutions has also led to the fragmentation of the agricultural research and extension system (Balisacan and Hill 2003). A weak research and extension system is a huge barrier for proper adoption and diffusion of new technologies/practices because of inadequate commitment and execution of evaluation.

Farmers’ Difficulties in Adopting SALT and its Variations

Cramb (2004) highlights the main reasons for farmers not adopting SALT as lack of time or interest, the perceived difficulty of maintaining contour hedgerows, and lack of ownership rights to the land. On the other hand, inadequate consideration of farmers’ local knowledge and resources, and poor participation of farmers in the research process are also regarded to be the main reasons for the poor adoption rate of SALT and its variations.

A high labor requirement in establishing and managing hedgerows was one of the major constraints to the adoption of complex SALT systems. Many farmers were resistant to adopting SALT mainly because the technology was labor (and skill) intensive (Nelson 1998, Garrity 1999, Cramb 2000, Cramb *et al.* 2003). In a study by Shively (1999), farmers reported 54 percent greater labor use per hectare on hedgerow plots than conventional plots. Researchers also found that farmers' labor investment to prune their leguminous-tree hedgerows was about 31 days per hectare, or 124 days of annual labor for four pruning. This increased the total labor for upland rice an average of 64 percent. Labor for a maize crop increased 90 percent due to pruning operations. Such an increase in production costs was seldom rewarded by a commensurate increase in returns (Garrity 1999). However Watson and Laquihon (1985) maintained that SALT is not a miracle system and there is not and never will be one system for all farmers. To establish a one-hectare SALT farm requires much hard work and discipline. They further stressed that it took many years to deplete the soil of nutrients and lose the topsoil and no system can bring depleted, eroded soils back into production in a few short years. Since the potential benefits of SALT (soil erosion control and fertility enhancement) are long term, this system can be studied and further improved.

Other factors such as poor adaptation of leguminous trees in acid upland soils and sources of planting materials not readily available (Mercado et al. 2001) were also seen as a barrier for adoption. Above and below ground competition between the hedgerows and food crops may reduce crop yields, which was also a limiting factor for adoption (Garrity 1999).

Summary

SALT was developed as a solution to the land deteriorating practice of slash and burn or shifting cultivation practiced in the Philippines. When it was introduced to the farmers who practiced shifting cultivation they resisted it because it was a drastic change from their traditional way of farming. In many cases monetary incentives were provided to encourage adoption. In some cases to overcome the resistance of farmers, the government employed a mixture of inducement and coercion. Farmers did not maintain the conservation measures and many actively removed them. They lacked the understanding, conviction, or resources necessary to adopt the technologies in the true sense of the term, that is, to maintain and reestablish them beyond an initial trial period. Even though MBRLC provided on farm trainings at its centre in Mindanao, farmers' adoption of SALT was still very low. However in Cebu and Managok where a participatory approach was applied, the rate of adoption was higher than other regions. High-value contour hedgerows are effective measures for reducing soil erosion and for use of income-generating crops; however for a variety of reasons the adopters abandoned the practice. Farmers who did not own their land are likely to not adopt the technology and even those who did are likely to abandon it after some time. Most find the maintenance of hedgerows to be too labor intensive. This highlights the need to further improve the technology to widen its domain and to target to those who are more likely to adopt and retain it. Modified versions like NVS adopted by farmers require less labor to establish and maintain than SALT. The evolution of low cost farmer adaptations of hedgerow intercropping demonstrates that economic viability is an important consideration in deciding whether to adopt.

CHAPTER 4: RAINFED FARMING SYSTEM AND SRI IN INDIA

This chapter consists of three sections. The first section describes rainfed farming systems. The development and methods of SRI are discussed in the second section. The last section comprises the adoption and diffusion of SRI in India with the description of roles of various stakeholders involved and the barriers faced in the process.

Rainfed Farming Systems

The rainfed farming system covers a large area in Asia, mostly within South Asia. The system is not supported by any large irrigation system, but in many instances relatively small irrigated areas reduce vulnerability to drought and permit dry season cropping. Being mostly dependent on rainfall, the system faces relatively high levels of risk. Agriculture is oriented towards subsistence; while most areas are poorly served by infrastructure and services, and are remote from markets (Dixon et al. 2001). Table 5 shows the status of rainfed agricultural lands in selected Asian countries.

Table 5: Rainfed agricultural lands in selected Asian countries

Country	Total rain fed area (10^6 ha)	Rain-fed area as proportion of total arable land (%)	Rain-fed production as proportion of agricultural GDP (%)	Population dependent on rain-fed agriculture (%)
Indonesia	9.1	62.7	19.1	36.8
Philippines	6.5	82.3	22.3	36.0
Thailand	13.8	81.6	49.9	59.4
Bangladesh	7.7	81.6	40.5	41.0
India	100.0	69.5	25.7	42.2
Nepal	2.6	84.0	40.9	74.8
Pakistan	5.4	26.7	4.6	11.5
Sri Lanka	0.5	49.4	20.1	29.1

Sources: ADB and Devendra et al. (1997, 2000).

Because of its dependence on rain, seasonal vulnerability is a critical attribute in this type of farming systems and is considered as one measure of poverty (Dixon et al. 2001). Crop failure in this system is therefore more likely than in other major farming systems. Agricultural extension services in these areas are typically weak; farmers mostly use traditional technology with a strong bias towards risk avoidance. Land tenure is often an issue and farmers may not have sufficiently clear titles to their land to be able to use it as collateral for obtaining institutional credit (Kerr 1996, Dixon et al. 2001). Unlike the upland farming system, the enterprise trends in rainfed farming systems, especially in South Asia, have been changing driven by market forces. However access to sources of information is important for the intensification and diversification of these systems. It is expected that there will be increasing scarcity of fresh water resources as agricultural and urban demands increase. Land degradation, including soil fertility is an increasing phenomenon and the use of hybrid seeds has become more widespread (Sterrett 2011).

Little can be done to significantly reduce poverty within the rainfed farming systems without increasing the overall water security of the farm household. If the improvements are to be sustainable, they will require social mobilization and participatory planning within the region. Along with that the emphasis must shift to the maximization of moisture and soil conservation for increased and sustained production.

Rainfed Farming System in India

India is one of the largest agricultural producers in the world. It has some 195 m ha under cultivation of which more than 63 percent are rainfed (World Bank 2012). Small and marginal farmers, whose land holdings are below 2 hectares, constitute almost 80% of all Indian farmers, and more than 90% of them are dependent on rain for their crops. A typical rainfed mixed poor farm household in India with six family members cultivates 3 ha of land. The crops include one ha sorghum (post-rainy season) with a yield of 1.3 t/ha, about 0.5 ha of chickpea yielding 0.85 t/ha, 0.2 ha of pigeon pea yielding 0.5 t/ha, 0.3 ha of groundnuts yielding 0.6 t/ha, 0.2 ha of rapeseed yielding 0.7 t/ha. The household owns two head of cattle, several goats and some poultry. It has a combined average income just beneath the international poverty line, and it is also vulnerable to crop failures (Dixon et al. 2001).

Low productivity of crops in India can be associated with many factors, including high dependence on rains, delayed sowing and transplanting, frequent floods and droughts, low sunshine hours with a cloudy weather, deficiency of micro nutrients and impaired soil health (Gujja et al. 2008). The technological and nutrient-related constraints both affect the total factor productivity. Several factors such as improper management of water resources, inefficient farm management, poor crop husbandry, ineffective infrastructure and unplanned capital development has plagued agriculture in India (Gujja et al. 2008). Increased yields achieved during the green revolution through intensive methods of high water and fertilizer use are now showing signs of stagnation. Environmental problems such as salinization and water logging of fields are prominent in many states like Haryana and Punjab (Prasad 2006). Agriculture is India’s largest use of water. Increasing competition for water between growing industries, domestic use for increasing population, and agriculture highlights the need for improving water resources and irrigation management. In parts of India the over pumping of ground water for agriculture is leading to falling groundwater levels and increasing water logging leading to the build-up of salts in the soils (World Bank 2012). Therefore in rainfed areas where the majority of rural population lives, agricultural practices need adapting to reduce soil erosion and increase the absorption of rainfall. Enhancing productivity of not only rice but other crops and vegetables as well that are native to particular regions can lead to greater food security for farming families. Considering deteriorating natural resources and increasing food insecurity India's agriculture, now in a post-green revolution stage of development, requires new strategies to enhance agricultural growth and address environmental concerns (Sharma 2004).

System of Rice Intensification (SRI)

System of Rice Intensification (SRI) was developed in Madagascar in the 1980s by Fr. Henri de Laulanié, a French Jesuit priest to improve rice production in the area through transplanting young seedlings at a wide spacing and enhancing the fertility of the soil with compost. SRI is a set of farming practices developed to increase the productivity of land and water, as well as other resources. SRI works by changing the management of the plants, soil, water and nutrients utilized in paddy rice production. Specifically, it involves transplanting single young seedlings with wider spacing, carefully and quickly into fields that are not kept continuously flooded, and whose soil has more organic matter and is actively aerated. This practice improves the growth and functioning of plants root systems and enhance the numbers and diversity of the soil biota that contribute to plant health and productivity (Stoop et al. 2002, Uphoff 2003, Uphoff 2011). The system is based on the principle of developing healthy, large and deep root systems that can better resist drought, water logging and wind damage. In SRI, practices like seeding rate per unit area, method of raising of seedlings in nursery, transplantation, control of water in the main field, weeding / hoeing are carried out to ensure enhanced yield of paddy. This methodology is based on four main principles interacting with each other (CIIFAD, Stoop et al. 2002, and Uphoff 2012).

- Early, quick and healthy plant establishment by nurturing the root potential.
- Reduced plant density, which gives each plant more room to grow above and below ground and to capture sunlight and obtain nutrients.
- Improved soil conditions through enrichment with organic matter, which keeps the soil well aerated to support better growth of roots and more aerobic soil biota.
- Reduced and controlled water application that favors plant-root and soil-microbial growth and avoids inundated, anaerobic soil conditions.

SRI was mainly developed through participatory on-farm research conducted in Madagascar, but its evaluation is still ongoing in Asia as well (Dobermann 2004, Uphoff 2012). The spread and improvement of Fr. de Laulanié's innovation was initially undertaken by an NGO called Association Tefy Saina (ATS) that he established in 1990 with some of his Malagasy colleagues. ATS began introducing SRI to farmers in a number of communities around the country. Later on their work was expanded through collaboration with the Cornell International Institute for Food, Agriculture and Development (CIIFAD) as an alternative to the local slash-and-burn upland cultivation. Dr. Norman Uphoff of Cornell University to other parts of the world further promoted it.

SRI has shown remarkable capacity to raise smallholders' rice productivity under a wide variety of conditions around the world such as tropical rainforests, mountainous regions, and river basins as well as arid conditions in places like Mali (Uphoff 2012). Under the drought conditions in Madagascar, de Laulanié experimented serendipitously with transplanting very young seedlings of only 15 days old. After much experimentation in subsequent years reliable yields, ranging from 7 to 15 t/ha, were obtained by small farmers cultivating soils with low inherent fertility, using much reduced irrigation rates, and no mineral fertilizers or other agricultural chemicals (Stoop, Uphoff 2002). After the principles and practices of SRI became fairly understood, farmers began extending its ideas and methods to other crops. NGOs and some scientists have also become interested in and supportive of this extrapolation, so that a process of innovation has ensued. Results of this process are the development of System of Crop Intensification (SCI), System of Wheat Intensification (SWI), Sustainable Sugarcane Initiative (SSI), System of Ragi Intensification (SRI), and System of Teff Intensification (STI). These variations of SRI can be applied as per the need of the land and farming systems.

General Steps of Farming in SRI

The basic method of SRI is to carefully transplant single seedlings at two-leaf stage, plant seedlings at a distance of 25 cm or more in a square pattern, keep soil moist and aerated, and finally fertilize with compost. These steps are applicable to all the variations of SRI. The fundamental steps are discussed below:

i. *Land preparation:* SRI requires careful ploughing, puddling, leveling and raking. The required moisture level has to be maintained uniformly, with drainage facilitated by 30 cm wide channels at two-meter intervals across the field.

ii. *Nurseries:* The seedbeds have to be nutrient-rich and established as close to the main field as possible. This will enable quicker and easier transportation between the nurseries and the fields, minimizing transport time and costs so that the seedlings are efficiently transplanted. Chemicals should not be applied to the seedbeds.

iii. *Transplanting:* The seedlings must be transplanted with their roots intact, while the seed sac is still attached. Transplanting has to take place when the seedlings are just 8 to 12 days old, soon after they have two leaves, and at least before the 15th day after sowing.

The seedlings must not be plunged too deep into the soil, but placed on the ground at the appropriate point on the planting grid. Transplanting should be at 1-2 cm depth at the most. Transplanting should be done quickly, after gently removing seedlings from the nursery bed to avoid drying out of the roots. Care should be taken to avoid causing trauma to the roots.

iv. *Spacing:* The seedlings should be planted at precise spacing, usually 25 X 25 cm, about 16 plants per square meter. Roots grow better if spaced widely, rather than densely. This also exposes each plant to more sunlight, air and soil nutrients, and allows easier access for weeding.

v. *Soil nutrients:* Organic nutrients serve better at promoting the abundance and diversity of microorganisms, starting with beneficial bacteria and fungi in the soil. Using organic fertilizers and compost promotes proper microbial activity, thereby improving production. Under SRI method, farmers who do not have access to organic manure may use less chemical fertilizers.

vi. *Watering:* SRI requires the root zone to be kept moist, not submerged. Water applications can be intermittent, leaving plant roots with sufficiency, rather than excess of water. Such management encourages more extensive, healthy root systems, and avoids root degeneration. Reliable and precise irrigation is important, especially in the early growth period. Once the roots are well established, irrigation can be halted for three to six days at a time to encourage downward root growth.

vii. *Weeding:* Since there is no standing water and no continuous submergence of rice plants under SRI, weeds tend to proliferate, requiring careful and frequent weeding. The first weeding has to be done within 10 to 12 days of transplantation, and further weeding may be required at intervals of 10-12 days. Weeding must continue until the crop has grown to such level that the canopy obviates weeding.

SRI's Approach to Sustainable Farming

Given the importance of rice as a staple crop in many farming systems in Asia, interventions that increase rice productivity can serve as a critical entry point in initiating and reinforcing the process of agricultural growth and income generation in uplands. Improved technologies for rice-based systems will promote income-generating activities by freeing household resources that are currently tied up in meeting food needs (Pandey, 2006).

SRI is a climate-smart, agro-ecological methodology for increasing the productivity of rice and other crops such as wheat, sugarcane, pulses and vegetables etc. by changing the management of plants, soil, water and nutrients. The principles of SRI are agreeable with the cultivation practices of many smallholder farmers as they are easily comprehendible and applicable. Planting young seedlings carefully and singly gives them wider spacing, usually in a square pattern, so that roots and canopy have ample room to spread. The soil is kept moist but not inundated, with sufficient water for plant roots and beneficial soil organisms to grow, but not so much as to suffocate or suppress either, e.g., through alternate wetting and drying or small regular applications. Organic matter (compost, mulch, etc.) is added as much as possible to the soil so that the soil can feed the plant. Weeds are controlled with mechanical methods (weeders) that incorporate weeds into the soil while breaking up the soil's surface, actively aerating the root zone in the process. This promotes root growth and abundance of beneficial soil organisms. The cumulative result of these practices is to induce the growth of more productive and healthier plants from any given variety (Stoop 2002, Uphoff et al. 2002, Uphoff 2012).

In the literature, SRI is presented as having two categories of advantages: the first relates to sustainability, and the second relates to productivity. It is argued that SRI uses far less water, demands less chemical fertilizers and pesticides, and makes better use of organic inputs, which supposedly makes the system more environment-friendly and sustainable in comparison with the conventional method of rice cultivation. The second frequently presented category of advantages of SRI, namely its claimed capacity to improve yields, reduce costs and enhance profitability of rural livelihoods, seem to have helped in enrolling audiences as well (Basu 2012).

Water Management and Soil Conservation

One of the features that make SRI attractive is its water saving potential. SRI methods can reduce water requirements for crops by up to 50 percent. In case of ground water, this also results in saving groundwater (by 30 per cent) and in electricity consumed to extract ground water. In surface irrigation, savings in irrigation water leads to possibilities of expansion of irrigated area (National Consortium on SRI 2012). Farmers apply water intermittently, which provides sufficient rather surplus water for the plants. Such management encourages more extensive, healthy root systems, and avoids root degeneration. The amount of water also depends on the soil biota therefore farmers can decide for themselves what amount of water is feasible for them and most beneficial for their crop.

Crops under SRI method respond well to addition of organic matter to soils. The practice of green manuring from trimmed biomass not only adds substantially to productivity but also improves soil health and structure which leads to soil conservation. Under SRI, the grains ripe and can be harvested earlier allowing the following dry season crop to take advantage of residual moisture in the soil (MPRLP 2011). Shortening the time between planting and harvesting is especially important for farmers who cannot irrigate their fields. The earlier they can reap the paddy and plant a follow-on dry season crop, such as mustard, linseed, lentils and peas, the more residual moisture there is in the soil to help the latter crop germinate and get off to a good start.

Productivity and Economic Viability

SRI plants are generally healthier and better able to resist stresses such as drought, extremes of temperature, flooding, and storm damage. With SRI management, yields have reported to increase by 50-100 percent with reduced requirements for seed (by 80-90%) and water (25-50%), with less or no requirement for inorganic fertilizer use if sufficient organic matter can be applied, and with little if any need for agrochemical crop protection against pests and diseases. The crop stalk volume in the SRI method is also much higher, providing more fodder for cattle, more farmyard manure for fertilizing fields and possibly increasing milk yields (Uphoff 2012).

SRI boasts lower production costs since farmers need only one tenth of the seed for SRI than for traditional paddy farming. This is significant saving for farmers with low resources. Studies indicate farmers reporting that the harvests are better than before, sometimes even double, and provide enough not only for households but also surplus to sell. Farmers report and researchers have verified that SRI crops are more resistant to most pests and diseases (Uphoff 2007). By enhancing plant root growth and the abundance and diversity of soil biota, SRI produces plants that are more resistant to biotic and abiotic stresses. The plants are better able to withstand the effects of drought and pest damage requiring lesser need of agrochemical protection or acceleration (Prasad 2006).

Limitations

Like many technologies, there are costs involved with SRI adoption. An initial barrier is labor-intensity, while the methods are being learned (Moser and Barrett 2003). Since there is no standing water and no continuous submergence of rice plants under SRI, weeds tend to proliferate, requiring careful and frequent weeding; which means more labor. But once farmers acquire the skill and confidence in the methods, more and more evaluations show SRI to be labor-neutral or even become labor-saving (Uphoff 2007). Labor constraint has nevertheless prompted farmer innovations in weeder design, including motorization, as well as modified methods of crop establishment that are labor-saving and profit-increasing. Farmers who are using SRI informed the researchers at MPRLP that it actually needs less labor as wider spacing and straight rows allow plants to be hoed, weeded and fertilized more easily (MPRLP 2011). Also as farmers learn and master SRI techniques, their labor inputs can be reduced in absolute terms, i.e. SRI can also be labor-saving as saving water and reducing costs of production (Prasad 2006, Uphoff 2011). This saving could become more important factor affecting adoption of SRI.

Another constraint on SRI adoption is water control, being able to manage irrigation systems sufficiently to provide reduced but reliable amounts of water on an intermittent basis. Where fields are low-lying and continuously submerged or mostly saturated, SRI methods will not produce their best results, e.g., where there is little water control and flooding creates anaerobic soil conditions (Uphoff 2011). Water control is relative, not an absolute, requirement as farmers in a number of countries have been adapting SRI concepts to rain-fed and unirrigated rice production (Uphoff 2010). Under SRI, farmers require some additional tools and time to level their plots to a higher standard to prevent accumulation of water and undertake appropriate water and weed management. In some contexts, there may not be enough available biomass, beyond the recycling of rice straw, to meet soil nutrient needs with compost. In this case, chemical fertilizer can and have been used. However, with innovative efforts, a solution can be considerably achieved.

The unpredictability of the weather is also a challenge for SRI. Rice planting in India traditionally starts when the rains arrive during the monsoon. Farmers customarily keep seedlings in the nursery for up to a month, which allows for some flexibility if the rains don't arrive on time. But SRI requires seedlings to be transplanted when they are one week old, and until the seedlings become established, they are vulnerable to dry spells, so SRI lacks some of the flexibility of traditional methods (MPRLP 2011).

Within SRI’s conceptual and practical framework, farmers have devised many innovations. SRI demands skillful farming, conscientious planting, good timing and careful drainage. With skill and confidence as well as innovation, SRI can become labor-saving over time, saving water (by 25-50%) and seed (by 80-90%), reducing costs (by 10-20%), and raising paddy output at least 25-50%,and often 50-100% and sometimes even more. The benefits of SRI far outweigh the obstacles and a growing number of countries around the world have started promoting SRI (Uprety 2005). CIIFAD has asserted in its website that the efficiency of SRI methods has been reported in 28 countries all over the world. Under the present constraints of lower production SRI methodology can be extended to a larger rice growing area consisting of small landholding farmers and thereby maximizing total production of rice, ultimately contributing to national food security.

SRI in India

Plant Research International (PRI) in the Netherlands first introduced SRI to the Tamil Nadu Agricultural University (TNAU) in the southern state of Tamil Nadu, India in early 2000. Dr. T. M. Thiyagarajan who was then serving as the Director of the Department of Soil and Crop Management Studies at TNAU was the only Indian representative at the 2002 international conference on SRI held in China. At TNAU, a modified SRI practice was evaluated that used water and fertilizer in excess of normal SRI recommendations. The results indicated considerable water saving and a reduction of seed costs, but no significant increase in yields (Thiyagarajan 2002). Nevertheless SRI was continuously tested and promoted with the support from farmers and various actors throughout India. Two important stakeholders in the innovation of SRI in India were the state funded research and extension agencies, especially in the southern states; and civil society groups.

Acceleration of SRI

The prospects of SRI adoption in India was increased when Dr. Norman Uphoff visited India in 2002. He made a presentation on SRI at the 2nd International Agronomy Congress held in New Delhi, the capital of India, as well as to top officials in the Ministry of Agriculture. The Department of Agriculture in two southern states, Andhra Pradesh and Tamil Nadu, agreed to send professionals to Sri Lanka for a visit sponsored by CIIFAD to learn about SRI from farmers who were using the methods successfully. The success of SRI in Sri Lanka was possible because of substantial involvement of farmers in experimenting SRI in their fields by investing their own resources. In 2003 a package of SRI practices were developed and tested in 200 farmers' fields through the Tamil Nadu State Government initiative to compare the performance of SRI and conventional cultivation in the Cauvery and Tamiraparani river basins. The results showed an average increase in grain yield by 1.5 tons/ha in both basins with reduced input requirements, and even an 8% reduction in labor needed per hectare. This evaluation provided a basis for officially recommending SRI adoption to farmers in 2004. Concurrently, at the state agricultural university in Andhra Pradesh, Acharya N.G. Ranga Agricultural University (ANGRAU), introduced SRI in farmers' fields during *Kharif* season[3] 2003, after ANGRAU scientists saw SRI in Sri Lanka. Comparison trials were conducted in all districts of the state and the results generated nationwide interest, as they showed average yield increases of 2.5 tons/ha, 50% over conventional irrigated rice cultivation (WWF-ICRISAT 2010). Meanwhile TNAU organized a conference on 'Transitions in agriculture for enhancing water productivity' at Killikulam in September 2003, jointly with Wageningen University (the Netherlands) and International Rice Research Institute (the Philippines) where SRI was enthusiastically discussed, using reports from farmers who were using the methods.

Since 2003, there has been a rapid spread of SRI with the help of a number of actors and partners in the dissemination of SRI. More NGOs started picking up SRI as a part of their work and were involved in demonstrations and rigorous experimentation, using locally available resources and knowledge (The Hindu 2008, Prasad 2006). Impressed by the SRI results of TNAU and ANGRAU, the World Wildlife Fund (WWF) and International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) joint dialogue project extended technical as well as financial support for a systematic evaluation of SRI methods by ANGRAU and the Centre for Rural Operations and Programmes Society (CROPS), a local NGO, through on-farm field trials

[3] *Kharif* season usually begins with the first rains in July, during the southwest monsoon season. Examples of *Kharif* crops: rice, corn, millet, sorghum etc.

in 11 districts in Andhra Pradesh over several years, starting with the *Rabi* season[4] of 2004-05. The evaluation in its second year involved scientists at ICRISAT and in the Directorate of Rice Research of the Indian Council for Agricultural Research.

WWF Dialogue on Water, Food and Environment Project:

In 2004-2005, WWF-ICRISAT approached the Government of Andhra Pradesh for scaling up adoption of SRI. The State Government responded positively and financed the establishment of SRI demonstration plots in many villages throughout the state. A program for training farmers and staff members of the state's Agriculture Department was initiated. The project (Dialogue on Water, Food and Environment based at ICRISAT, Patancheru) along with ANGRAU supported trials of 250 farmers' fields that had taken up SRI with an objective of evaluating SRI methodology for its potential to save water and increase productivity in different agro-climatic and irrigation sources. Over five years (2003-04 to 2007-08) and two seasons each year, the average yield increase from SRI demonstrations was 26.5% more than from conventional practices (WWF-ICRISAT 2010).

A national symposium on SRI has been organized every year since 2006 by the ICRISAT-WWF project. The symposia provide a forum for exchanging ideas and experiences on research, adoption, extension and policy issues. The ICRISAT-WWF project also publishes a quarterly *SRI Newsletter* to disseminate new developments and experiences in SRI (Gujja 2009, WWF-ICRISAT 2010). The WWF project was significant in highlighting farmer innovations and incorporation of farmers experiences and difficulties into the research agenda, involvement of civil society groups, backing scientific investigation of SRI, placing SRI in the context of the

[4] *Rabi* season starts with the onset of northeast monsoon in October. Examples of *Rabi* crops: wheat, gram, pea, mustard, linseed, barley etc.

water crisis as well as moving governmental and other players to modify policy to provide the necessary investments that could provide a boost to SRI. This not only allowed a greater focus on assessing SRI in the state but also broadened the scope of SRI studies in Andhra Pradesh and India. Funded by the Ministry of Foreign Affairs, Norway, and WWF Netherlands, WWF-ICRISAT Project activities have included research to generate scientific understanding of SRI principles, initiatives to support SRI introduction in different agro-climatic conditions, field trials and demonstrations, farmer to farmer interaction workshops, field-based resource centers, media events, and actively promoting and organizing interactions among farmers, scientists, government agencies, and the civil society (Prasad 2006, Gujja *et al.* 2008).

In an evolving system such as SRI, a clear categorization of actors cannot be done, especially because actors, such as farmers, have multiple roles. Farmers are extensionists and researchers apart from being users of knowledge. In case of SRI, the NGOs were often in the forefront of research and also acted as mediators (Prasad 2006). For the purpose of analysis of innovation as a process, the actors are divided into four categories and are discussed in the following sections.

Role of Prominent Figures

While Dr. Norman Uphoff from Cornell University was trying to persuade other state governments to try SRI, new stakeholders started participating in the process leading to new partnerships. It was his energy and enthusiasm that made it possible for SRI to attract government attention (Prasad 2006, Glover 2011). In 2002 a prominent NGO, the Chennai-based M.S. Swaminathan Research Foundation (MSSRF) tried SRI on small plots in its 'bio-village'. This provided an undoubted boost to SRI because the foundation's chairman, Prof. M.S.

Swaminathan, is a person of immense stature in India, where he is celebrated as the 'father of the Green Revolution' (Glover 2011). At the state level in Andhra Pradesh, Dr. Satyanarayana who was then the Director of Extension of ANGRAU played an important role in mobilizing support and in building partnerships, and participated in the international debate after he published in Nature (Prasad 2006, Basu 2012).

Furthermore, Basu (2012) points out that the manner in which SRI was introduced fortunately bypassed the normal procedures for the introduction of new agricultural technologies in India. After coming back from Sri Lanka, Dr. Satyanarayana with the permission from government authorities at the state level released the SRI methodology directly at the farmers' field level. In India, the general practice for agricultural extension for releasing new management packages or technologies (e.g. crop varieties) to farmers involves quite a few formal procedures. Experimentation with a new variety or a new methodology of crop cultivation has to be approved by the Indian Council of Agricultural Research (ICAR) in New Delhi. Then it will be sent for trial in different agro-climatic zones in India. Only when trials yield positive results, can the packages be released for commercial use and wider extension activities. This whole process of research evaluation usually takes considerable time to reach the ultimate beneficiaries. But the case of SRI extension took a radical deviation from this regular practice and thus skipped the usual time consuming process to reach the farmers' level (Prasad 2006, Basu 2012).

Role of Civil Society

Civil society in the context of the spread of SRI in India, is not only limited to organized activities of some NGOs, but also included autonomous activities by farmers groups and farmers of various categories (conventional rice farmers who have been growing rice, farmers who want to grow rice but cannot due to lack of water, farmers who are keen on experimentation, first-time SRI farmers, adapters, etc.) as also certain groups and individuals who are not directly involved in farming activities but who have played an important roles and are likely to do so in the years to come (Prasad 2006).

The most important civil society group involved in the spread and adoption of SRI technology in India is the NGOs. For instance, Auroville, an international commune that has been in the forefront for reclaiming degraded land and one of leaders in sustainable agriculture was one of the first NGOs in India to take up SRI. They heard of SRI in 1999 through a pamphlet in French brought from Madagascar by a visitor to a local farm. The farm, which had turned organic since 1987, tried small experiments with SRI on traditional varieties of paddy from 1999 to 2003 with unremarkable yields (Prasad 2006, Glover 2011). At the same time, a number of NGOs and farmers in other Indian states who were struggling with water and productivity issues were trying SRI in small steps. In 2003-04, outside the government system, more NGOs started picking up SRI as part of their work and were involved in demonstrations and experimentation with use of bio-pesticides and other formulations using locally available ingredients and knowledge (Prasad 2006).

The role of NGOs was not limited to promoting the technology, in some cases they also helped identify early adopters. In the state of Madhya Pradesh, Madhya Pradesh Rural Livelihoods Project in Madhya Pradesh (MPRLP) started to talk to the village farmers and as a result, the Village Community helped pick out progressive farmers who might be interested in trying SRI. The project team organized showing of demonstration videos that explained the technology to farmers. MPRLP provided interested farmers with one kilogram of seed for a 0.1 ha trial plot. The farmers were trained on their farms and the team was available to help solve problems as they arose. When the progressive farmers got good results they started converting their entire paddy to SRI. This paved the way for MPRLP to roll out SRI to more farmers through village committee meetings, where the pioneer farmers were invited to share their experiences and assuage villagers' doubts. As more farmers embraced SRI, MPRLP regularly checked how they were doing and helped them overcome any problems. The first batch of farmers played an important role, guiding those who took up SRI later and their paddy fields served as classrooms where other farmers could see and learn SRI implementation. In Madhya Pradesh, at the last count in 2010, 23,418 farmers in 940 villages were growing paddy intensively on 4865 ha and earning an average of R. 20,300 (~ $500) per hectare (MPRLP 2011). In the northern states of Uttarakhand and Himachal Pradesh, NGOs and research institutes played prominent roles in promoting the technology. The Centre for Participatory Watershed Development (CPWD) at People's Science Institute (PSI) included SRI as part of its research activities and supported eight NGOs in the two states. These NGOs executed field trials of SRI covering 25 villages and 40 farmers with an area of 6 hectares. They provided the resource persons in the training cum demonstration program and gave regular field support to the farmers during the crop period. At the workshops, farmers who had cultivated paddy by SRI method were encouraged to share their experiences with farmers from surrounding areas who were interested in SRI method (PSI 2007). CIIFAD reports that about 30 capacity building workshops have been organized covering about 1000 farmers and more than 600 farmers in the state have adopted SRI.

In states where there has not been enough government support, some NGOs have taken on the responsibility for spreading SRI. They have published manuals in local languages such as Tamil, Telugu, Assami, and Kannada and distributed in villages. In recent years, US philanthropist and co-chair of the Bill and Melinda Gates Foundation, Bill Gates, has shown a personal interest in SRI in India by visiting a village in Bihar where the system is being promoted by a large NGO with support from India's National Bank for Agriculture and Rural Development (NABARD) (Glover 2011). Other stakeholders include networks of farmers' organisations such as Kisan Forum or Water Users Associations; or formal NGOs and International Non-Government Organizations (INGOs). In many cases small farmers have taken the role of innovators and leaders. The farmer organizations have often helped to spread of ideas. These organizations are more active in the south than the north of India. These networks are often knit informally and are not exclusive, so the members of the group play different roles in the networks. They have facilitated organizing meetings with officials and in many cases played the role of transferring information to farmers or other organizations (Prasad 2006, WWF-ICRISAT 2010).

The civil societies were later joined by a variety of government agencies such as the Department of Agriculture in Tripura State; colleges and universities such as TNAU, ANGRAU; institutions such as the Xavier Institute of Management in Bhubaneswar; private entities such as Tilda Ricelands Pvt. Ltd.; foundations such as the Sir Dorabji Tata Trust (SDTT); and banks such as the National Bank for Agricultural and Rural Development (NABARD). All brought different capabilities and approaches to the dissemination of SRI knowledge and opportunities (Prasad 2006, Basu 2012, WWF-ICRISAT 2010).

Policy Implications and Role of the Government

Initially when the idea of SRI was introduced, the response from the Indian government was not enthusiastic. WWF's Dialogue on Water, Food and Environment project was significant in drawing the government's attention towards SRI. WWF has played an important role in influencing policy makers in many Indian states and engaging the scientific establishment in India and worldwide. WWF's work attracted high-level political support and financial backing, and in the following years, SRI begun to attract significant financial and political investments, further enhancing the credibility and building the momentum of the 'SRI movement' in India (Gujja et al. 2008).

Policy support to SRI has mostly been in the form of state-level input subsidies on weeders and markers in some states. The states of Andhra Pradesh and Tamil Nadu have by contrast seen more involvement by the state universities and agricultural departments. The scaling up of SRI, outside the research system began in Tamil Nadu for the first time through the Department of Agriculture. Beginning August 2004, SRI was promoted under the 'Integrated Cereal Development Programme-Rice' with a target of 9000 acres to be covered in 2004-05 under the system. In 2010 Tamil Nadu state government led a US $500 million program along with the World Bank, and the Tamil Nadu Irrigated Agriculture Modernization and Water-bodies Restoration and Management (TN–IAMWARM) Project, aimed at promoting SRI methods and water-saving technologies such as drip-fertigation to farmers in Tamil Nadu. The program aimed to improve agriculture and water management in 63 sub-basins of Tamil Nadu, covering up to 750,000 ha in 2010 (Glover 2011).

Krishi Vigyan Kendras (KVKs) are front-line agricultural extension centers financed by the ICAR. These centers function in all districts throughout the country by conducting on-farm testing to identify the location specificity of agricultural technologies under various farming systems, organizing frontline demonstrations of various practices on the farmers' fields, and organizing need based training for farmers and extension personnel about improved agricultural technologies through an appropriate extension programmes. The KVKs in the states of Tamil Nadu, Andhra Pradesh, Kerala, and Tripura have been instrumental in promoting SRI in several districts. Following the success of SRI in these states, the KVKs of other states like Bihar, Jharkhand, and Orissa have also included SRI in their extension programs.

SRI within the National Policy

SRI is now being promoted within the framework of the central government's National Food Security Mission (NFSM). The Indian Government allocated $40 million USD (about $8/ha) for extension of SRI methods to 5 million hectares of rice-growing areas in targeted districts with high incidence of poverty under the NFSM (WWF-ICRISAT 2010). Recent 12th five-year plan (2012–2017) of India has also incorporated SRI in its agriculture development program. To promote SRI to as many farmers as possible, state -organized village meetings in each village cluster to make sure all farmers in the district knew about SRI. After a few successful years, the farmers themselves are now spreading the word about SRI and are becoming effective advocates for the technology. In recent times in many states, the State Agriculture Department along with the local organizations is providing training courses and demonstrations to farmers. They also provide seed and help farmers get started with SRI on small plots, regularly checking on how the farmers were doing and troubleshooting any problems that came up.

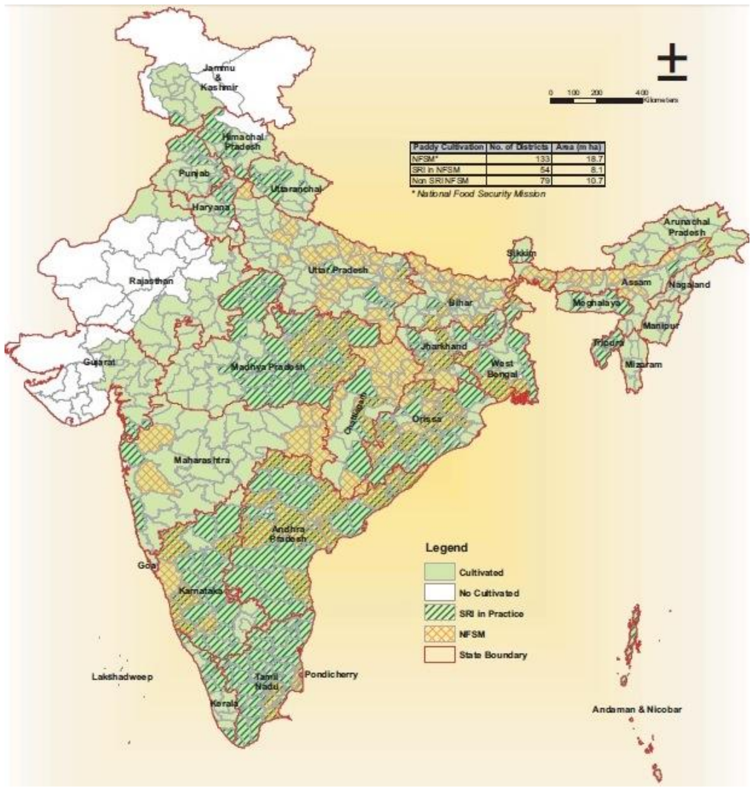

Figure 10: Districts where SRi is practiced within the NFSM Program
(Source: www.sri-india.net)

Role of Mass Media and the Internet

Starting from the initial phase, SRI was regularly reported in the mass media. Several adopters have referred to the mass media as a source of information about SRI. Both local and national newspapers have reported extensively about the activities and projects of SRI (Prasad 2006). Leading newspapers like The Hindu and The Hindustan Times have published many articles on SRI. Local NGOs have also published manuals in local languages and distributed them widely in many areas of the country. Many websites were created to provide relevant and timely information to scientists, policy-makers, extension-staff, and farmers. The CIIFAD website provides a detailed and regularly updated overview of different activities, news and articles on SRI from almost 55 countries around the world. The profound involvement of mass media and Internet is significant as media have a well-established potential to shape the awareness and views of innovation system actors about SRI, which in turn is likely to have played a role in the further development of a support network (Basu 2012).

Outcomes

The extent and nature of involvement of actors and stakeholders are varied among and within the states. Networks and organisations have played an important part in the spread of SRI along with some influential individuals who were the pioneers in adopting SRI. SRI in India has several such individuals who have learnt about the innovation, practiced and championed it in different places and platforms and that too in a very short time. Civil society groups have been at the forefront of experimentation, dissemination and have contributed significantly in bringing out several technical and institutional innovations.

Various individuals, organizations and institutions through research, extension and promotion helped SRI spread in the country. Research institutions, extension departments and civil society organisations in Tamil Nadu, Andhra Pradesh, Tripura, Orissa, Jharkhand, Himachal Pradesh, and Uttarakhand have conducted a number of on-farm evaluations in farmers' fields. Similarly the Directorate of Rice Research (DRR) of the ICAR has started to carry out a systemic nationwide evaluation of SRI (Gujja 2009). These evaluations were helpful in providing farmers with a lot of exposure. Currently there are several virtual SRI groups, communities, farmers' associations and networks functioning in India that are making SRI adoption effective.

Indian districts with rice cultivation and where SRI method has been introduced are shown in the table below.

Table 6: Districts with rice cultivation and where SRI has been introduced

State	SRI Introduced Districts/Total Districts	State	SRI Introduced Districts/Total Districts
Andaman & Nicobar	2/3	Maharashtra	2/33
Andhra Pradesh	22/23	Manipur	0/9
Arunachal Pradesh	0/16	Meghalaya	4/7
Assam	2/24	Mizoram	0/8
Bihar	5/38	Nagaland	0/8
Chhattisgarh	4/16	Orissa	21/30
Goa	0/4	Pondicherry	2/4
Gujarat	3/23	Punjab	7/17
Haryana	1/19	Rajasthan	0/31
Himachal Pradesh	5/12	Sikkim	0/4
Jammu & Kashmir	1/15	Tamil Nadu	19/31
Jharkhand	14/22	Tripura	4/4
Karnataka	22/27	Uttar Pradesh	6/70
Kerala	6/14	Uttaranchal	5/13
Madhya Pradesh	3/48	West Bengal	3/18

An important feature of SRI in India is that it has no uniform characteristic nor any single agency or organisation driving it. It has been carried out by both government agencies and civil society with a varying combination of collaboration amongst them in the states. Each state shows very distinct and diverse characteristics and therefore the adoption and diffusion of SRI has been different. Even after adoption there are few differences in the technical practices too, as a closer look at the manuals would indicate. The emphasis on organic modes of production is more in Andhra Pradesh, whereas Tamil Nadu extension agencies recommend use of an LCC (Leaf Color Card) to enable farmers to apply fertilizers at regular intervals based on a comparison and standardization of rice fields in the laboratory and the farmers' fields. SRI still requires more attention and involvement. Promotion across the country is highly variable: aggressive in states like Tamil Nadu, Andhra Pradesh, and Tripura, and yet to take off in some states. At the moment, SRI-area in the country could not be more than one percent of the total rice area of 44 million hectares (Gujja *et al.* 2008). The attitude of all stakeholders in rice production requires a drastic change if the majority of rice farmers have to change over to SRI.

Challenges and Constraints in Adoption and Diffusion

Although the spread of SRI in India is currently increasing, introducing SRI to farmers wasn't very easy in the beginning. The main obstacle to SRI adoption is the farmers who are hesitant to change the traditional way of farming and take up SRI. Farmers are not easy to convince when it comes to changing the way they farm. The suggestion that they could double their harvests by sowing only a tenth the amount of seed is often met with suspicion. The belief that 'more seedlings = bigger harvests' and 'more plants = more rice' was deeply embedded (MPRLP 2011). Due to insufficient two-way flow of information between farmers and researchers in the system, the rate of adoption was low.

Another major constraints in adopting SRI is need to weed fields several times during the harvest cycle which requires extra time and labor. Farmers have come up with mechanical methods that are not only cheap and easy to use but are also used for incorporating weeds into the soil while breaking up the soil's surface. This actively aerates the root zone in the process further promotes root growth. Experiments conducted by Rajendran *et al.* (2005) showed that using a weeder increased grain yield by 24% compared to hand weeding. The cost of weed management in conventional cultivation (hand weeding twice at 15 and 30 days after transplanting) is about Rupees 3,200/ha, while the cost of using a weeder (four times: at 10, 20, 30 and 40 days after transplanting) is about Rupees 1,520/ha (Thiyagarajan *et al.*, 2002). This implies a 52% reduction in the cost of weed control and proves to be an effective way to over the constraints of labor for weeding.

Summary

SRI is a set of principles that requires a different method of planting rice in water scare regions. The water saving characteristic of SRI is one of the most important aspect of SRI. However, farmers usually need incentives and encouragement to make the initial shift from one set of practices to another. In case of India, the adoption of SRI has so far been successful since its introduction in 2000. This has been possible because of the involvement of diverse stakeholders and the interaction between them. Also the adoption at farm level is increasing as different approaches of diffusion that are farmer oriented have been enforced. Even though the methods under SRI are simple to comprehend and implement there are some barriers that act against its adoption. However, this has so far been minimized in many states in India. As long as an appropriate spirit of innovation and volunteerism is maintained while working with and through local government bodies this challenge can be subdued if not overcome.

CHAPTER 5: DISCUSSION AND CONCLUSION

The previous chapters have focused on the identification of two farming systems in the Philippines and India, technologies/practices used in them, and the adoption and diffusion of those technologies in the countries. The discussion so far suggests that the SALT or modified contour hedgerow technology and other integrated agricultural technological options have great potential for conserving soil and water on upland areas. Similarly SRI is also very useful for rain-fed farming lands that have limited water resources because of its water saving characteristics. This chapter comparatively discusses the major findings of the research in four sections; technology adoption at farm level, characteristics of adoption and adopters, institutional factors, and the outcomes. The chapter concludes with a brief summary of the research and further policy implications.

Technology Adoption at Farm Level

The perceived benefits and limitations of the technologies reviewed are significant in determining their adoption at farm level. Adoption of SALT in the Philippines was varied across the regions. In most places the adoption rate was very low. Despite the benefits of resource management, adaptability, diversity etc. there were several limitations of the technology. Major reasons for the dislike of contour hedgerows were: labor demanding, reduction in arable land area, lateral spread of hedgerows over the field and shading vegetable crops, regular maintenance requirements, and not providing immediate financial return. There are variations in the species used as hedgerows, which gave different outcomes in different parts of the country. The key points can be summarized in Table 7.

Table 7: Perceived benefits and limitations of SALT

Benefits	Limitations
Resource management	High demand for labor
Diversity (crops, livestock, cash crops)	Competition between crops and hedgerows for resources
Reduced soil loss & need for fertilizers	Decrease in arable land area
High value crops occupy up to 75% of land (economic benefit)	Regular maintenance requirements
Adaptability to varying conditions (SALT 1, SALT 2, SALT 3, SALT4)	No immediate financial returns

Another challenge was the problem of land tenure in the Philippines, which served as a barrier in adoption as farmers who did not own land were reluctant to invest in SALT. When the Certificate of Stewardship Contracts (CSCs) implemented in Domang leased land to the farmers to use SALT, there was a very high level of adoption.

In India there was resistance as well to the SRI system. The high outputs that SRI had promised, despite the use of less seeds, was hard for many farmers to believe. Scientists all over the world were also skeptical about SRI, since the principles of SRI are very different from the principles of green revolution that many had already adopted. The key benefits and limitations related to SRI that were influential in the adoption process are as summarized in the following table.

Table 8: Perceived benefits and limitations of SRI

<table>
<tr><th>Benefits</th><th>Limitations</th></tr>
<tr><td>Water management</td><td rowspan="2">Hard to break conventional practices (high water, fertilizers use)</td></tr>
<tr><td>Short time between planting and harvesting allows early harvest</td></tr>
<tr><td>Used for rice as well as other crops and vegetables</td><td rowspan="2">Need for some mechanical devices (weeder) can put economic pressures</td></tr>
<tr><td>Agreeable with small farms</td></tr>
<tr><td>Easily comprehendible and applicable</td><td>Demand for labor</td></tr>
</table>

Nevertheless, SRI adoption in India is not driven by any single agency or organisation but has been carried out by both government agencies and civil society with a varying combination of collaboration amongst them in the regions. Each state and region show very distinct and diverse characteristics and therefore the adoption and diffusion of SRI has been different.

Characteristics of Adoption

Even though both SALT and SRI are efficient practices for farmers they were seen as labor intensive, more so for SALT than SRI. Clearly, a major factor influencing the sustainability of land management practices is the requirement for high labor inputs, which discourage some farmers from adopting it, particularly the poor ones who cannot afford to hire labor. Several of the practices of SRI including square grid making and alternate wetting and drying required leveled lands to make water uniformly spread across the field. Land leveling increases the ease of SRI practice but this requires extra labor. Similarly SALT requires farmers to make the contour and plant hedgerows, which demand extra work. When labor is limited, farmers have to hire workers, adding to their production costs. However, a study done by Lapar and Pandey (1999) showed that a larger proportion of households that have adopted SALT were members of *alayon*, a local labor-sharing group.

Membership in farmers' association (like Kisan Forum in India and Alayon in the Philippines) was positive influence for adoption (Cramb *et al*. 2003, Prasad 2006). Farmers' associations have better access to technical information and receive support from extension workers (Ntege-Nanyeenya *et al.* 1997). Membership into farmers' association allows the farmers to share their experiences about farming to the other farmers in the group, discuss the problems and explore new opportunities on farming which increases their confidence. It implies that the membership into farmers' association significantly affects the probability of adoption of both SALT and SRI.

The study found that the adoption of SRI in India was more successful than that of SALT in the Philippines. Despite the multiple advantages of SALT, farmers need incentives to make the initial shift from one set of practices to another, requiring some relearning, absorb the additional labor costs during learning, undertake appropriate land and water management, the latter requiring some additional tools and time. This takes a lot of time for training, experimentation, and evaluation, which the farmers might not want to invest which can be limiting to the rate of adoption.

Institutional Factors

The study of adoption of SALT and SRI in the Philippines and India highlight the role of various stakeholders (including the farmers) and strategies used for promotion and dissemination. In India, SRI seems to have emerged and spread through various channels and involved diverse interactions among NGOs and civil society organizations, farmers and farmers' groups, agricultural extension agencies, national and international agricultural research organizations, policy makers and funding bodies. In the states of Andhra Pradesh and Tamil Nadu the state universities and agricultural departments have been more involved. In northern states Uttarakhand and Himachal Pradesh, mainly NGOs have been the prominent actors. In the Philippines even though there were some level of participation of diverse group of organizations both national and international, the effort was short-lived. There were hardly any national policies that supported SALT in the uplands, unlike the situation in India where SRI has been incorporated into the Indian government's 12th five-year plan.

Another key factor that influenced the success of the SRI in India is the involvement of prominent figures like Dr. Norman Uphoff in addition to national NGOs like PRADAN, MSSRF, WASSAN and international NGOs like WWF. On the other hand the Philippines lacked prominent figures that championed the spread of SALT. SRI promoters in Tamil Nadu and other parts of India were also successful in generating media coverage that presented SRI in more favorable light and encouraged farmers to adopt it. The role that media played in the providing detailed information on the technology also assisted many adopters. Prasad (2006) gives examples in India where farmers learnt SRI on their own by reading the information on websites and manuals. There is a huge difference in role of media in India and the Philippines and this can be seen from the websites of MBRLC for SALT and CIIFAD, sri-india.net, and many more for SRI in India. While CIIFAD and sri-india.net provide updated information on their websites every day, MBRLC has not updated its website in many years. Therefore it can be said that the roles of institutions play a great role in successful adoption and diffusion of technologies.

Findings

The findings of the study show the various stakeholders that took part in the adoption and diffusion process and the roles they played. In each case the respective technologies were promoted in a different way. The adoption and diffusion of SALT and SRI in the Philippines and India respectively can be presented in a table as follows:

Table 9: Comparative review of SALT in the Philippines and SRI in India

Stakeholders	**The Philippines**	**India**
Civil society	Innovation, promotion, training and some extension	Innovation, promotion, providing information, identifying early adopters, training, research & extension
Government	No policies in favor	Inclusion in National policy
Research & extension	Sporadic and isolated	In collaboration with other stakeholder, especially farmers
Farmers	As receivers of technology	As users and extensioners
Media	Limited involvement	Eminent involvement
Outcome	Initial adoption, decrease once external support removed	Initial slow adoption, increased when more information & trainings made available
Barriers	Technological complexities and institutional weakness	Some technological complexities

In the Philippines the promotion of SALT was mainly by the collaboration between Philippine government and international donor agencies like ADB, World Bank, Ford Foundation, and USAID etc. Because of a top down approach, where the local farmers were only incorporates as recipients of technology, the dissemination of knowledge in the Philippines was not as strong as in India where most of the SRI adoption projects involved farmers as users and extensioners right from the beginning. Initially the extension of the SRI technique in India was slow due to some apprehensions surrounding the principles of SRI. However, with continuous implementation, improvisation, communication the adoption of SRI has scaled up lately. The projects that promoted SRI mostly included knowledge analysis and sharing, farmers' experimentation, and participatory monitoring and evaluation. This method was applied in very few projects in the Philippines. In many cases to overcome the resistance of farmers, the government used a mixture of inducement and coercion. Adoption induced or coerced in this way, sometimes even without the direct participation of the farmer, is not likely to be sustainable once the project concluded.

In case of SALT in the Philippines, most cases farmers did not maintain the conservation measures and many actively removed them since they lacked the understanding, conviction, or resources necessary to adopt the technologies in the true sense of the term, that is, to maintain and reestablish them beyond an initial trial period. Even though MBRLC provided on farm trainings at its centre in Mindanao, farmers' adoption of SALT was still very low. However in Cebu and Managok where a participatory approach was applied, the rate of adoption was higher than other regions. The result in the Philippines also showed that participatory technology development process involving farmer experimentation was more effective than conventional on-farm research and dissemination of new information and technologies. In the Philippines the promotion of SALT/contour hedgerow was done mainly by the collaboration of Philippine government and international donor agencies like ADB, World Bank, Ford Foundation, and USAID etc. Because of a top down approach, the dissemination of knowledge in the Philippines was not as strong as it is in India.

Discussion

According to the discussion in previous chapter, direct and visible benefit, rapid return of investment and labor, available resources, continued technical and monitoring support, low cost and input requirement, integration of various components with cash generating options were very crucial in determining the adoption of technology. Similarly, raising awareness through strengthening and mobilizing farmers and farmers group, government support to incorporate some of the activities to provide some level support to the community and training to farmers regarding the technology were some of the fundamentals for creating favorable environment for farmers to adopt the technology.

In the Philippines, there is need for support and commitment from the government institutions and concerned stakeholders for suitable technology dissemination for upland farming systems. Even though there was some adoption of SALT initially it started to decline. Due to lack of careful planning, research, and meaningful networking and partnerships, the popularity of SALT began to decline in later years. This explains that the successful development, dissemination and adoption of improved technologies for smallholders depends not only careful planning of research and the use of appropriate methodologies in extension, but also on the formation of coalitions of key actors – including key farmers as well as a range of key outsiders, researchers and others who want to contribute to development of complex agricultural systems. This also implies that the appropriateness or the effectiveness is not the only factor that determines the adoption. The findings show that by involving the local farmers in communication rather than just asking to believe what they were told helped the organizations to promote the technology to hesitant farmers.

The problem in implementing sustainability in marginal farming systems is not only a technical one but more institutional which involves limited R&D in farming research, sociopolitical neglect of marginalized societies, and inappropriate development planning. Agricultural development projects frequently fail to deliver the expected outcomes in terms of community-based resource management. This happens not because they are not effective but most of the times they are superimposed on diverse and dynamic communities and rural environments, with their own pre-and post-project paths.

Conclusion

Farming systems in many Asian countries show unmistakable symptoms of unsustainability. This is mainly so due to the current patterns of resource use and production practices. Signs of unsustainability are seen in the form of land degradation, soil erosion, water scarcity, declining productivity etc. which act independently and in combination to further exacerbate the frail and marginal uplands. The dynamic nature of farming systems implies that one alternative will not result in sustainable utilization of recommended technologies.

Because of its focus on small farmers, SALT incorporates major ingredients of sustainable farming such as land use by incorporating livestock, resource management, and can be done using local resources. SRI methods are ‘fundamentally ‘‘pro-poor’’’ focusing on small-scale farmers with limited resources. This suggests that both SALT and SRI address a perceived and unmet demand for technical options that suit small and marginal farmers in upland and rain-fed farming systems. However, labor is a limiting input in both the systems and even though both were efficient resources for farmers the labor-intensive nature of SALT and SRI discourages many farmers from adopting it. It is particularly so among those who are poor and cannot afford to hire labor. Apart from labor, constraints such as land tenure, and improper dissemination of the technologies act against the successful adoption of the technologies.

In the Philippines, the policy and institutional frameworks governing the agricultural sector have not provided the incentive structure, enabling environment and level and quality of public goods and support services necessary to promote and efficient and sustainable growth path in the uplands. In India, SRI has recently been included within the national policy in the 12th five-year plan (2012-2017). SRI-area in the country could not be more than one percent of the total rice area of 44 million hectares (WWF-ICRISAT 2010). SRI still requires more attention and involvement. Promotion across the country is highly variable: aggressive in states like Tamil Nadu and Tripura, and yet to take off in some states. The attitude of all stakeholders in rice production requires a drastic change if the majority of rice farmers have to change over to SRI.

Given the evolution of farming systems, promotion of technologies is likely to be more successful if done by encouraging the farmers. It is necessary to encourage leaderships in scaling up technologies. Training and exposure visits are crucial to bring new farmers to the fold. Thus, the role of extension personnel is critical which was somewhat lacking in the Philippines. This suggests the need for an adaptive management approach, which recognizes the need for a continuous extension presence. In this regard, there is a need to incorporate, say in agricultural development policies, incentives for households to participate in off-farm employment, particularly in areas where similar conditions exist. Such incentives might include investments in human capital (health and education), improvements in rural roads and infrastructure, and efforts to ensure fair and equitable wages for those engaged in off-farm employment.

Recommendations and Further Research

The future development of upland and rain-fed farming systems is constrained by the availability of land, water, and other resources. There is an imperative to promote technologies that address the farmers' needs directly with the genuine participation of farmers. Bringing farmers and researchers together on equal terms for discussion of the problems helps in the identification of appropriate practices for the region. Farmers' participation in research assists researchers in conducting experiments in a wider scale across the landscape, and it raises interest and curiosity among other farmers in the locality and facilitates farmer-to-farmer technology transfer. This provides a great opportunity for mutual learning between the farmers and the researchers. Interventions need to be long-term in nature, accommodating various stakeholders, and adaptive rather than prescriptive in the technology and other changes promoted. Given the social and cultural diversity within each country, the active involvement of farmers as resource users is essential in the development and promotion of suitable practices and technologies for upland and rain-fed farming systems.

Making information and tools easily available to the farmers can facilitate large scale adoption. Without access to improved technologies and better marketing infrastructure, farmers are unlikely to view investment in conserving agricultural land as being economically worthwhile. Investment in rural infrastructure and policies to facilitate the development of an efficient marketing system could, therefore, encourage adoption. Lapar and Pandey (1999) stress that promoters of technology have to consider it not in isolation but as an integral component of interventions designed to increase the profitability of the overall production system. Otherwise, research efforts are unlikely to make a significant change on the continuing problems in the farming systems of Asia. Similarly, monitoring the implementation and adoption of technology and continued evaluation of technologies and extension workers provides opportunities to improve and overcome the deficiencies.

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